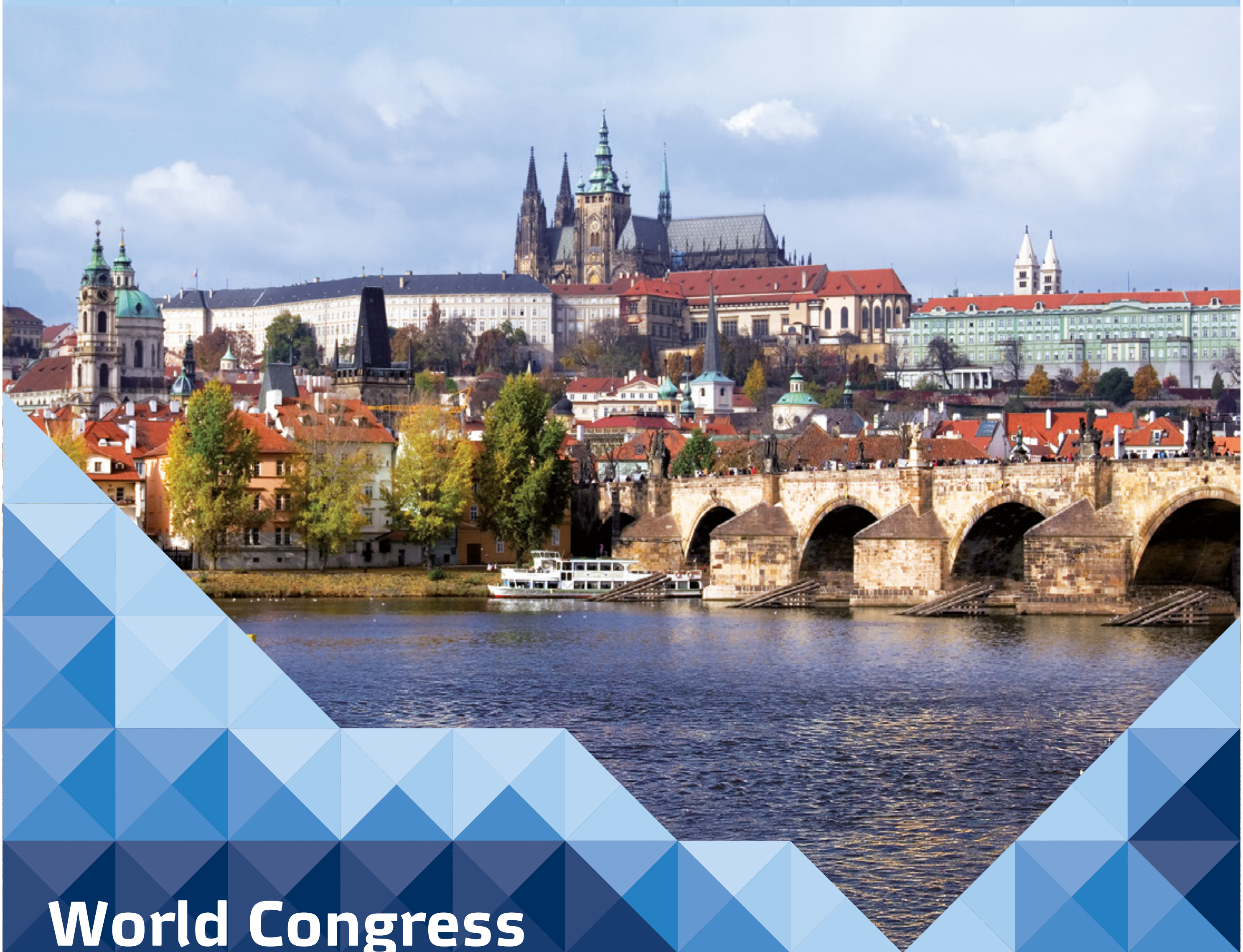
Motto: "Make Progress, Face Challenges, Get Solutions"



World Congress on Medical Physics & Biomedical Engineering

June 3–8, 2018
Prague, Czech Republic

IUPESM
PRAGUE 2018

Book of Abstracts

CONTENTS

PREFACE

This volume presents the Book of abstracts of the IUPESM World Congress on Medical Physics & Biomedical Engineering, a triennially organized joint meeting of medical physicists, biomedical engineers and adjoining health care professionals. Besides the purely scientific and technological topics, the 2018 Congress will also focus on other aspects of professional involvement in health care, such as education and training, accreditation and certification, health technology assessment and patient safety. The IUPESM meeting is an important forum for medical physicists and biomedical engineers in medicine and healthcare to learn and share knowledge, and discuss the latest research outcomes and technological advancements as well as new ideas in both the medical physics and biomedical engineering fields.

Biomedical engineering and medical physics represent challenging and rapidly growing areas. Building on the success of the previous World Congresses, the aim of the World Congress 2018 is to continue in bringing together scientists, researchers and practitioners from different disciplines, namely from mathematics, computer science, bioinformatics, biomedical engineering, medical physics, medicine, biology, and different fields of life sciences, so that they can present and discuss their research results. We hope that the World Congress 2018 will serve as a platform for fruitful discussions among all attendees, where participants can exchange their recent results, identify future directions and challenges, initiate possible collaborative research and develop common languages for solving problems in the realm of biomedical engineering and medical physics.

The book of abstracts represents in brief form all contributions that will be presented in oral and poster sessions. It provides an excellent overview of the breadth and depth of topics that are in the focus of researchers, teachers and practitioners in biomedical engineering and medical physics.

The editors would like to thank all the participants for their high quality contributions and GUARANT International for publishing the Book of abstracts of the World Congress 2018.

May 2018
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ABSTRACTS

Contribution ID: 1936

PRESIDENT'S PLENARY PAPER: Engineering Innovations for Future Healthcare

James Goh[1,2,3]
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Healthcare services landscape is changing rapidly due to multiple factors, ie healthcare economics leading to reformation in the healthcare system, major trends in public health, continuing advances in our understanding of human biology that has the potential impact on medical practice and the development of new innovative technologies for effective and precise diagnosis, treatment and monitoring. With advances in technology, how then would future healthcare and medicine look like? Would the approach gravitate towards patient-centered and personalized medicine? Particularly with the development wearables, data analytics, IoT and artificial intelligence etc. The proliferation of health centric devices and digital health will certainly give rise to connected health with increased fitness awareness. Aside from the digital revolution, multi-scale bioengineering approaches are also making impact in healthcare and medicine. In the understanding of cellular and molecular processes in pathology, and integration of computational modeling and in-vivo experimentations to address issues in tissue remodeling, injury risk prediction and device design. As such the field of medical and biological engineering has an important role to constantly attain scientific innovation and translate invention to practice, so as to enhance the healthcare interventions. Even so, there are four key challenges which must be overcome to achieve better healthcare services, ie comparative effectiveness, cost containment and reduction, global inequities and accessibility to medicine. In view of these challenges, a systems and multidisciplinary approach would be required to address the complex interactions to achieve better healthcare services.

Contribution ID: 947

5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

PRESIDENT'S PLENARY PAPER: Global distribution of medical physicists, their growth over the past 50 years and future development

Slavik Tabakov
Med. Eng. Phys, IOMP and King's College London, London, United Kingdom

Medical physicists are now an intrinsic part of the global healthcare. While currently there are around than 26,000 medical physicists globally, these are unequally distributed. The IOMP data shows that around 17,000 of these are in North America and Europe, while the rest are serving the three largest continents – Asia, Africa and Latin America. In these places the number of medical physicists per head of the population is minimal, what reflects on the quality of healthcare in radiotherapy, medical imaging, radiation/hospital safety, etc.

The recent Report of the Global Task Force on Radiotherapy for Cancer (Lancet Oncology, 2015) estimates that, only for the needs of Radiotherapy by 2035, the number of newly-trained medical physicists will be of approximately: 17,200 for High-income countries and 22,100 for Low-and-Middle-Income countries. Adding the needs for medical physicists contributing to Medical Imaging (there is a current project about this at present) will result in approximately tripling the global number of medical physicists in the next two decades.
This challenge in front of the profession can only be addressed with concerted efforts in the field of education. These will surely embrace e-learning – an area in which medical physics is one of the world pioneers. The statistics of the IOMP shows that at its formation (around 1965) there had been roughly 6,000 medical physicists in the world. In the next three decades (1965-1975; 1975-1985; 1985-1995) their growth had been about 2,000 specialists per decade. With the introduction of e-learning, soon after 1995, the growth in the decade 1995-2005 had doubled to 4,000. In the following decade (2005-2015) the expansion of e-Learning use and the focus on education has further doubled the growth to 8,000 per decade. These figures present an important trend, which will be the main solution to the expected growth by 2035.

Contribution ID: 1355

5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

PRESIDENT'S PLENARY PAPER: Inovations in medicine- the role of medical physicists and biomedical engineers

Kin Yin Cheung
Medical Physics & Research Department, Hong Kong Sanatorium & Hospital, Hong Kong, China

Medical physicists and biomedical engineers play a key role in patient management in healthcare and in the evolution of medicine. They contribute to diagnosis and treatment of diseases, research and development of better devices for clinical use, testing and commissioning of new technologies and clinical modalities for proper and safe clinical applications, and management of such technologies in healthcare. The importance of medical physicists and biomedical engineers in healthcare may be demonstrated by the continual and rapid manpower growth of the two professions over the years. These professionals were brought together by IUPESM in 1980 when IFMBE and IOMP formed a Union. The Union formed a platform for scientific interaction and collaboration among the two streams of professionals. It also created the synergy for cross-cultivation of new ideas and innovations in research and development. In front of them are challenging but exciting new frontiers in medicine. Promising new approaches in disease management and intervention procedures are being developed which are based on new biological models that are built to the genetic and DNA level. These new procedures are potentially more effective in prevention, diagnosis and treatment of diseases. For instance, early diagnosis of diseases is possible by studying the molecular behavior or DNA sequence in cells and treatment of resistive diseases can become effective by modifying the genetic makeup of cells and molecules in the immune system or diseased tissue volume. Other new innovations such as systems medicine and personalized medicine are gaining momentum in their development. The application of artificial intelligence, big data and associated analytical tools, DNA sequencing and associated laboratory testing and analytical tools, and high precision and automated diagnostic and therapeutic systems are under development and testing. Medical physicists and biomedical engineers have a lot to offer and contribute in these new developments in medicine.

Contribution ID: 1138
SS-01 IFMBE Student Design Competition

Rapid fabrication of paper-based microfluidic analytical platform for biomolecular sensing with a low-cost 3D printing technology

Chen-Kuang Chiang[1], Chen-Yu Kao[1], Meng-Jiy Wang[2], Fu-Yuan Tai[1]
[1]*Graduate Institute of Biomedical Engineering, National Taiwan University of Science and Technology, Taipei City, Chinese Taipei*
[2]*Department of Chemical Engineering, National Taiwan University of Science and Technology, Taipei City, Chinese Taipei*

This article describes an innovative method to fabricate microfluidic paper-based device (μPAD). μPAD is a simple, rapid, cost-effective device. These devices can easily perform a quantitative result for POC and environment monitoring [1, 2]. Over the past ten years, μPAD has been through a rapid development. The utilization of μPAD becomes more and more versatile [3]. However, the methods of μPAD fabrication remain at either high cost with good resolution or cheap with low resolution.
Here we introduce an innovative method to fabricate a μPAD with a simply ameliorated three-dimensional printer. The Procedure only requires one step. Just put the filter paper on printer and μPAD will be done within 3min. Besides, this process is a mask-free procedure, the design of μPADs can be arbitrarily changed for the customized usage or research applications. The resolution is up to 445 um. Besides, no metallic mask is needed, and it only cost 1/5 or below compared to other wax printing facility.
To verify the μPAD prepared in this method can be used in detecting disease, the μPAD was utilized to detect nitrite and glucose. The results showed these μPADs offering accuracies for quantitative analysis of nitrite and glucose. We believe this new technology can bring benefit to the research of μPADs in the future.
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Contribution ID: 1169
SS-01 IFMBE Student Design Competition

A compact, low-cost and self-sustaining telemedicine device carried by unmanned aerial vehicles to provide prenatal care in resource-scarce communities

Kuei Hsien Chao, Hau Jyun Yang, Meng Chen Li, Pei Chen Chen, Sheng Yu Lin
Biomedical Engineering, National Cheng Kung University, Tainan, Chinese Taipei

Although prenatal care is extremely important for pregnant women and their babies, such care is still lacking in many areas with scarce medical resources. Although there has been some efforts to develop telemedicine tools for prenatal care, such tools are typically designed for developed countries with access to Internet and electricity that could be unavailable in remote or destitute areas. Considering the distance and economic situations, we propose a self-sustaining telemedicine device that can be carried by an unmanned aerial vehicle (UAV). This device will be equipped with its own power and communication system based on a portable satellite modem as well as necessary tools to assist the diagnosis for prenatal complications. After the UAV carries this system to a remote site, the obstetrician can use it to remotely examine the pregnant women with a two-way video conference. The system will also involve necessary instruments for real-time and remote physiological monitoring, including a thermometer, weight scalar, a heart rate meter, an electronic sphygmomanometer, an electronic stethoscope and a fetal Doppler. A push-button blood collection device will be included to allow self-administered blood sampling. Urine samples could be tested for proteinuria and glucose levels directly through test papers. The signal acquisition and processing will be built upon Raspberry Pi, which is relatively cheap, light-weighted and easy to maintain. The estimated cost of the system, excluding the UAV, is below USD$500 and its weight to be under 3kg. In addition to the UAV installation, we may also deliver the proposed device by light aircrafts or make it into a compact box for physicians to carry during trips to provide medical services in rural areas. The implementation of the proposed device is currently under way and we expect to have a prototype system ready for testing soon.

Contribution ID: 1267
SS-01 IFMBE Student Design Competition

Mobile device for skin screening

Marta Lange, Martins Zeidaks, Emilija Vija Plorina, Matiss Lacis, Karola Panke
Institute of Atomic Physics and Spectroscopy, University of Latvia, Riga, Latvia

Nowadays when our everyday lives are busy, it is extremely important to find the time and accessibility to regularly check our health. One of the biggest risks in all parts of the world is skin cancer so we came up with a portable, non invasive and accessible mobile device that can be used for skin screening.
Biomedical imaging has become a powerful tool for diagnostics and monitoring of human health. This device has many advantages: non-invasiveness, remote operation (avoiding infections) and the ability to quantify the tissue using specific image parameters. Dermatologists and other skin experts need compact, self-sustaining and easy-to-use imaging devices. The proposed device uses visible light source and skin malformations which are analyzed in few seconds with different mathematical algorithms.
This device uses smartphone as a base (imaging, data analysis, data transformation to the cloud) and a defined light source to capture data from skin. The device is low-cost, easy to use (for dermatologists, general practitioners), does not harm patient, because it uses visible light, and is accurate for skin screening.
There are several commercially available skin diagnostic imaging devices for dermatologists, but most of them are bulky, cable-connected and expensive. The recently commercialized pocket-size digital dermatoscopes, video-microscopes and smartphone-based solutions have shown potential for primary skin diagnostics. Almost every doctor can use this method for primar check-ups, because smartphones are accessible, even in the low-developed countries.
The market is wide, starting with end users, like, general public who is concerned about their skin condition, as well as general practitioners, beauty salons, dermatology clinics, and even bigger hospitals. Design can be potential over new device generations, because it could be applied over different platforms (Android, iOS), and after new smartphone development it is easy to adapt to new platform.

Contribution ID: 1356
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Detrended fluctuation analysis of inter-breath intervals in asthmatic children overnight

Javier Gracia[1], Ville-Pekka Seppä[1], Anna Pelkonen[2], Anne Kotaniemi-Syrjänen[2], Mika Mäkelä[2], Pekka Malmberg[2], Jari Viik[1]
[1]*Biomeditech, TUT, Tampere, Finland*
[2]*Department of Allergology, University Central Hospitall, Helsinki, Finland*

Current research has shown that respiratory obstructive diseases reflect as a reduction in temporal complexity on the breathing pattern. Techniques quantifying complexity, such as detrending fluctuation analysis (DFA), require long, low-disturbance recordings. Therefore, overnight monitoring of respiratory complexity appears as a potential non-invasive diagnostic tool. Nontheless, there is a lack of studies on this regard. Perhaps, because interpretation is hindered by the influence of sleep stages on the control of respiration.
This study assesses long-term correlations during breath-defined REM and NREM in 31 children with different levels of asthma risk. Specifically, patients were grouped as: 11 high risk (HR), 13 low risk (LR), and 7 under medication (ICS). Inter-breath intervals (IBI) were extracted from overnight impedance pneumography recordings. A threshold in the median absolute deviation of the IBI signal defined the REM and NOREM stages. DFA2 on a time scale of 2-24 breaths was calculated for joined REM and joined NOREM sections during the early (22-2h) and late (2-6h) parts of the night.
As reported on the literature, α showed low memory during NREM and increased memory during REM. NREM α showed no significant difference between groups across early and late night. We discovered a slight increase in NREM α for the late night, where obstruction is known to occur. This increase was significantly higher in ICS relative to HR (p=0.029) and LR (p=0.004), but not between HR and LR.
Results suggest that long-term correlations during NREM increases overnight parallel to the known increase in IBI variability. However, such increase degrades in the presence of obstruction. Larger population and healthy controls should be study in order to support this claim.

Contribution ID: 1665
3. Information Technology in Healthcare
03.03. Systems for quality assurance and dose tracking

Low cost system design for traceability and control of surgical instruments in a public hospital

Francisco Ubaldo Vieira Junior[1,2], Rafael Farias[2], Eduardo Costa[2]
[1]*Information Technology, Federal Institute of São Paulo, Campinas, Brazil*
[2]*Biomedical Engineering, State University of Campinas, Campinas, Brazil*

The Materials and Sterilization Center (CME) is a technical support area for processing hospital materials. CME process, cleans, disinfects, prepares, sterilizes, stores and distributes hospital materials. Brazilian legislation requires the control and monitoring of the process for traceability in case of occurrences.
The objective of this work was to implement a sterilizable instruments traceability system in a public hospital in Brazil.
The design of the current work process was carried out and the critical points were identified. After general analysis of the group, a new process was designed with the hospital professionals.
A solution was developed with radio frequency identification (RFID) with passive TAG for attachment to the surgical boxes. The instruments were coded with Data-Matrix codes and software components used were HTML, Ruby and ORACLE. Laser coding and marking solutions were developed on instruments with code dimensions ranging from 4 to 10mm. Two models of

passive tags for autoclave operation were tested and none of them supported more than 50 cycles. RF infrastructure, antennas and readers, were installed in 4 points: the assembly of the surgical boxes, the entrance of the autoclaves, the entrance of the stock and the exit to the surgical center. The system is in the final stages of testing and implementation

Contribution ID: 1817
SS-01 IFMBE Student Design Competition

Innovative health technologies for low-resource settings: photopupillary reflex monitoring via smart phone

Davide Piaggio[1], Georgy Namm[1], Nicola Logrieco[2], Leandro Pecchia[1]
[1]University of Warwick, Coventry, United Kingdom
[2]University Hospital Federico II, Naples, Italy

Photopupillary reflex is a widely investigated reflex, as it is an indirect way to assess traumatic brain injury, pain and the conditions of patients in critical care. As of now, pupilometers and specific algorithms have been developed to help clinicians in assessing this reflex, but these products are rather expensive and inappropriate in low- and middle-income countries (LMIC), where there is a major need for those technologies, given the limited number of specialized doctors.
Since mobile phones are widely spread in Sub-Saharan Africa (e.g. over the last 15 years there was a 75% increase in the population owning a mobile phone in Kenya/Tanzania compared to a 25% in the USA), they seem to be the best viable solution to the problem.
Our study aimed to assess the feasibility of developing a pupilometer for low-resources settings via a mobile app. We started with the realization of the setup for the acquisition of eye images: it included a mobile phone on a tripod, Neutral-Density Filters to obtain different intensities of light and a light sensor reader. Videos of the eye were acquired in a normal lighting condition, followed by flashes of light at different intensities with some resting time in between. Afterwards, relevant parameters (e.g. pupil diameter) were calculated out of the processed frames. These parameters showed how the pupil reacted to light and could be used to assess non-physiological behaviors. This talk will present the results of this study.

Contribution ID: 143
SS-02 Innovative Biomedical Engineering Research in Asia

The relationship between spine curvature and balance stability in older adults

Wei-Li Hsu[1,2], Pei-Yu Su[1], Jau-Yih Tsauo[1,2], Rong-Sen Yang[3]
[1]School and Graduate Institute of Physical Therapy, National Taiwan University, Taipei City, Chinese Taipei
[2]Physical Therapy Center, National Taiwan University Hospital, Taipei City, Chinese Taipei
[3]Department of Orthopedic Surgery, National Taiwan University Hospital and National Taiwan University College of Medicine, Taipei City, Chinese Taipei

Background: Aging people often have thoracic kyphotic posture, which may lead to decreased activity, poor balance and gait performance, increasing the fear of falling and risk of falls. However, few studies showed the relationship between kyphotic posture and balance stability. Therefore, the purpose of this study was to determine the relationship between spinal curvature and balance stability in older adults.
Methods: Forty-five participants (38 women and 7 men, age: 66.19±6.20 years) participated in this study. Quiet standing trials were recorded by using a motion analysis system with 10 cameras (Vicon Bonita, UK). Spherical reflective markers attached to the participants' bony landmark, according to full body Plug-In-Gait marker set. Center of mass (COM)-center of pressure (COP)

inclination angle in anterior-posterior (IncAng_AP) and medial-lateral direction (IncAng_ML) in quiet standing was calculated in MatLab. Spinal curvature of thoracic spine (SCoT) was measured by Spinal-Mouse® (Idiag, Switzerland) under neutral upright position.
Results: The findings revealed that IncAng_AP ($r=0.121$, $p=0.430$) and IncAng_ML ($r=-0.190$, $p=0.211$) was not significantly correlated with SCoT. However, when we divided the participants in low kyphotic group (SCoT < 47) and high kyphotic group (SCoT≥47, n=19), a significant positive correlation between IncAng_AP and SCoT ($r=0.463$, $p=0.046$) was found in high kyphotic group. And there was no significant correlation was found between IncAng_ML and SCoT in high kyphotic group ($r=0.144$, $p=0.556$).
Conclusions: The Inc_AP during quiet standing was significantly correlated with SCoT under neutral upright position in older adults with more kyphotic posture. Moreover, no significant correlation was revealed between Inc_ML during quiet standing.
Implications: The results suggest that the COM of older adults with more kyphotic posture were closer to their limits of stability than those older adults with less kyphotic posture. More kyphotic posture could lead to a poor static balance in standing and to have a higher risk of fall.

Contribution ID: 508

SS-02 Innovative Biomedical Engineering Research in Asia

Sophisticated hydrodynamic simulation of pulmonary circulation for the preclinical examination of right heart circulatory assist device

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To evaluate systemic circulatory support devices such as left ventricular assist system, surgical heart valve prosthesis, and transcatheter aortic valve, various in vitro hydrodynamic tests have been performed. As these devices are being applied to the pulmonary circulatory support in recent years, novel evaluation platform for right heart support is increasingly demanded. This study aims to develop a pulmonary mechanical circulatory simulation system to assess the hydrodynamic performance of newly designed artificial cardiovascular devices.
For the construction of the system, we developed the components of the system by the pneumatically-driven polymer right atrial and ventricular models with the pulmonary arterial valve chamber, silicone-made peripheral pulmonary artery model, and a venous reservoir. Next, a woven polyester vascular graft and commercially available mechanical bileaflet valve were installed into the valve chamber. Then, the right ventricular pressure and pulmonary arterial pressure ware regulated by the peripheral resistive unit to maintain those values within physiologically normal ranges.
As a result, we successfully obtained the standard conditions of our mechanical circulatory system to be 28/3 (systolic/diastolic) mmHg of right ventricular pressure, 29/7 mmHg of pulmonary arterial pressure, 6 mmHg of mean right atrial pressure, and 3.0 L/min of pulmonary flow rate.
In this study, we could simulate the physiological waveforms in natural pulmonary circulation by our mechanical circulatory simulator. To carry out the sophisticated assessment of the diseased pediatric or adult pulmonary hemodynamics for the support of the surgical and transcatheter treatments, we are preparing the next step with the reproduction of respiratory changes in pulmonary peripheral resistance, and the development of a patient-specific shape vascular model including catheter access vessels. Under the highly simulated both pulmonary anatomical

morphology and hemodynamic function conditions, effective preclinical examination of newly designed surgical or percutaneous pulmonary circulatory support devices can be performed.

Contribution ID: 869
SS-02 Innovative Biomedical Engineering Research in Asia

Photocrosslinkable gelatin for regenerative medicine: manipulating interactions between cells, drugs and scaffolds

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Modification of gelatin with photocrosslinkable methacrylamide groups maintains the unique properties including the biocompatibility and biodegradability of gelatin, but additionally endows the material with the ability to solidify from liquid to solid upon light exposure. Furthermore, by varying the methacrylamide modification degree, the material concentration and the light exposure time, i.e., to change the hydrogel network structure, the mechanical, degradation and biological properties of the photocrosslinkable gelatin (GelMA) can be easily and robustly tuned. Such control of the hydrogel network structure also makes fabrication of the GelMA hydrogel into all sorts of scaffolding system for various biomedical applications possible. When combining with different cell types such as keratinocytes, dermal fibroblasts, endothelial cells, mesenchymal stem cells and/or growth factors, the GelMA hydrogels can be used as injectable gels to create epidermal substitutes, and fabricated into 3D nanofibrous wound dressings to regenerate vascularized skin. Moreover, its microsphere format has been developed as injectable osteogenic tissue constructs for bone regeneration. In this talk, we will give a brief introduction of the GelMA hydrogel and discuss how their properties can be manipulated, how they can be created into different scaffolds and how to manipulate the material to interact with different cell types and drugs to regenerate various tissues.

Contribution ID: 975
SS-02 Innovative Biomedical Engineering Research in Asia

Intelligent Monitoring and Assisting System for the Elderly with Stroke in Daily Life

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This intelligent monitoring and assisting system, which is based on statistical data of stroke data-band, clinical experience of doctors and practical demands of managers from professional long-term care of nursing center, intended to provide a platform with three purposes, including prevention, warning and care, together with medical commonality. In addition, Internet of Things of healthcare service technology will be applied to implement long-term health prevention, warning and care of stoke, which has been recognized as a serious global clinical disease.
Based on the big data of international journal published, factors to cause stroke in Taiwan and mainland China were collected and analyzed to prevent high-risk groups from stroke. In addition, applications of the Internet of Things of healthcare service technology were specially designed to

establish a risk probability prediction model to prevent recurrent stroke with daily care service for patients who are disable because of stroke. The main content of the work had two parts. One was focused on prevention, and the other one was focused on rehabilitation treatments, including the special design of Chinese Tai Chi. The health prevention focused on the high risk group of stroke to design and implement stroke prevention with the application of the Internet of Things of technology. For the rehabilitation treatment, smart wearable devices were developed for sustainable fitness, training and rehabilitation. The target focused on stroke patient undergone physical therapy for rehabilitation, as Chinese Baduanjin exercise.
A new opportunity will be created by the multiple site collaborations. It is expected to accomplish effective talent education training instantly, and to establish the Internet of Things cloud health service with integration and application of high technology from the aspect of global commonality and homecare demands in different regions.
Keywords: Stroke, Baduanjin exercise, prevention, rehabilitation

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SS-02 Innovative Biomedical Engineering Research in Asia

A surgical robotic system for transurethral tissue resection

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Transurethral surgery is a noninvasive interventional procedure that delivers a tubular surgical instrument via the urethra to access surgical sites in the prostate or bladder for abnormal tissue resection. Typical application includes transurethral resection of the prostate (TURP) and transurethral resection of bladder tumor (TURBT). In above procedures, a rigid resectoscope is inserted via the urethra to access the surgical site. The resectoscope consists of an endoscope which provides surgical vision, and a cutting loop which performs tissue cutting and coagulation. In the current clinical practice, the resectoscope is manually operated by the surgeon under the feedback of the endoscope, which is laborious. Due to the limited field of the view (FOV) of the endoscope, difficult hand-eye coordination, hand tremor, and lack of depth information, the procedure is non-intuitive and error-prone, requiring a long learning curve for novices. We develop a master-slave robotic system prototype for transurethral tissue resection. The system is composed by a user console and a slave robot. The user console provides surgical vision and intuitive human-robot interaction interface with a joy stick, and the slave robot performs the surgery accordingly. The slave robot further consists of a 6 DOFs (degree of freedom) serial robot arm and a 1 DOF end-effector. The robot arm is used to accurately position and orient the resectoscope inside the body. The end-effector is designed to hold the resectoscope and precisely control the linear motion of the cutting loop by reproducing the user's motion at the console side. Preliminary experiments were performed to evaluate the proposed system and the results have confirmed its effectiveness.

Contribution ID: 1100
SS-02 Innovative Biomedical Engineering Research in Asia

Soft printable robotics for wearable rehabilitation

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Stroke is a leading cause of motor disability worldwide, where rehabilitation is necessary to recover from such disability. However, due to growing manpower constraints and greying populations, rehabilitative care may gradually become limited. In recent years, soft robotics is progressively

becoming popular as an ideal choice of technology for wearable robot-assisted rehabilitation. Traditional methods of fabricating actuators for soft robots typically require the use of mold-casting, which is a tedious multi-step process. Therefore, this work aimed to develop a single-step printable pneumatics technique to fabricate soft bending actuators for wearable rehabilitation, with consistent quality and performance. We further characterized the printed pneumatic actuators in term of their bending curvature and force output. We found that the soft wrist rehabilitation device, based on our soft printed actuators, is able to guide the wrist model and the human wrist through bidirectional flexion-extension motions. In addition, we developed a fully 3D-printed soft robotic glove that can be easily customized to any patient's hand dimensions, and provide lightweight and safe robot-assisted hand exercises to the user. We have also developed a new folds-based design approach, which has shown its efficiency and versatility when applied to pneumatic actuators. This is evident by its ability to be used in a variety of rehabilitation, locomotion and manipulation applications with adequate force and torque output. Collectively, we have demonstrated 3D printing as an important fabrication method for building soft wearable rehabilitation robots in an automated manner with consistent quality and performance.

Contribution ID: 442
SS-03 Results and Recommendations from a Canada-Italy Workshop on Patient Safety

Patient safety and Health Technology Assessment of medical devices: where are we?

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Medical device safety depends upon several factors, including compliance of medical locations with international standards, user skills, good maintenance and other operational conditions. Those factors evolve in time and become evident over temporal scales that overcome the one of trials.
Health Technology Assessment of medical devices struggles to consider the specific circumstances in which medical devices will be nonoperational, which can affect its safety.
This talk will present the state of the art of Health Technology Assessment methods and tools in relation to medical device safety and discuss the extent of which patient safety is properly considered during the assessment of a medical device.
Recommendations from a recent IFMBE HTAD survey will be also presented.

Contribution ID: 862
SS-03 Results and Recommendations from a Canada-Italy Workshop on Patient Safety

Information Technology and Patient Safety

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Patient safety issues have changed dramatically in recent years and include a concern with adverse events and medical errors. Several types of events can occur: adverse drug events and improper transfusions, surgical injuries and wrong-site surgeries, restraint-related injuries or death, falls, burns, pressure ulcers, and mistaken patient identities. Factors that interfere with cognitive or technical performance of providers are: insufficient use of information technologies (ITs) for decision-making, fatigue, sleep deprivation, supervision of junior staff, and a culture that portrays errors as individual failure. ITs that help reduce AEs are: practice guidelines and protocols at the point-of-care; automated reminders for patients and providers for tests or follow-up; adequate patient outcome information that can be benchmarked to identify unacceptable variations. AE tracking systems and online clinical information systems can be a solution. There exist pharmacy and nursing information systems and computerized physician order entry systems (POES) for medication management, Electronic Medical Records, automatic and biometric identification technologies; Clinical Decision-Support Systems (CDSSs). Human factors engineering and usability testing ensure that new technologies and procedures are easy to use, relevant, and safe. Other approaches are: promoting the adoption of standards for data and systems; systems that communicate with each other; measuring and preventing AEs; making existing quality structures meaningful and improving regulation. Clinical Engineers (Ces) must become aware of new IT developments and understand the benefits and drawbacks of these technologies. CEs should also seek information on health technology assessments (HTAs) of new Its. CEs should ensure that researchers, developers, and vendors of the new ITs involve them prior to a clinical trial or the delivery of a new system. Training users on the safe and effective use of medical devices and of the benefits and limitations of newly introduced information technologies is critical to maintain patient safety at the highest level possible.

Contribution ID: 924

SS-03 Results and Recommendations from a Canada-Italy Workshop on Patient Safety

Human factors and aligning corrective actions and causal factors

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Healthcare is under huge pressure. Overstretched budgets, rising costs, staff shortages, and new technologies and innovations increase the likelihood of safety incidents. The rate of serious safety events in Canada has not decreased significantly in the past 15 years, despite dedicated efforts and resources to do so. We need more effective ways to ensure patient safety. Analyses of safety incidents have revealed a wide range of contributing factors. Too often, however, investigative teams focus on the first causal factor identified (e.g., staff violation of a policy) rather than considering such factors holistically as parts of a sociotechnical system (i.e., interactions between people and technology embedded in an organizational structure). Moreover, investigative teams often jump to corrective actions on the basis of a single case analyzed using a single method and overestimate the importance of some factors, potentially missing other important contributing factors altogether. Consequently, interventions are implemented that do not address the causal factors as intended and may even introduce new risks. Aligning corrective actions to causal factors is key to identifying effective interventions. Application of Human Factors and safety science is needed to assist hospitals with analysis of incidents to uncover and resolve deep system problems by prompting thinking around proper alignment between corrective actions and causal factors, and by generating evidence about which corrective actions should subsequently be implemented.

Contribution ID: 1025

SS-03 Results and Recommendations from a Canada-Italy Workshop on Patient Safety

Education and training of Biomedical and Clinical Engineers. Are we aware of the new threats to patient safety?

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The Clinical Engineering Division of the International Federation for Medical and Biological Engineering (IFMBE/CED) has the mission to become an international forum for developing and promoting of the clinical engineering profession resulting in improvement of global healthcare delivery through the advancement of safe and effective innovation, management and deployment of healthcare technology.

In the last years, CED has proposed many projects that have a positive impact on the patients' safety. All these projects are lead by professionals with excellent worldwide experience and benefit from the support of about 35 among elected members, collaborators members and coopted members.
These projects span from writing (and translating) guidelines to e-courses for technicians in low-income settings, from CE-IT training and education, to designing of undergraduate CE programs.
Decision support systems, artificial intelligence, risk management, process analysis, EMC analysis, process (re-)engineering, evidence based maintenance. These are just some of the many fields of knowledge that today's Clinical Engineers are supposed to know and to master.
The patients, in a healthcare setting, are today immersed in a sea of technology, tangible and intangible, not just hardware. Their safety is intimately connected to the appropriate management of these technologies and to the safe management of the processes that govern it.
A few examples of situations where the clinical engineers in a healthcare setting can directly impact on the patients' safety will be shown.

Contribution ID: 1301
SS-04 Healthcare Facilities - Emergency Preparedness Assessment and Training

Education Successes Applied to Disaster Preparedness: Meeting infectious diseases and malnutrition challenges Health Worker Focused Distributed

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Hurricanes, floods and earthquakes have devastated part of the Caribbean and Latin America Region: "Maria" hurricane in Puerto Rico, flooding disaster in Peru, the several serious earthquakes in Mexico, Colombia, Chile, Argentina, occurred recently; it is required to ensure the effective functioning of the health systems at the potential situation of an emergency. Natural disasters and other emergencies around the world put the populations at risk; they may cause diseases and/or the disruption of health systems, facilities and services. The health risks of a disaster can be mitigated by building capacities of individuals, community and the country with developed or developing economies to protect health, Preparedness should address all the health disciplines.
Responding to the effects of climate change on 2017 the National Institute of Health of Peru trained health workers from the 6 regions seriously affected by dengue disease, the result improved the effectiveness of the regional laboratories through the on time distribution and correct use of supplies to respond to the emergency. On 2014, the Philippines trained to prepare health professionals working in hospitals to detect and safely manage Ebola virus disease (EVD): public, private and local government hospitals were engaged. The confidence in managing EVD increased significantly ($P = 0.018$) with 96% of participants feeling more prepared to safely manage EVD cases. In other country like Ethiopia the adequate preparedness in emergencies and disaster response improved the capacities and better understanding of context specific causes of acute malnutrition and contributed to prevent the increase of severe acute malnutrition in the Horn of Africa in 2013 and 2014.

Contribution ID: 1514
SS-04 Healthcare Facilities - Emergency Preparedness Assessment and Training

Use of Hybrid Training to Support Emergency Preparedness

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There is a global movement to support and embrace hybrid delivery methods for education and training. A hybrid course is one in which 25-75% of the class time is conducted online via asynchronous and live webinars or chat rooms, with the remainder taking place face-to-face in the classroom. The advantages seen by students are increased flexibility, lower costs, and improved student engagement through multiple interactive channels.
Asynchronous online courses have a number of advantages over classroom training especially for working adults: 24x7 access, full use of the world wide web resources, no limitation on location, and no travel time or costs. The resources of the world wide web consist of documents, tutorials, case studies, scenarios, computer-based simulations, and videos. Another form of online training is webinar based commonly used today for professional education. Webinars allow interactive presentations to review concepts and data, discuss issues, answer questions, and give interactive quizzes
This hybrid interactive education has direct application to health systems training for emergency preparedness particularly for learners in geographically distant locations. Emergency centers are typically based in the country capital, but have many regional offices. Bringing all staff into the capital for training or performing training in each regional office is both very expensive and time consuming. If hybrid training principles are applied, typically live classroom training is held to start the course with an additional live classroom session midway through the course or at the end. To implement the virtual educational component, the organization only needs to arrange for a platform to load content, messaging, and assessments along with arranging for interactive webinars with a service. Case studies will be provided demonstrating applications of hybrid training.

Contribution ID: 1515
SS-04 Healthcare Facilities - Emergency Preparedness Assessment and Training

Crisis and emergency risk communication in emergency preparedness and response

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Crisis and Emergency Risk Communication (CERC) is the use of risk communication in emergencies to inform the public about an event or issue to enable members of a community to protect themselves. CERC combines the fundamentals of crisis communication and risk communication as they are applied during an emergency response. CERC involves experts (government, scientists, engineers) who provide information allowing individuals or an entire community to make the best possible decisions about their well-being. Communicators must also help people accept the imperfect nature of choices during the crisis and that a decision must be made within a very short time.
Communicators must inform and persuade the public with the aim that they will plan for and respond appropriately to risks and threats. CERC draws from lessons learned during past emergencies and multi-disciplinary research in the fields of public health, psychology, and risk management (risk perception, risk communication and risk assessment). The six principles of CERC established by the US Centers for Disease Control and Prevention (CDC) are Be First, Be Right, Be Credible, Express Empathy, Promote Action and Show Respect.
In order to be effective in CERC, we must understand how people process information during a crisis – risk perception. Planning is the most important step in effective CERC. It requires understanding the pattern of a crisis in order to anticipate problems and respond effectively. By dividing the crisis into phases, the information needs of the media, stakeholders, and the general public could be prepared.
Some aspects of CERC use and shortcomings identified during the Fukushima Daiichi nuclear disaster will be discussed.

Contribution ID: 1519
SS-04 Healthcare Facilities - Emergency Preparedness Assessment and Training

Preparedness and response of Diagnostic and Therapeutic Radiology Services to natural and technological disasters

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Natural disasters such as earthquakes, hurricanes, floods and fires can disrupt health services when the medical facilities offering them are in the disaster area. Yet, in case of mass casualties, certain health services such as radiology may be essential to facilitate triage decisions. Power can be restored connecting equipment to emergency generators, but, since medical devices for medical imaging and radiation therapy are very vulnerable to disasters due to their design complexity, they need to be evaluated before they are placed back in service. Medical physicists, radiation protection specialists, and clinical engineers are the professionals who can identify the functions that may have to be restored and the parts that may need to be replaced. In the meantime, if patient transportation to another hospital is not viable, hospital management should be able to call in mobile radiology services, such as computed tomography scanners. If the disaster involves nuclear and/or radioactive material, in addition of the potential structural damage caused by the event, contamination risks may force both patients and staff to be relocated. If the contamination is extensive, or if the damage to the radiological devices may compromise patient or staff safety, the hospital should contact the country's Radiation Control Agency as well as the National Organization in charge of Disaster Response. These entities may require international assistance. The presentation will address plans and resources for emergency preparedness involving medical imaging and radiotherapy equipment and list the type of international assistance available. It will discuss potential problems with radiology equipment performance, such as misalignment of the imaging chain components of an angiography unit and loss of networking capabilities among various medical imaging and therapy devices. It will also describe technological innovations, such as the use of robots to assist or replace humans in performing dangerous response and recovery tasks.

Contribution ID: 1520
SS-04 Healthcare Facilities - Emergency Preparedness Assessment and Training

Disaster Preparedness Training for Health Technology Managers

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Introduction:
Global warming and climate change lead to variations in the planet's ecosystem with an increase in number and intensity of natural sudden disasters. Furthermore, the ongoing man-made conflicts in the world, the permanent risks of nuclear threats and biological hazards also lead to manmade disasters that can have devastating impact on healthcare services and the environment.
Hence it is critical for all engineers to develop disaster preparedness plan, policies and procedures in every field of their competence.
Methods:
In disaster preparedness, hospital plays a central role because it represents the first response to any emergency. Hospital can also guarantee the implementation of an integrated and coordinated response involving all roles such as clinical staff, technicians, patients and volunteers.
Several hospitals have already adopted plans and procedures for disaster preparedness and internal or external emergencies. The major complexity of this task consists in allocating appropriate resources and staff for unpredictable (time and type) event.

Clinical Engineers (CE) are central figures to be involved in disaster-preparedness working groups because of their deep knowledge and wide overview of the hospital technologies. Furthermore, they have the technical and organizational skill for focusing in an all-hazard risk analysis.
One of the biggest challenge is the need for training and testing of disaster preparedness programs and plans for clinical staff. Another big challenge is a specific training for CE on technology management during emergency in hospitals. In fact, the reliability and the availability of health technologies is a crucial point for an effective response to emergency and patients' management.
Conclusion:
Disaster preparedness is central and crucial issue due to the increase of potential of life-risks. Emergency management starts from hospitals that guarantee a first response. CE are those practitioners that have the suitable skills for updating and improving disaster preparedness plans and training.

Contribution ID: 728
SS-05 Patient and Technology Management Challenges in Rural Health Centers

A rural mother and Child Health Center in Northern of Bangladesh: Challenges and Perspectives

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The inhabitants of the northern areas of Bangladesh have poor access to the health system facilities, despite government guarantees due to both social and geographical considerations. To reach the modern health service facilities with updated technologies a remote area has been selected named Ikarkuri, Noagaon in the Northern of Bangladesh to establish a Mother-Child-Health- Center (MCHC) in 2010 cooperating with the Bangladesh Study and Development Center (BSEZ) in Wiehl, Germany. This health centre provides medical care especially for pregnant women and their new-born babies in the surrounding area reaching about 50,000 people and aims to reduce maternal and infant mortality according to SDG goals and also avoiding unnecessary travel to secondary or tertiary health care hospitals. Its tasks are Infant care and child rearing; Nutrition and health education; Hygienic management; Family planning; Medical care of pregnant women and their children; implementation of important vaccinations. The multi-functional gynaecological area supports natural births, caesarean sections for complicated births in an operation theatre also having a pathological laboratory, physiotherapy facilities and medicine shop and ECG, ultrasonography machine. As in these areas, electrical hazards are common so solar panel and LED light had been provided. Many hindrances came during the management of this centre like maintenance of technology, lack of qualified staff, quality treatment service. In the rural area qualified staff are hard to get, also part-time expert engineer is not enough to continue the equipment functioning. To combat these challenges in future, there is a plan for telehealth with networking system and continuous training of the local people to avail quality treatment led by knowledgeable staff. Our experience would be a model for setting up a health centre in other rural areas in Bangladesh for patient and technology management.
Index Terms: Mother and Child Health Centre (MCHC), Technological challenges, Bangladesh

Contribution ID: 886
SS-05 Patient and Technology Management Challenges in Rural Health Centers

Characteristics of rural health centers. Part 1: General Considerations

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The Health Technology Training Group (HTTG) is an expert group of IUPESM, created in 2006 to assist countries in defining their health technology needs. As part of this group work, the idea of writing a book came up. The book published recently is titled “Defining the medical imaging requirements for a rural health center”. Our contribution to this book has been the introductory chapter. In this chapter some aspects are defined as what a rural health station is, the characteristics of a region which needs a rural health station, the actions taken in this type of center, the staff composition, the types of pathologies handled in these remote stations, the equipment and necessary devices, the most important national and international guidelines and standards to use for the regulation of the work and the correct implementation of each procedure, as well as how to compact / transmit digital images based on a telemedicine network. All these topics are treated in depth through the pages of this book, together with experiences of personnel working in these conditions. In the special session we will develop the topic introduction.

Contribution ID: 1006
SS-05 Patient and Technology Management Challenges in Rural Health Centers

Experience of indigenous technology based Telemedicine in rural Bangladesh - years of successful implementation

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About 70% of Bangladesh population lives in villages where no qualified doctor is available. The rural people take consultation of quacks or phramacists often leading to maltreatment and further complications, besides misuse of antibiotics and steroids. Telemedicine using internet has the potential to provide some redress. Under the author’s leadership his department has developed home-grown technology for PC based and mobile phone based Telemedicine, which includes integrated online diagnostic devices like stethoscopes and ECG equipment and a cloud based software platform with archiving of data. After a successful field trial over two years the technology was deployed in rural areas in Bangladesh in 2015, based on a service delivery model involving entrepreneurs with a target to become self-sustainable in a few years’ time. The project is named ‘Dhaka University Telemedicine Programme’ with approval of relevant authority. The patients are charged a fee but the poor are given need based supports, both for consultation fee and medicine, up to a limit for which the patient has to apply. Mutual trust and the will to do something good to others are the key motivation points used in the scheme so that when the network grows very large, a distributed responsibility and management system can be established. In the last two years about 8000 consultations have been provided and the present number of rural centres in Bangladesh is 26; expected to increase soon. 75% patients were females, children and elderly. Recent experience with a limited mobile phone based service delivered to the doorsteps of the rural people through female Roving Telemedicine Operators (RTO) had this figure increased to 95% and it also revealed the promise of increased health awareness and timely medical intervention. Already the programme has been credited with national and international awards.

Contribution ID: 1018
SS-05 Patient and Technology Management Challenges in Rural Health Centers

Characteristics of rural health centers. Part 2: Rural hospitals in Cuba as a support for immediate medical attention

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Rural medical care in Cuba is marked by transcendental moments in the reality of our country. Rural services were created in 1960, accompanied by the location of rural hospitals in the most more or difficult to access areas. Then, a unified, free public funding, focused on primary care National Health System came up. The Rural Social Medical Service was set up in 1963, so that the recent graduates now work as doctors in these areas for a period of 3 years, essentially in mountainous areas. Starting in 1980, the family's doctor and nurse category was also created, which was also extended to rural areas, where the pharmacy for medicines and other first aid devices was implemented. As a result of this strategy, currently rural hospitals make up the 20% of the total existing hospitals, there among them, mammography, conventional Rx and ultrasound units that allow initial assistance and refer the necessary cases for units of greater level, both provincial and nationally-subordinated units. The National health System is focus in prevention, guaranteeing health care for all citizens. The use of renewable energy solutions has been applied to these services, so that electrical energy has been guaranteed in the most remote places. All this effort has been closely linked to the competence of human resources and the injection of new technologies in the last 5 years.

Contribution ID: 1151
SS-05 Patient and Technology Management Challenges in Rural Health Centers

Equipment, protocols and quality control

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A healthcare quality management system (QMS) aims to create a framework for defining and delivering quality outcomes, managing risk and continual improvement. The ultimate goal is to minimize medical errors and ensure patient safety. However, in resource-limited settings, innovative actions are needed to face the challenges of implementing QMS. An effective and well-organized medical equipment maintenance program that conforms to international protocols ensures medical equipment is serviceable, safe, and properly configured to meet intended needs. The program should address equipment selection, preventive maintenance, and procedures for troubleshooting and repair. It is essential that good documents and records be maintained. An integral part of the QMS is a quality assurance program that identifies and corrects equipment hazards and defects to minimize risks to patients, staff and public. In radiation medicine, optimized imaging and treatment protocols are essential to avoid unnecessary patient exposure. There is also a need to identify the stakeholders in the implementation process and establish a working relationship with those involved with clinical, medical, risk management, finance, and information technology. With an effective implementation of QMS, we will attain accountability in healthcare: 'Doing the right things right.'

Contribution ID: 1290
SS-05 Patient and Technology Management Challenges in Rural Health Centers

Health conditions and pathologies managed in rural health centers

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Patients in rural areas may visit the health center for illnesses or certain health conditions such as pregnancy. The health practitioners in the center should have minimal medical knowledge to decide whether the patient can be diagnosed and perhaps even treated locally or has to be referred to a higher health care level, such as a rural district hospital or a tertiary hospital in an urban center. The issue is whether simple medical imaging technologies such as conventional radiography and ultrasound can help these health practitioners making such decisions in an environment where most probably there are no radiologists or radiological technologists present. The clinical practitioner in the center must know the normal images of the examined anatomical region, and thus, be able to detect when an abnormality is present, even though he/she may not be able to reach a diagnosis. The person acquiring the images must have received training regarding the right acquisition and protocol management of the images. Specific protocols should not be rigid and they should always be a complement of the clinical examination and other tests, such as laboratory exams, if available. Common health conditions that may be seen in a rural health center include: Chest illnesses (e.g. viral and bacterial infections such as tuberculosis), trauma, degenerative diseases of the musculoskeletal system, acute abdominal pain, diarrhea, blunt abdominal trauma, kidney stones, pregnancy and gynecological problems. Types of radiological and ultrasound exams which may aid in their diagnoses will be reviewed and discussed. How to interpret some radiological and ultrasound findings will be illustrated. The importance of primary health care, where the majority of diseases can be prevented and diagnosed, and the need of having functional links between centers of differing degrees of complexity will be emphasized. Recommendations regarding patient referral in resource-poor settings will be presented.

Contribution ID: 1561

SS-05 Patient and Technology Management Challenges in Rural Health Centers

Technological Challenges in Rural Health Centers

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Dependency of healthcare on technology for the delivery of its services is at all time high and growing, in every setting of care provisioning, from advanced resources region to low resources or the rural ones. It is therefore critical that technological tools be managed in the most optimal, safe and secured methods. In rural health centers, where professional skills and access to materials (parts) are usually limited, ensuring robust and continuous availability of technology that complies with quality and safety guidelines for the support of patient management presents unique challenge.

The diagnosis of patient condition and determination where care should be managed necessitates the reliance, among other factors, on diagnostic and telecommunication technologies. Coupled with increased use of mobility-based technologies such as smart phones, video capturing, telehealth systems, informatics, and other point-of-care diagnostics, it demonstrates the critical role of communications and inter-operability features that must be planned for and managed. Versions of hardware, software and middle are included.

Technology has life cycle that span from planning to implementing, from funding or donation to commissioning, and from early use to repairs, calibration, upgrade and retirement. This occurs in an environment where staff turnover is high, training is limited and support is not nearby. In addition, clinical engineers with technical know-how, clinicians with clinical expertise, and center managers attempt to communicate through issue solving session using various terminologies. Also, at times software or communications application versions making interoperability difficult and not reliable.

This presentation describes steps in technology planning from planning to implementation, problem resolution, and privacy protection using example of rural healthcare transformation through case study of telemedicine program deployment in rural center by clinical engineers working together with other members of the healthcare team. Proper management of technology supports optimal patient services and maximized benefits from the tools.

Contribution ID: 849
SS-06 Expanding Horizons of Medical Physics: Patient Safety and Beyond

Quantitative molecular imaging biomarkers and how they impact patient safety

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Quantitative imaging biomarkers (QIB) are gaining in importance, as they are pushing the application of imaging beyond qualitative (diagnostic) applications. They are essential for target definition or treatment response assessment. QIBs require quantification of the whole imaging chain from image acquisition, reconstruction as well as image analysis. QIBs also require detailed assessment of the uncertainties, which can in turn be used to define confidence intervals which define what changes in QIB signal can be deemed significant. These confidence intervals, typically defined through repetitive test/retest scanning, can be used to define clinically significant changes of disease response or progression. Furthermore, QIB need to go through the whole biomarker qualification/validation chain before they can be reliably used in clinics. Unfortunately, most of the QIB in use today, have not gone through proper biomarker qualification/validation steps. Improper use of QIBs beyond their proven validity severely affects patient safety. An example of the QIB based on NaF PET/CT scanning of metastatic prostate cancer to bone, including test/retest and clinical validation will be presented. Potential use of such validated QIBs to assess metastatic prostate disease and guide treatment decisions will be presented.

Contribution ID: 873
SS-06 Expanding Horizons of Medical Physics: Patient Safety and Beyond

Advances in intraoperative imaging, registration, and robotic assistance in surgery

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Recent advances in intraoperative imaging offer the means to extend beyond conventional goals of geometric precision and surgical navigation to offer new capabilities to ensure accurate targeting, evaluate the quality of the surgical product, and detect suboptimal surgical constructs and/or complications in the operating room with opportunity to revise if necessary. Such advances include: new platforms for cone-beam CT (including mobile and fixed-room systems); algorithms for high-quality 3D image reconstruction with improved image quality and/or reduced radiation dose; 3D-2D image registration methods to annotate radiographic views with planning and navigation information; 3D-3D image registration methods to combine multi-modality image information in a manner that accounts for complex deformation; integration of imaging with robotic assistance to increase precision, safety, and workflow; and data-intensive approaches to improve planning and better predict (and minimize) variations in surgical outcome. Such approaches aim to improve patient safety, provide independent checks and decision support in the OR, streamline

intraoperative workflow, and provide quality assurance to improve surgical outcomes and reduce the rate of revision surgeries.

Contribution ID: 926
SS-06 Expanding Horizons of Medical Physics: Patient Safety and Beyond

Treatment Optimization in Theranostic Radionuclide Therapies

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The administration of a tracer quantity of a tumor targeting agent in order to determine patient specific pharmacokinetics of the radiotracer prior to a therapeutic activity is the foundation of treatment planning for radionuclide therapies. In this presentation, different theranostic approaches will be discussed in which the treatment can be imaged pre and during therapy; thus providing quantitative feedback which can be used to intervene and alter the therapy.
The examples presented will include: (i) the use of re-differentiation therapy with BRAF inhibitors in radioiodine management of thyroid cancer, (ii) The use of Lu-177 labeled peptides as theranostic agents to image and treat neuroendocrine cancers and (iii) the use of Zr-89 and I-124 antibodies to study tumor uptake and assist in optimizing new targeting immunoconjugates. Theranostic strategies provide an opportunity for careful individualized radionuclide dosimetry to ensure that each patient achieves the maximum tumor dose safely within the tolerances of the dose limiting tissues.

Contribution ID: 1580
SS-06 Expanding Horizons of Medical Physics: Patient Safety and Beyond

Novel approaches to patient dosimetry measurements in radiotherapy and interventional radiology: The role of in vivo dosimetry. Part 1 Radiotherapy

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The dosimetric quantity in Radiation Therapy is absorbed dose to water (TG 51 or TRS 398). Today, the ionization chambers are calibrated in terms of absorbed dose to water, which is used in treatment planning systems (TPS). Some modern day TPS are moving toward Monte Carlo or Boltzman calculations to determine dose in different tissues. This novel approach has been limited by the calculation time. However, in certain cases, it becomes very important to be able to calculate with different tissue types. A reference ionization chamber must be used for absolute measurements in radiation therapy. The characteristics of the ionization chamber are important to consider for precise and accurate measurements. The introduction of small fields for treatment has resulted in important considerations for correct measurements. Other detectors, such as TLD, diamonds, semiconductors, and scintillators, have been introduced as alternative means of measurement. The most important consideration is the size of the detector relative to the field to be measured. Each of these detectors must be compared against an ionization chamber as the standard. There are small ionization chambers but sometimes their characteristics can be questionable. So it is important that the ionization chamber to be used has well known characteristics. Brachytherapy applications as part of Radiation therapy require knowledge of the source being used. Generally the dosimetric quantity in use is air kerma strength with the TG 43 protocol. The dosimetric quantity for electronic brachytherapy is air kerma and a modification of the TG 43 protocol is used. The clinic must measure the sources with a calibrated well chamber. Generally, the dose is short range but again different tissue types should be taken into consideration as appropriate.

Contribution ID: 1662
SS-06 Expanding Horizons of Medical Physics: Patient Safety and Beyond

Novel approaches to patient dosimetry measurements in radiotherapy and interventional radiology: The role of in vivo dosimetry. Part 2.

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Absorbed dose determination in patients undergoing radiological procedures has two main purposes: ensuring that patient doses are commensurate with the medical purpose of the procedure and obtaining dose-effect relationships for epidemiological studies. Given the harmful tissue (deterministic) effects they may cause, fluoroscopically-guided interventions, named here interventional radiology (IR) procedures, require the most accurate patient dose determination. Dosimetric quantities applicable to IR are incident air kerma (Kai), entrance surface air kerma (Kae), air kerma area product (PKA), and the reference point air kerma Ka,r. Kai, Kae and Ka,r can be measured with calibrated ion chambers or solid state dosimeters; PKA, with either a KAP meter or an ion chamber and film. In modern angiographic systems, cumulative Ka,r and PKA are routinely determined, displayed, stored and transferred electronically. To check their accuracy, the systems need to be calibrated before being put into clinical use. Whilst these dose metrics are very useful for the determination of and the comparison with Diagnostic Reference Levels (DRL), they are not patient doses. Surface patient doses can be determined from Kae measurements by application of the appropriate dose-to-air kerma ratios. However, because of the often-overlapping radiation beams in IR procedures, measurements at specific points may miss the peak doses. Therefore, it is necessary to obtain dose distributions for the patient’s most exposed regions, which for IR procedures is the skin. Calibrated silver halide or radiochromic films placed on or around the patient at the entrance of the radiation beams permit determination of the peak dose to the skin and to other critical organs such as the eye lens. Various film arrangements for cardiology and neuroradiology procedures will be presented. How the method could be used to assess the accuracy of the organ doses estimated by the new DICOM Patient Radiation Dose Structured Report will be explored.

Contribution ID: 1728
SS-06 Expanding Horizons of Medical Physics: Patient Safety and Beyond

Electronic recording of radiography, fluoroscopy and computed tomography dose metrics: When should they be included in the patient chart?

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Dose metrics generated by medical imaging devices are useful in guiding proper use of equipment, adjusting acquisition protocols, providing feedback for operators, and for comparing practices. They also contribute to setting representative exam-specific Diagnostic Reference Levels (DRLs). In certain circumstances, because dose metrics are only peripherally related to patient dose, the values are potentially misleading. Dose metric quantities applicable to projection radiography and fluoroscopy include entrance surface air kerma (Ka,e), incident air kerma (Ka,i), incident air kerma at the patient entrance reference point (Ka,r), and kerma area product (PKA). For computed tomography (CT), dose metric values include volume CT dose index (CTDIvol) and dose-length product (DLP). All dose metric indicators, Ka,e, Ka,i, Ka,r, PKA, CTDIvol, and DLP should have calibrations verified for each type of equipment, and should ideally be sent to a radiation dose management system (RDMS) for evaluation, accumulation and retention of ionizing radiation

events. Dose-metric values must be included in the EHR/interpretive report when local, regional, or national laws require such documentation (for example, California 2012 CT reporting law). While this can be helpful to identify overuse, a negative impact could be denial of appropriate and justified exams. Misinterpretation of dose metric information by physicians or patients can result in inaccurate under- or over-estimates of patient dose without sufficient knowledge of the details. Recent approval of the DICOM Patient Radiation Dose Structured Report (P-RDSR) and its implementation should provide improvements in patient-specific characterization of radiation doses. In this presentation, event recording of dose metric values for each modality by an RDMS is discussed, including benefits and pitfalls that can occur. Estimating patient doses with use of dose metric values and/or the P-RDSR by a medical physicist and identifying potential actionable findings to be included in the patient chart are considered.

Contribution ID: 1750

SS-06 Expanding Horizons of Medical Physics: Patient Safety and Beyond

Optical surface imaging to improve the precision and accuracy of radiotherapy delivery

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The advents of precise radiotherapy planning and delivery tools have necessitated the need for mitigating both inter- and intra-fraction patient motion uncertainties. Surface imaging (SI) allows users to view the patient’s topography without ionizing radiation or invasive surrogate markers. Commercial SI systems read the patient position in the room in real time and compare it to the expected treatment position as dictated by the external surface, which is derived from the patient’s planning CT scan. Detected deviations are potential surrogates for patient positioning error. This information is useful both during initial patient setup, as it can guide accurate and efficient positioning, and during treatment to ensure radiation is delivered only when the patient is in the correct position. The opportunity of direct and continuous patient surface tracking, without additional risk from increased imaging radiation dose and time-on-table, makes SI a valuable tool that is safe, efficient, and accurate. Aside from real time patient position monitoring, SI has shown potential for Stereotactic Body Radiotherapy (SBRT), pediatric treatments, Deep inspiration breath hold treatments, and Stereotactic radiosurgery (SRS). The use of SI for DIBH obviates the need for more invasive respiratory motion management techniques, such as active breath hold, while allowing for safe and accurate treatments. For SRS, these systems give patients the option of undergoing treatment with open-face masks without compromising precision of radiation delivery.
However, as any other system, SI has its limitations. It only tracks external motion so any internal target movement independent of external surface motion is not detected. This technology was never meant to substitute internal imaging. Despite its limitations, SI has a positive impact on precise and safe radiotherapy delivery, and as its applications expand beyond the current use, its impact will only become greater.

Contribution ID: 860

SS-07 The Valley of Death in medical technology transfer: why it exists and how to

Medtech4Health - a Swedish model for commercialization of innovations in biomedical engineering

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Medtech4Health (MT4H) is one of 16 strategic Innovation programs in Sweden supported by Sweden's innovation agency (Vinnova). It is a three-year project with option to prolong for 3+3 years. It was started in 2016 and have funding's 10 MEUR for the first 3 years. The participating parties in Sweden includes research institutes, 11 counties, 7 University hospitals, 10 universities and 64 medtech companies. The Medtech industry in Sweden is well renowned and has a unique research- and innovation culture. The MT4H work promotes cooperation between academia, health care and industry in a triple helix format that results in improved health. The aims are: A patient-centered and efficient healthcare system in terms of health outcomes per cost; Continued national and international success of medical technology companies based in Sweden and that Sweden is internationally recognized for excellence in medical technology innovation, research and education. The methods to reach the aims are focusing on three key initiatives: K1 Calls, K2 Addressing "Valley of Death" and K3 Collaboration. In K1 and K3 Projects are financed for developing new Medical technology in Health care, support to small companies and for Courses and national/international collaboration. In K2 significant efforts are made for bridging the gap in Death Valley by verification in Clinical setting and through financing innovators in Health care. Efforts are also put on cross competencies education. Today, more than 93 Projects all over Sweden are financed and going on in MT4H. Most of the Projects involves medtech industry and will result in Products on the Health care market. Most of the members working with MT4H are based at an existing organization and participating in Medtech4Health part-time. The strength of the program is based on the existing organizations long term experience in the field and the cooperation between them.

Contribution ID: 921

SS-07 The Valley of Death in medical technology transfer: why it exists and how to

Experience from industrial graduate (PhD) schools

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Traditionally, research education is performed within the universities, and the PhD students are working within a research group. However, technical development and also research is performed within companies, and the need to keep up with the latest findings in research and to strengthen the competence within the private business sector is increasing. The Swedish financier Knowledge Foundation offers a co-production programme in form of Industrial Graduate Schools. The programme aims to strengthen the research environments of the universities involved in these schools, and to develop expertise in the business sector and strengthen their long-term competitiveness through education of PhDs and licentiates. The financier states: "Since 1995, the Knowledge Foundation has funded nearly 30 Industrial Graduate Schools. The Foundation's evaluation shows that the individual Industrial Graduate Schools well have met the Foundation's objectives for the programme, i.e. they have achieved good results as measured as PhDs awarded, and have contributed to the development of the universities as well as the business partners."
At Mälardalen University, we have experience from working in several Industrial Graduate Schools. The collaboration with the companies gets intensified and deepened trough such programmes, and that the university tends to keep the good contact with previous PhD students and their companies also many years after their examination. The Graduate Schools also give the companies good insight in the university world.
Presently, we are invloved in two Graduate Schools, and several of the PhD projects are focusing within Biomedical Engineering. Further, one of the graduate schools is linked to the research profile Embedded Sensor Systems for Health, which is supported from the same financier. Companies are involved also in the research profile, and through these activities, the Industrial

PhD students form a critical mass and can exchange both experience and knowledge with other companies and with researchers.

Contribution ID: 982

SS-07 The Valley of Death in medical technology transfer: why it exists and how to

Bridging the Valley of Death – how early HTA can help span the gap

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Taking new technology, good ideas and fundamental research through to deployable systems and new capability is fraught with difficulties. When the new technology, good ideas and fundamental research relates to a complex and highly regulated environment like healthcare, those difficulties are magnified. Most med tech innovations never make it through the so called 'valley of death'. This valley has been described in various ways but is essentially that phase of the product development when the research funding is running out but the commercialisation funding is not yet realised. It's a widely recognised challenge but are there solutions?

Biomedical engineers are ideally placed to help medical technology products navigate, or indeed bridge, the valley of death: We have research skills and knowledge so can work with and understand the primary research demands; we are anchored in healthcare service provision so understand and relate to the clinical need and we have, or at lease should have, good relationships with the med tech industry and be able to support them develop their products and make them ready for the clinical environment. In short, we should be the people building the bridges that span the valley of death and helping the adoption and deployment new technology.

However, bridging the valley of death requires more than empathy, more than understanding, more even the collaborations. It needs certain tools and skills in Health Technology Assessment. This presentation will describe the typical 'geographical' features of the valley of death and introduce tools and techniques design to help navigate. In particular, it will expand on why biomedical engineers are best placed, and most suited, to this bridge-building role.

Contribution ID: 1599

SS-07 The Valley of Death in medical technology transfer: why it exists and how to

"Diapetics" Telemdicine Technology on The Way to Medical Practice

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Diabetes Mellitus is a metabolic disorder which is recognized by multiple long-term complications that affect every system in the body. Foot ulcers are one of the main complications of diabetes mellitus. However, there is limited evidence on the ocurrence of foot ulcers and influencing factors in Colombia. The DIAPETICS is a telemedicinesystem that integrates 10 modules that allow the visualization of clinical information, biomechanics and the conditions of health of the patient. The system classifies the patient of agreement to his or he, your level of risk and offers an intervention by personalized recommendations and the design of an orthopedic personalized insole based on the information obtained from an expert system and made by means of the computer-aided design. This line of research initiated in the year 1998 and was consolidated in the year 2012 by the creation of the first laboratory specialized in the design and manufacture CAD/CAM of insoles for the integral managing of the Diabetic Foot in Colombia (FootLab), which San Ignacio was born with the support of the Department of Electronics, the Vicerrectoría of Investigation(Research), Colciencias and the University Hospital, allowing to approach this way the problematics of the disease of way to interdisciplinary where the engineering and the medicine converge supported the technologies of the information and the communications. Nowadays one possesses, DIAPETICS, platform that supports the diagnosis and treatment of the complications related to the diabetic foot, which, with the support of the Direction of Innovation of the PUJ, is being protected across the mechanisms of the intellectual property. Hereby, from a complex but satisfactory way of research and development, one could have faced to the major disease of our century, the Diabetes, offering a better quality of life to those who suffer it. The plaform is in the process of been implemented at the hospital in a real clinical environment as a health service.

Contribution ID: 1613

SS-07 The Valley of Death in medical technology transfer: why it exists and how to

Biodesigning medical devices: Current concepts and their disqualification by "fake news"

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Upcoming years will see huge progress in the application of combination products for the treatment of severe diseases. The combined use of biological cells and polymeric scaffolds requires knowledge about basic principles and underlying hypotheses not only from biology but also from physico-chemistry. Bioengineering steps must be designed in such a way, that device characteristics in terms of stability and performance allow for reliable in vitro and in vivo testing of the final combination product. Problems of product sterilization, use of defined cell lines and culture media, or synergistic reactions between either cells and scaffolds or administered medicinal drugs must be foreseen and tackled. Thus, a translational approach has always to be taken. The directive “Better safe than sorry” was the basis for the Regulation 1394/2007 of the European Parliament on Advanced Therapy Medicinal Products (ATMPs). Combination products are considered to be ATMPs, which need market approval comparable to medicinal drugs.
However, recent years have seen a series of promises from researchers and engineers, which did not come true, when medical devices have been transferred from academic research to industrial application. Corporates trying to simply repeat experiments, which have been published in renowned scientific journals were unable to do so. The term Floppy Science emerged. Floppy science created worthless cures, crushed hope and wasted huge amounts of grant money and cost for industrial investment. Reasons for failure did not only base on scientific fraud, but also on the use of undefined cell lines or non-medical grade polymers, lot-to-lot variability of cell culture media, or the wrong use of statistical power. In addition, social media have been informed too early about premature data and thus, therapy expectations were raised that could later not be realized. Therefore, research integrity must be a major target for the clinical application of combination products.

Contribution ID: 1861

SS-07 The Valley of Death in medical technology transfer: why it exists and how to

Technology Commercialization from Colombian universities: Are the proof of concept enough to overcome the valley of death?

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In knowledge societies, universities play a leading role, by being both generators of knowledge and training spaces of human resources with certain skills and competencies required in a competitive and changing environment. In this new role, universities have been called to seek mechanisms to transfer the knowledge generated by them, either through licensing processes or through the

creation of business initiatives known as spin-off. This has led universities to have units that support the identification, protection, valuation and commercialization process in order to transfer their technologies and structure their own transfer models.
The Pontificia Universidad Javeriana has not been alien to these processes and at this time has its own model of technology transfer that has called "from the idea to the market" and that involves the stages mentioned above. This model built "learning by doing", has allowed the University to count from 2009 to date with a portfolio of 57 patent applications; 22 of them have been granted: 13 in Colombia and 9 in other countries (European Patent, Spain, Mexico, United Kingdom, United States of America). As well, the university has a portfolio of technologies to transfer via spin-off route.
Although there is a set of technologies to transfer, we are faced with a bottleneck in the transfer process, which is how to bring them to market, what many call the "valley of death", which is where the technologies require an additional effort to make them viable and visible in their field of application. The reason for this is that, for the most part of the technologies generated by the University, require additional maturation phases and proof of concept activities in order to validate or scale them. On the other hand, in the case of spin offs, they require significant investments, particularly for business initiatives in the biotechnology sector.
In this article, we present the transfer model of Pontifical Universidad Javeriana and some success and failure cases in the processes of licensing and spin-off creation and the strategies implemented to help researchers overcome the "valley of death".

Contribution ID: 1788
SS-08 Real-time tracking technologies for interstitial brachytherapy

Accuracy and limitation of passive electromagnetic tracking technology for brachytherapy

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Recently, electromagnetic tracking (EMT) was tested in combination with interstitial brachytherapy (iBT). The initial studies manually combined an EMT system with the iBT systems, i.e. implanted needles or catheters. The EMT-determined geometry can be used for reconstruction of the implant or for error detection, such as swaps or shifts of the implanted catheters. The purpose of the contribution is to provide an overview of possibilities and limitations of the technology for iBT.
Specifically, initial experience of EMT in breast iBT will be covered. In an IRB approved study more than 50 breast patients were EMT-measured throughout the steps of their treatment, i.e. immediately after implantation, after the treatment planning CT scan and during each fraction of the treatment. Initially, the measurements were performed by manual insertion of the EMT sensor in the catheters. Meanwhile more than 20 patients were measured using an afterloader prototype that has an EMT sensor mounted on an additional drive. The data show that swaps of catheters and gross shifts of individual catheters can be detected with the accuracy and precision the EMT-based geometry allows. This is in line with earlier data from other research groups who tested EMT in a phantom setting.
EMT accuracy and precision is sufficiently high for various tasks in iBT in particular error detection. The scientific findings need to be translated into products for clinical use; prototype technology and institutional solutions are already existing.

Contribution ID: 1816
SS-08 Real-time tracking technologies for interstitial brachytherapy

Source tracking with in vivo dosimetry

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In vivo dosimetry (IVD) is one of the most direct ways to ensure that the correct dose is delivered to the patient. Still, IVD is not standard practise in brachytherapy (BT) today. The main reason is the steep dose gradients in BT, which requires a very accurate positioning of the dosimeter. Only a few millimeters-offset of the dosimeter or of a nearby (<3cm) needle can lead to dose deviations >20%, without having any impact on the quality of the treatment. However, larger shifts of needles far away from the dosimeter, but in critical positions for the patient, can go unnoticed if the resulting small dose deviations at the dosimeter position are not detectable. Furthermore, commercially available IVD systems for BT report the total dose post-treatment, which limits the possibility to react on treatment errors. As a consequence, BT clinics are not using IVD and in principle are delivering the dose blindfolded. New developments within flat panels as well as point detectors for IVD in BT have opened up for a paradigm shift. The new dosimeter systems can provide dose rate measurements with high precision and in real-time. The systems can also provide information at a sub-second level, which allows for both real-time treatment verification and dose rate information for individual dwell positions. The steep dose gradient in BT makes it possible to determine the relative distance between the source and dosimeter with a high accuracy based on the dose rate information. This enables tracking of the source with triangulation-based algorithms that use the measured dose rates to determine the position of the source relative to the dosimeter.
The latest developments within IVD will be presented together with a discussion of the pros and cons of source tracking with IVD.

Contribution ID: 1828
SS-08 Real-time tracking technologies for interstitial brachytherapy

Active MR tracking for adaptive real-time dosimetric guidance of brachytherapy

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Purpose: Brachytherapy plays an essential role in the management of gynecologic cancers with interstitial techniques used for large tumors. Magnetic resonance is the preferred means to visualize pelvic anatomy. While real-time quantitative dosimetric guidance of brachytherapy is used in permanent brachytherapy implants, the practice has not been feasible in an interventional MR environment. Recent technological advances in active MR tracking make real-time treatment planning feasible in a timeframe relevant to an MR guided interstitial implant.
Methods: Actively tracked brachytherapy needle obturators allow measurement and MR visualization placement in near real-time. A new optimization algorithm provides HDR treatment plans that respect normal tissue tolerances in times comparable to the time to place a single needle. The needle geometries and anatomy contours of MR guided implants of gynecologic tumors were analyzed to evaluate the clinical relevance of the a optimization algorithms.
Results: Active MR tracking coils have been constructed on a brachytherapy needle obturator. Initial experience demonstrates accuracy appropriate for brachytherapy planning and QA. A fast planning optimization algorithm was evaluated on twenty implants. Dose optimization produced a clinical acceptable plan in a mean of 1.6 seconds. This speed makes it feasible to add these functions to an MR guided implant, which take from ~1 to 2 hours or more.
Conclusions: Active MR tracking based needle digitization in conjunction with fast optimization algorithms have evolved to the point where dosimetric based decision support can be provided in a time frame relevant to MR guided interstitial implants. These advances enable in-procedure

dosimetric feedback to the clinician about the dosimetric quality of the achieved for interstitial gynecologic implants.

Contribution ID: 1830
SS-08 Real-time tracking technologies for interstitial brachytherapy

Overview of tracking technologies for brachytherapy use

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Brachytherapy is one of the oldest forms of radiation therapy, which gain a tremendous therapeutical advantage by bringing one or more radioactive sources in close proximity or directly inside a tumour volume. In doing so, one can take advantage of an extremely sharp falling dose deposition kernel around a source. For many cancer sites, the cancer specific survival and the overall survival following brachytherapy are excellent. The introduction of image-guidance has further improved the therapeutical ratio of brachytherapy as demonstrated by the outcome for cervical cancer for example. Nevertheless, the use of a small numbers of high dose fractions (e.g. 19 Gy for prostate monotherapy) has highlighted a number of shortcoming is getting more precise dose delivery, in particular for interstitial brachytherapy, the need for faster and more accurate catheter and applicator reconstruction approaches and methods that can better identify and prevent common sources of errors related to the preparation and delivery of brachytherapy treatments.
In this introductory talk, an overview of various upcoming technologies that can be used in conjunction or embedded within catheters, needles and applicators to add a new layer of real-time guidance, improve targeting and channel reconstruction accuracy as well as to provide new modes of error detection will be presented. These include passive and active electromagnetic tracking sensors, optical tracking and fiber-shape sensing (Bragg-grating). A short overview of the working principals will be presented for each technology, while a more in-depth description of two of them will be provided in subsequent talks within this special session.

Contribution ID: 1837
SS-08 Real-time tracking technologies for interstitial brachytherapy

Challenges and clinical usage scenarios for tracking technologies in brachytherapy

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Key new technologies are emerging that will enable dramatic improvements in brachytherapy clinical practice. Every technology (electromagnetic, MR-based, fiber Bragg grating, etc.) aims to bring a new dimension to brachytherapy practice, but each also has limitations that need to be carefully considered for successful translation to the clinic. Both technological and workflow changes need to be considered when bringing technology from the lab to the clinic. And each disease site (gynecological, prostate, breast, e.g.) has specific needs. Other talks in this session will cover breast; this talk will present examples for prostate and gynecological use cases.
Integrating new technology into a clinic with existing brachytherapy technology has its own challenges that range from communication with afterloader control systems to treatment planning. This talk will present ideal workflows for several disease sites and discuss how each technology

will be impactful. Considerations early adopters will be presented as well as a preview of the work of the professional society's brachytherapy tacking task groups.

Contribution ID: 349
SS-09 Guidelines on the early assessment of biomedical innovations using multiple criteria

Predicting the organizational impact of biomedical innovations in early HTA

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The paper aims to guide developers to facilitate adequate adoption of biomedical innovations through an early evaluation of the potential organizational change induced by the technology.
As any new technology adoption should result as a compromise between individual (the user) and organization (the adopter) needs and behaviours, we discuss the reasons why early organizational evaluation should be one of the most relevant dimensions in early-stage HTA being likely to increase the probability of future adoption.
In this paper, we develop a conceptual model of the organizational fit in new medical device development. Among the dimensions of an early HTA (e.g. expected cost-effectiveness, acceptability, analysis of the diffusion barriers), the paper focuses on criteria and tools to forecast the organizational implications of biomedical innovation adoption. It introduces to the analysis of organizational network, administrative behavior, information flows and hierarchies, behavioral/individual and environmental factors directly or indirectly involved in accelerating or reducing the rate of biomedical innovation adoption.
The paper proposes a framework of different analytical tools that manufacturers need to adopt early for increasing the probability of adoption: (i) analysis of data processed and returned by the new device; (ii) mapping of the target organization; (iii) visibility-level of the technology performance; (iv) models of rationality, adaptation and learning. In particular, considering communications, information, and decisions flows through organizations, we highlight the importance of understanding early whether the new technology will be likely to disturb the organizational balance of the target institution, and which learning barriers and communication biases within the target organization directly influence the future adoption.
The theoretical framework is completed by some explanatory case studies of success as best practice and failure related to an early assessments (or the lack of) of the organizational change induced by the biomedical innovation.

Contribution ID: 438
SS-09 Guidelines on the early assessment of biomedical innovations using multiple criteria

Health economic assessment of biomedical innovations in early stages of development

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One of the most challenging task in any MCDA problem is the problem structuring, especially in healthcare. This is due to several factors, including the empirical nature of the field, which is characterized by the huge variety of applications, and a limited number of theoretical principles that can guide scholars through the formalization of the problem they are trying to solve.
Leveraging on previous practice experiences a heuristic method is will be presented in this talk and supported by several cases studies.
Common difficulties, challenges of problem structuring in MCDA and how limits in problem structuring propagated in MCDA problems will be also systematically presented and analyzed.

Contribution ID: 664

SS-09 Guidelines on the early assessment of biomedical innovations using multiple criteria

The Lean Assessment Process (LAP) for developing early-stage medical technologies – experiences of NIHR London IVD Cooperative

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In medicine, evidence generation by means of technology assessment is an integrated part of innovation, safe-guarding patient safety as well as informing resource allocations. However, the pharmaceutical model of drug development is cost prohibitive and time consuming. In the last decade, early-stage health technology assessment has been increasingly recognised as a mechanism to enhance the match between healthcare needs and product design and development.
The NIHR London in-vitro diagnostic cooperative has, over the past 4 years, engaged with over 100 device companies in the UK and elsewhere. We developed the Lean Assessment Process (LAP) to align evidence generation with resources available at an early stage of product development.
LAP has two main characteristics. Firstly, it is iterative and multi-disciplinary. Identifying stakeholders and clinical needs is carried out in parallel to assessing technology acceptance, early economic modelling and marketing strategies. This requires a close collaboration amongst human factor experts, decision analysts, health economists and marketing experts. Secondly, the whole process can be done within 90 days, given access to key clinical experts and stakeholders. LAP achieves this by a set of restrictive go/no-go steps, enabling ideas and concepts to be reviewed and assessed by a multidisciplinary team.
The key to successful assessment lies with the diversity of stakeholders which typically include, though not exclusively, clinicians, patients, lab technicians, procurement professionals and commissioners. This pool of experts provides feedback in terms of design, usability, and safety in use, clinical utility and potential pathway for adoption and commercialisation.
We have applied LAP to joint projects between DEC and Imperial and Oxford AHSNs. As an early HTA tool, LAP provides a structured yet flexible process for achieving prioritisation of clinical needs, alignment of stakeholder preferences, thus supporting manufacturers in deciding and refining directions of product development.

Contribution ID: 668

SS-09 Guidelines on the early assessment of biomedical innovations using multiple criteria

Making an impact: case study reviews of HTA support for MedTech innovations.

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“Innovation Health and Wealth - Accelerating Adoption and Diffusion in the NHS” was published by the UK Government at the end of 2011 and is a hugely important strategy for all those interested in improving healthcare systems. This strategy made it clear that rapidly adopting innovative ideas

and products is one of the best ways to improve quality and productivity and that these are clear priorities for the healthcare providers. It sets us this challenge: "Searching for and applying innovative approaches to delivering healthcare must be an integral part of the way the NHS does business. Doing this consistently and comprehensively will dramatically improve the quality of care and services for patients. It will deliver the productivity savings we need to meet the growing demand for services"

Healthcare providers clearly need new and innovative technology to provide improved health outcomes, improved efficiency, enhance the quality of life for people with long term conditions, prevent people from dying prematurely, help people recover from ill health and ensure that patients have a positive experience of care. Innovators and the MedTech Industry need help and support to get their ideas and research realised and adopted by healthcare providers.

The establishment of CHEATA (the Centre for Healthcare Equipment and Technology Adoption) was in direct response to this challenge. Our vision is to enable new medical technologies to be rapidly validated, evaluated and adopted into clinical practice thereby supporting the improvements to health outcomes, increasing the efficiency of healthcare delivery and supporting the growth of the medical technology industries.

Since its establishment, CHEATA has worked with over 100 clients and projects, providing a range of HTA support for medical technology. This presentation will review a number of these case studies, highlighting the tools used and, importantly, the impact made for industry, innovators and healthcare.

Contribution ID: 1216

SS-09 Guidelines on the early assessment of biomedical innovations using multiple criteria

Integrating the diverse assessments with multi-criteria decision analysis

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Health technology assessment (HTA) examines healthcare technologies from multiple perspectives to support implementation and reimbursement decisions. In early HTA, developers proactively analyze the likelihood of later implementation and reimbursement of their innovation. Multi-criteria decision analysis (MCDA) has been increasingly applied in healthcare to support (early) HTA decisions. These techniques help decision makers to estimate the preferences for the innovations in comparison with the gold standard in health care, or other competitive alternatives under a finite number of decision criteria. MCDA can support individual decision makers, as well as groups of decision makers. If conducted in a group setting, MCDA can support the efforts of panel members to share information about their beliefs, attitudes, and knowledge underlying the preferences they have for the alternative technological options. These preferences may relate to the technology's health economic value as well as its social, organizational and regulatory impacts on healthcare. We illustrate the use of MCDA to support group decision making in early HTA, and how MCDA can integrate the multifaceted values of innovations into an early health technology assessment.

Contribution ID: 1836

SS-09 Guidelines on the early assessment of biomedical innovations using multiple criteria

Assessment of medical devices: regulation and practices

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In 2012, the European Commission began discussing better functioning and improved safety of medical devices. On 5th April 2017, the European Parliament passed a final vote on new EU regulations on medical devices and in vitro diagnostic tools. The result was an endorsement of two provisions finally applicable to 27 Member States of the European Union. The implementation of the new legislation is set within a 3-year period, and for in vitro medical devices within a 5-year period.
The Directive 93/42/EEC applies in accordance with the new European regulations. The introduction of these new rules should result in an improved traceability and transparency of medical devices both on the manufacturer's side and on the importer's side. New legislation introduces most stringent conditions for control, technical documentation and clinical evaluation of medical devices. This is where we see the scope for incorporating legislative requirements into the early stage HTA, the assessment of medical devices in the early-stage HTA must undoubtedly reflect the legislative requirements for medical devices.
This paper deals with the process of implementing the legislative requirements for the evaluation in the early stage HTA, and their inclusion in the multiple-criteria evaluation. Within these guidelines, schemes that may be helpful in practice have been proposed for flow charts and process maps. Specific examples of such an embodiment will be shown in the presentation. The paper also deals with the issue of criteria determination for particular legislative aspects, and with the issue of an evaluation of individual legislative parameters. Here, however, it is worth mentioning that the main emphasis in the evaluation is still put to the effectiveness (clinical, technical, user´s, economical, etc.) of the medical device while maintaining the maximum safety.

Contribution ID: 431
SS-10 HTA research and education: challenges and opportunities for BMEs

IFMBE HTAD Guidelines on HTA of Medical Devices

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Introduction:
There is an increasing trend to evaluate the impact of medical devices within various health and social care systems. Existing HTA guidelines may benefit from the contribution of the biomedical and clinical engineering community working in all stages of the product lifecycle. Our study objectives were to: i) review current HTA medical device guidelines; ii) develop recommendations to address the identified gaps in the guidelines from a biomedical and clinical engineering perspective; and iii) to reach a consensus on the proposed recommendations.
Methods:
A grey literature search of HTA agency websites was conducted to identify, review, and summarize current HTA methods guidelines for medical devices. The International Federation of Medical and Biological Engineers (IFMBE) then convened two structured focus group sessions to develop recommendations to address the gaps in these guidelines. A modified Delphi survey is underway to enhance and achieve consensus on the proposed recommendations. Respondents include biomedical and clinical engineers involved in the design, development, implementation, maintenance, and assessment of medical devices.
Results:

Seven HTA guidelines for medical devices were identified. Our review indicated that gaps exist in the guidelines as the methods described to conduct clinical, ergonomic, and economic evaluations were not specific enough for devices. None addressed the shorter product lifecycle, and one guideline only discussed issues in use. The proposed recommendations centered on the medical device characteristics and functionality. To ensure their comprehensiveness, they were organized by the product lifecycle, clinical evaluation, user issues, and costs and economic evaluation.
Conclusions:
As the medical device characteristics and functionality are unique, current HTA methods may not accurately reflect the conclusions of their assessment. Recommendations proposed by the IFMBE focus group aim to address the existing gaps and to provide a more integrated approach in medical device assessments. Final recommendations from the Delphi survey will be presented.

Contribution ID: 1029
SS-10 HTA research and education: challenges and opportunities for BMEs

Health Technology Assessment (HTA) research and education: challenges and opportunities for Biomedical Engineers (BMEs)

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Health care delivery is technology driven today. The potential for new prognostic, preventive, diagnostic and treatment means, with new drugs, devices, methods and procedures are becoming available at an accelerated pace. However, the budget spent in health care, remains limited, compared to the needs. Therefore, there is pressure for more effective resource allocation. HTA as a process, is aiming to provide the best available evidence for correct decisions in health care budget spending. Assessment reports bring together evidence based information about the benefits but also the possible harms and the costs associated with the use of medicines, interventions, devices, or health care services.
A lot of work is done in identifying the best methods for conducting HTA and perform research in developing new methods and tools. However, the approaches and methods used for medicinal products is not adequate for addressing medical devices (MDs). There are important differences between MDs and drugs that impact the assessment of their effectiveness. For instance, unlike drugs, MDs regulations for marketing require different procedures to be followed, since issues like training and user skills, required infrastructure and maintenance are important and influence the effectiveness and cost of use. Therefore, HTA approaches and methods must differ.
Biomedical Engineers are involved in the whole MDs lifecycle, from prototype development, till obsolescent. The involvement of BME is therefore essential in MDs assessment and is expected to increase over the next years. So, it is important to introduce the HTA as topic in the curricula of the BME programs and provide the required basic knowledge and skills the young BMEs, to be well prepared to play the important role that biomedical engineering deserves in this field.

Contribution ID: 1179
SS-10 HTA research and education: challenges and opportunities for BMEs

IFMBE HTAD Guidelines on eHTA

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Patients and healthcare pose high and diverse demands on biomedical innovations. The value of the innovation they perceive is not dependent on clinical and economic considerations alone. The value of innovations may relate to health-related as well as economical, as well as social, legal, ethical, and organizational criteria. Early health technology assessment is increasingly advocated in the development stage of new medical technologies, i.e. from initial idea up to phase III-like trials anticipating market access and reimbursement. The HTA Division of iFMBE developed guidelines on how developers can assess the potential multifaceted value of their innovation and increase the likelihood of entrance to the healthcare market. We focus on the early assessment of the innovation's health economic value as a requisite for reimbursement, as well as social, organizational and regulatory aspects that may impact the acceptation and implementation of the innovation in healthcare practice. We provide guidelines on how to conduct the early assessment, and, in specific, how multi-criteria decision analysis can integrate the diverse demands into the early assessment of biomedical innovations, and provide the developers with recommendations on how to optimize the value of the innovation.

Contribution ID: 1813
SS-10 HTA research and education: challenges and opportunities for BMEs

IFMBE HTA Division Activities 2012-18

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Health Technology Assessment (HTA) is one of the fast growing areas of research within the BME community. One of the reasons is that medical devices (MD), main BME outcomes, represent the element of most innovative growth within healthcare services worldwide. An unprecedented number new MDs is expected to enter the world market in the newt years. National health services respond to this pressure reinforcing HTA agencies.
Therefore, there is a huge need of HTA training in our BME community. This will help BMEs to consider HTA during R&D, making MDs more cost-effective and appropriate.
The IFMBE has been very farsighted dedicating great attention to this emerging topic. Since 2012, the IFMBE Health Technology Assessment Division (HTAD) was reactivated, giving a significant acceleration to the spreading of HTA as a teaching and research topics within the BME community, and reinforcing the dialogue with other international scientific societies focusing on HTA (e.g., HTAi, ISPOR) and relevant international agencies (e.g., WHO, NICE).
Thhis talk will be given by the last two Chairs of the IFMBE HTAD, Prof Pallikarakis (2012-2015) and Dr. Pecchia (2015-2018), aiming to disseminate the work done and the huge number of resources created to serve the BME community in this field.

Contribution ID: 1815
SS-10 HTA research and education: challenges and opportunities for BMEs

HTA Education in BME: IFMBE HTAD Summer Schools and the eLearning Platform

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The IFMBE has been very farsighted dedicating great attention to Health Technology Assessment (HTA), which is one of the faster emerging topics in BME.

Since 2012, the IFMBE HTA Division (http://htad.ifmbe.org/), among other projects, has been very active in supporting HTA education worldwide, organising summer schools, delivering short training sessions.
This resulted in the production of more than 60 hours of lecturing material on HTA, specifically designed for BMEs and medical physicist, which has been collected in an eLearning platform developed ad how, which is now online and freely available to IFMBE affiliated societies (http://www.htad-ifmbe-elearning.org/).
This talk will present the IFMBE activities aiming to spread HTA culture among BME community and to promote BME proactive contribution to HTA.

Contribution ID: 1838
SS-10 HTA research and education: challenges and opportunities for BMEs

What's it got to do with me anyway? Engaging the unengaged in HTA

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Biomedical Engineers are generally good at measuring stuff. It's more-or-less a fundamental requirement of our trade. Measurement and calibration, cause and effect, accuracy and precision, verification and validation: these are words in our vocabulary, tools of our trade – it's what we do. Ask a Biomedical Engineer to measure the input impedance of biomedical amplifier and they'll give you chapter and verse? Ask them how to detect foetal heart rate anomalies and they can design measurement circuits and differential amplifiers all day long. But ask them to measure the impact of a new medical device on the patient pathway and they often look at you blank. Ask them about the cost consequences of new technology and they think you're from another planet.
Why do professionals who stock trade is based on measurement find it hard to understand how we might measure the impact of medical devices on healthcare? Or even why we might want to?
Spoiler alert: this presentation will not really answer that question. It will however, try to explain why HTA is such an important discipline and why BMEs are so well placed to contribute in this field. It will also look at the challenges we face engaging with a profession that has previously shown little interest in this area and suggest some strategies that might be helpful to increase awareness and participation.

Contribution ID: 1683
SS-11 Context-driven BME interventions in Limited Resources Settings

IFMBE Clinical Engineering Division project for Training in lower income settings

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One of the main goals of the Clinical Engineering Division of the International Federation for Medical and Biological Engineering (IFMBE/CED) is fostering the advancement of safe and effective management of healthcare technology.
One of the most interesting CED projects is denominated "Electronic courses (E-courses) for lower income settings". The aim of this project is to train people living in resource-scarce environments on the activities involving medical equipment maintenance and management. The project design has started back in late 2015, with the choice of target environment, the definition of the criteria to the eligible students (language being an important criterion), the body of knowledge to be used in preparing the courses and the technical requirements for the online video courses.

Part of the contents have been purposely developed by CED collaborators and consultants, while other contents – already available – are acquired through agreements with high level content providers.
The project – run in partnership with the World Health Organization (WHO), the Pan American Health Organization (PAHO) and the IFMBE/Working Group for Developing Countries – has faced many challenges related to technical aspects (online platform, asynchronous video lessons plus synchronous webinars, local tutors and facilitators, minimum requirements for local clients, etc.) as well as legal and bureaucratic ones (mainly related to copyright issues, contents management and selection on participants).
The project, after an initial delay to solve not expected difficulties, is at the time of writing, in a very advanced stage and the first pilot course should be initiated in April 2018. The main intent of this pilot is identifying and solve difficulties likely to be encountered in resource-scarce settings, identifying opportunities for innovation and developing a framework to inform subsequent efforts in capacity building in Clinical Engineering and Health Technology Practice using distance-learning methodologies and tools.

Contribution ID: 1811
SS-11 Context-driven BME interventions in Limited Resources Settings

Resilience of Medical Devices in lower-income settings

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87% of medical devices are marketed in USA, EU and Japan. As consequence, medical devices are designed to comply with needs, markets and regulations of those countries, which have very high standards for medical location design and maintenance, and abundance of specialised personnel. What happens when a medical devices designed for EU is donated to a low-income setting hospital? Is a pulmonary ventilator still safe if used in where there is a lack of anaesthesiologists, much less culture of maintenance and much higher humidity, dust and temperature than in the Europe? How effective and safe medical devices are, if operationalised by other than specialised medical doctors and if the quality of power supply is not the same as in Europe?
The Department of Biomedical Engineering of the Ecole Polytechnique at the University Abomey-Calavi (Epac)'', Benin, has started a timely and interesting work inveterating all the medical devices, also using a software developed ad hoc, in three local hospitals, aiming to improve patient safety and optimise health technology management.
With their support, the University of Warwick run two field studies in order to measure the quality of local medical locations, starting from electric plants, and comparing them the European ones. Preliminary results shown clear gaps and provided ideas to start overcoming current problems in a sustainable manner. This talk will present those projects and discuss how this can inform the design of resilient medical devices for LMICs.

Contribution ID: 1533
SS-12 BME contributions to medical device trials

Clinical Engineers and ethical committees in Italy, a national survey

Stefano Bergamasco
Italian Clinical Engineers Association, Palmanova, Italy

The Italian Clinical Engineers Association (Associazione Italiana Ingegneri Clinici, AIIC) was founded in 1993 with two main goals:

- To spread and advance scientific, technical and organizational knowledge in Clinical Engineering
- To represent the professional interests of Clinical Engineers and promote the establishment of clinical engineering services in health institutions for the governance of medical technologies

AIIC is therefore collaborating with other associations, public institutions, universities and all involved parties in order to promote clinical engineers as a key profession in all areas of Health Technology Management. As already described in other presentation of this special session on medical device trials, the development and validation of innovative medical device is a key step in the overall HTM process and clinical/biomedical engineers should be involved from equipment design to clinical trials and safety evaluations.

From this perspective, a great result was achieved when the Italian government in 2013 issued a Decree (Decree 8 febbraio 2013 of the Ministry of Health “Criteri per la composizione e il funzionamento dei comitati etici”) to define the criteria on the composition and functioning of ethical committees; for the first time, that Decree explicitly included clinical engineers as a necessary component of ethical committees, with reference to the medical-surgical areras of interest of the study to be performed.

Since then, AIIC has organized training courses, special sessions in national conferences and other initiatives to train clinical engineers on the specific issues related to the activities of an ethical committee, and after 5 years from the publication of the Decree we made a survey to collect information on:

- Number, qualification and role of the clinical engineers involved in ethical committees
- Activities required and technologies evaluated
- Geographic distribution

The results of this survey and the overall impact of the new legislation will be presented.

Contribution ID: 1534

SS-12 BME contributions to medical device trials

Safety and efficacy of new and innovative medical technology

David Watson
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Healthcare technologies are evolving at a rapid rate. Pressure within healthcare communities to adopt and implement these can be challenging in terms of determining effectiveness and assessing their associated benefits to quality of care.

Health Technology Assessment (HTA) is a key process that addresses the systematic and quantitative evaluation of the safety, efficacy, and cost of health care interventions and technologies. HTA considers the ‘efficacy’ aspects of an emerging technology and at a practical level should address such questions as “How much will this technology improve the healthcare of the patient?” and “What is the financial profile (expense or saving) associated with this improvement?”.

The benefits of ‘Value Analysis’ as a potentially useful approach for the assessment of new and emerging technologies is discussed. Such a process considers the full context around a range of variables such as the prospective patient population, the technology application point and desired outcomes for both the healthcare provider (and patient).

Running concurrently with the HTA process is the need to consider the safety aspects of any emerging technology under consideration. Safety analysis is not limited to hospital settings. Technologies are rapidly permeating into community settings driven by a range of factors placing new demands on home based care.

Any safety analysis needs to examine a potential exposure to poor outcomes and risks to both patients and the organisation concerned. Safety consideration can include:

- A safety focussed technology selection supply chain process
- Effective and comprehensive incoming technology acceptance testing

• Comprehensive pre-use and ongoing training
• Appropriate maintenance processes
• Follow up and evaluation of the implemented technology to determine actual effectiveness
This presentation discusses the benefits and challenges of these approaches when applied to new and innovative technologies.

Contribution ID: 1544
SS-12 BME contributions to medical device trials

Clinical and Biomedical Engineering as a key profession in ethical committees

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Two new Regulations on Medical Devices and in-vitro Diagnostic Medical Devices [(EU) 2017/745 and /746, respectively], entered into force on 2017. Further, it is worth remembering that a previous existing Regulation [(EU) 2014/536] referred to Clinical Trials, with the purpose to reach the highest standards of safety for participants and increased transparency of trial information.
In this way, a relevant update of all the regulatory aspects was achieved for clinical trials in general, i.e. when employing drug experimentations, medical devices and in-vitro diagnostic medical devices. Biomedical Engineering, in its various branches, provided fundamental contributions in the drafting of these three documents (mainly 745-6), through experts from Academia, Biomedical Industries and Regulatory Bodies. Further, it is clear that every stakeholder in the process of design, implementation, development and use of these technologies needs of experts in the area to fulfill the mandatory requirements which are expressed by these Regulations and in many cases it is possible to say that Biomedical or Clinical Engineers (and also Medical Physicists) constitute a pivotal role in many of these tasks.
Ethical committees are strongly involved in the approval of clinical trials, which might include not only tests or sperimentations on drugs, but also on medical devices or in-vitro diagnostics. On the other hand, [(EU) 2014/536] presents two basic limitations: i) only “traditional clinical trials” are considered (only for drugs, with the exclusion of medical devices) and ii) ethical aspects are considered topics of pertinence of the single Member States and the organisation of the ethical committes are referred to national legislations.
The impact of these relevant regulatory aspects on Biomedical Engineering market is discussed in the paper, by remarking the importance of multidisciplinary training of Biomedical/Clinical Engineers or Medical Physicists and the need of their contributions also inside the ethical committees.

Contribution ID: 1612
SS-12 BME contributions to medical device trials

BME contributions to medical device trials

Bradley Schoener
Association for the Advancement of Medical Instrumentation, Arlington, VA, United States

Clinical medicine continues to be propelled by breakthroughs in medical technology. This presentation will attempt to clarify the importance and opportunity for our field to shape the rapidly changing landscape of clinical devices. AAMI provides global leadership to support the healthcare community in the development, management, and use of safe and effective healthcare technology. This U.S. market focused presentation provides an examination of ANSI/AAMI/ISO 14155:2011 and the FD&C Act requirements affecting clinical device trials. It will also examine U.S. regulators’ perspective of the role of CEs and BMEs in clinical device trails. Real life examples of clinical device trials performed by global medical device developers and manufacturers will illustrate the current state of our discipline's role. Recommendations regarding potential future needs and roles for CEs and BMEs will also be provided.

Contribution ID: 1670

SS-12 BME contributions to medical device trials

CED IFMBE - Global initiatives for the advancement of the Clinical Engineering profession

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The Clinical Engineering Division of the International Federation for Medical and Biological Engineering (IFMBE/CED) has the mission to become an international forum for developing and promoting of the clinical engineering profession resulting in improvement of global healthcare delivery through the advancement of safe and effective innovation, management and deployment of healthcare technology.
Many global initiatives have been carried on during the last three years (2015-18) for the advancement of the clinical engineering (CE) profession. In particular, CED has focused its efforts in three main directions:
- Global credentialing: pursued through projects dedicated to publish guidelines for national and international accreditation of Ces and insertion of Biomedical Engineering and Clinical Engineering professions in the international classifications of occupancies
- Education and training: a dedicated taskforce in CED has been designing specific e-courses for low income countries, collecting contents, signing agreements and selecting the learners
- Creating a comunity: a big effort has been lavished in creating tools and events dedicated to all the CE professionals worldwide. Biennial CE conferences, annual Global CE day, Twitter community, a dedicated website (cedglobal.org), monthly webmeetings attended by about 40 professionals, monthly webinars

Many other initiatives, well in harmony with the above directions, have been carried on, including books publishing and translation, designing of undergraduate CE programs, CED awards, and a brand new CE journal that will be born in 2018.

Contribution ID: 1807

SS-12 BME contributions to medical device trials

The rule of BME in medical device trials, EAMBES and IFMBE HTAD prospective

Leandro Pecchia
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Medical devices are crucial for healthcare service delivery. Since 2014, about 1000 new medical device patents applications have been filed each month in Europe (twice the number of patent applications for drugs). Moreover, the time form the patent application to the market is becoming shorter and shorter. Those two facts, suggest that an unprecedented number of medical devices will be marketed in the next few years. This is changing the priorities of clinical trials units, ethical committees, HTA units, which require, more than before, biomedical and clinical engineering contributions.
Biomedical engineers, biomedical engineers and medical physicists are called to give in this area and what are the emerging challenges they are facing in this field, from luck of training to luck of

professional recognition. Since 2015, both IFMBE Health Technology Assessment Division (HTAD) and EAMBES have been very active in interacting with European Institutions and WHO, providing inputs, data and suggestions to manage the imminent change.
For instance, in 2015, the European Economic and Social Committee (EESC) published a report on the economic impact of BMEs and in 2017, the European Union introduced a new regulation on medical devices, which will be fully in place in 2020, introducing new rules for medical device clinical trials, among other things. Different Nations are responding to these changes in a heterogeneous manner. For instance, in Italy, a new legislation required that all the ethical committees engage at least one biomedical or clinical engineer, while other Nations are still lagging behind.
This talk, will give a comprehensive view of the work done in this area from IFMBE and EAMBES, in cooperation with European Institutions and WHO, aiming to disseminate the work done, present resources available and stimulate the discussion within IUPESM and in its federated National members.

Contribution ID: 1325
SS-13 IFMBE Session on BME Education and Accreditation

Harmonisation of BME programs: guidelines and limitations

Nicolas Pallikarakis
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Biomedical Engineering (BME) plays a pivot role in the development and safe use of medical devices. The harmonisation of studies in BME of prime importance and has been identified as such by the BME community and the international associations (IFMBE, EAMBES and CORAL) quite early. In Europe efforts started since the late 90's, based on the Bologna process and a number of projects with this objective addressed this issue in Europe. The thematic network TEMPERE, under the SOCRATES EU programme was one of the first. TEMPERE was involving professionals and professional bodies in the fields of Medical Physics (MP) and BME. The project provided a forum for productive interaction among professionals and provided a set of recommendations on education, training and accreditation in the fields of MP and BME. A few years later the BIOMEDEA initiative, contributed towards the same objective. On the same line the TEMPUS CRH-BME project provided in 2011, a set of updated recommendations on BME curricula and recently the follow-up Tempus BME-ENA project (2017) applied this harmonised approach, through the creation of 4 joint multidisciplinary MSc programs in Armenia, Georgia, Moldova and Ukraine. However, harmonisation of BME studies and the adoption of commonly accepted core curriculum is quite difficult. Consensus on core knowledge and skills should be reached. Additionally, the content of the core curricula, recent and future developments of medical technology should be taken into account, having in mind the high rate of technology advancement. Learning and training methodologies which facilitate innovativeness and entrepreneurship are also very important. Apart from the benefits to direct users (students, academics and their institutions), harmonisation is also very important to indirect users such as health institutions and medical device manufacturers. Finally, commonly accepted basic knowledge background, skills and characteristics for BMEs, would greatly facilitate the acceptance of the profession.

Contribution ID: 1595
SS-13 IFMBE Session on BME Education and Accreditation

Quality assurance of engineering education through Washington Accord outcomes-based accreditation framework

Kai Sang Lock

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Washington Accord (WA), formed in 1989, is an international agreement among signatories responsible for accrediting engineering degree programs in 19 jurisdictions. The signatories agree to multi-lateral recognition of substantial equivalency of programs accredited by participating accreditation bodies. To maintain quality consistency of accredited programs among its signatories, WA has introduced a set of graduate attributes to serve as the benchmark standard for outcomes-based accreditation. WA's outcomes-based accreditation framework has now been widely adopted as the benchmark for accreditation globally. Setting the appropriate measurable outcomes for objective assessment is crucial for differentiating various levels of technical education and for improving and assuring the quality and relevance of engineering education. Evidences of achievement of learning outcomes for engineering programs have to be demonstrated with abilities to deal with various aspects of complex engineering problems. The author shall share his perspectives and experience gained from his various roles of active involvement in accreditation: as the Chairman of an accrediting body, as a WA mentor and reviewer, as a program evaluator, and as a faculty preparing programs for accreditation.

Contribution ID: 1703

SS-13 IFMBE Session on BME Education and Accreditation

CE/BME Accreditation Linking to BME Education in Taiwan

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In order to implement a national professional accreditation system, the Taiwanese Society of Biomedical Engineering (TSBME) has offered professional accreditation for engineerings in Taiwan. To enhance learning outcomes for students in the department of biomedical engineering (BME), counseling programs planed specially for BME students have been designed and implemented in universities. All the programs are clearly linked to accreditation of Clinical/Biomedical Engineers offered by TSBME. The programs include two purposes. One is to enhance the recognition of professional knowledge of Clinical/Biomedical Engineers, and the other is to simulate the TSBME accreditation examination, so that students could be familiar with the form of TSBME examinations, and counseling students on successfully obtaining a BME accreditation. The incentives of professional skills accreditation for students include: special project credits could be waived for those having passed the TSBME accreditation exam, and to earn a bonus award. If a student fails to pass the TSBME exam before graduation, alternative credits for graduation are accepted, which are to complete the course of "Certified Professional Courses", and to pass the BME examinations provided by universities. All participants in the examination are required to complete courses included "Introduction to BME", "Physiology", and "Anatomy" in advance. The contents in the examination will include "biomedical material and mechanical technologies", "biomedical information" and "biomedical instrumentation", which are similar to topics included in the TSBME examination. The courses planned in the BME department have also been connected to the requirements equivalent to the Washington Accord Accreditation reviewed by Institute of Engineering Education Taiwan. In the past 5 years, 40~50% BME students passed the TSBME examination in each year. After after-class questionnaire review, 92% of participant

showed more understanding of medical device/instrumentation; 88% of which were satisfied to the examination topics, and 94% of which were satisfied to the course contents.

Contribution ID: 1918
SS-13 IFMBE Session on BME Education and Accreditation

Development and Improvement of Engineering Education in Europe: a Drive in Engineering Education to Meet Future Challenges

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In Europe, there exist several international organizations and networks, whose members are European universities providing engineering education. The two most important ones are SEFI (European Society for Engineering Education) and EAEEIE (European Association for Education in Electrical and Information Engineering).
SEFI is the largest network focused on engineering education in Europe. Its members are higher education institutions, individuals, associations and companies who share the common goal of improving the engineering education and strengthening the image of the engineering profession.
EAEEIE seeks to foster good practices in education for Electrical and Information engineering; improve the understanding of educational practices throughout Europe, and determine corresponding educational criteria with a view to establishing common standards of education in Electrical and Information Engineering.
They organize various meetings and conferences that serve as platform for exchanging information and experience in engineering education. In the 1990ies after adoption of Bologna declaration, the structured curricula was the hot topic. In last two decades adaptation of content and style of education have become focus of attention. More stress is laid on project- and problem-basd education. Mobile technologies, Internet of Things, Industry 4.0, robotics, nanotechnologies, 3D printing are the most frequently disucssed topics. We observe similar shift in topics in biomedical engineering, which means that the graduates can find jobs in more areas, e.g. home care connected with IoT or assistive technologies applications. However, it must also initiate a discussion on the content and possibly splitting the curricula into specializations that will better correspond with the society needs. Definitely biomedical engineering jobs in hospital have (at least partially) different requirements on graduates´ knowledge and skills than the jobs connected with outpatient care or social care utilizing advanced technology. In the presentation we will discuss these topics in more detail and illustrate them by several examples of good practice.

Contribution ID: 859
SS-14 Women in Medical Physics and Biomedical Engineering

Gender balance in medical physics – lost in transition?

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Before the toppling of the communist regime in Romania in 1989, the gender distribution in physics college students was bent towards males with an approximate two-thirds to one-third ratio.
A recent statistical analysis made among researchers that have applied for research grants in the area of health science (including medical physics) shows that the number of male applicants is around double the number of female applicants. However, a look at the current gender balance among clinical medical physicists shows a clear bend towards females. Theoretically, this could

result in an increased number of female researchers in medical physics, though practically this does not happen due to the large clinical workload in the Romanian hospitals which limits the time and effort necessary for scientific explorations. This fact leads us to the actual category of skilled people who undertake research: the academic staff. Among them, the gender balance is off, as the male to female ratio is greater than 3. Given these facts, it is interesting to think about the choices made by males and females after graduation, entering the workforce.
Despite the general decline in science students over the last few decades, medical physics keeps being an attractive educational offer presented by several Romanian universities. An interesting shift is that among current medical physics students, the large majority are female both at undergraduate and postgraduate levels. Does this mean that in 20 years we will see a dominance of females in higher academic positions and research grant applications? Can we afford to just let nature take its course, or do we have to actively intervene to encourage women to choose an academic and research career after graduation?

Contribution ID: 893
SS-14 Women in Medical Physics and Biomedical Engineering

Athena Swan: Promoting Equality and Diversity. The case of the University of Warwick School of Engineering

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Evidence demonstrates that numbers of women in science, technology, engineering, maths and medicine (STEMM) are significantly lower that numbers of males. Although there is evidence of improved gender diversity in undergraduate and postgraduate communities, the number of women progressing to senior positions in the academy remains significantly lower than their male counterparts. The Athena SWAN Charter, established in 2005, encouraged and recognized commitment to advancing the careers of women in STEMM employment in higher education and research. The Charter now recognizes work undertaken to address gender equality more broadly, not just barriers to progression affecting women.
The School of Engineering at University of Warwick is committed to promoting equality and diversity for all staff and students regardless of protected characteristics (such as age, gender and so forth). A dedicated team of staff and students meets periodically to develop ways of enabling a more inclusive culture. Following analysis of data and feedback from staff and students, we established key areas for action, including: improved methods of communication throughout the department; improved awareness of promotion and recognition processes, and encouraging more women into engineering education and careers. We were particularly proud to have our Athena SWAN Bronze Award renewed in April 2016 in recognition of sustained work in this area. We are continuing this journey to improve gender diversity in Engineering as we prepare our application for a departmental Athena SWAN Silver Award, and support the application for renewal of Warwick's institutional-level Silver Award. As the School of Engineering engages with great initiatives that promote equality and diversity in the academy, taking a leadership role in many of these initiatives, the impact is to increase positive support for women at key points in their careers, improving culture and gender balance in its decision-making, and implementing best-practice that supports work-life balance for all.

Contribution ID: 973
SS-14 Women in Medical Physics and Biomedical Engineering

International Organization for Medical Physics women survey: From participation to leadership

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Introduction
"Women account for only 28 % of researchers across the world, with the gap deepening at the higher levels of decision-making. Women have less access to funding, to networks, to senior positions". All these are reported at the latest UNESCO Science Report. The International Organization for Medical Physics (IOMP) is taking action in order to increase women participation in the field of Medical Physics (MP). Within this context, a survey was initiated and the results will be presented.
Material and Methods
An online questionnaire was created, prepared as a Google Forms survey with a number of simple questions relating not only on the total number of MPs and women MPs, but also on issues related to leadership or high level professional or scientific roles. The questionnaire was sent to all national member organizations of IOMP. In the attempt to have as much data as possible, even non-IOMP member countries were included in the survey.
Results
The results of the survey included data from 92 countries in total. Total number of MPs were 29086, 20421 being men and 8665 women (30%). The percentage of women is slightly better than the 28% found in an earlier IOMP survey in 2015. The percentage is lower than the European target set at 40% and the United Nations 50% target for 2030. A number of interesting comments were received and will be presented which partially explain the reasons for this small representation which is much more evident in higher professional and leadership positions.
Conclusion
The IOMP survey showed slight progress in women presence in the MP field the last years. On the contrary, representation of women in leadership positions is very low. Strong efforts are needed to grow future women leaders in the MP field.

Contribution ID: 1081
SS-14 Women in Medical Physics and Biomedical Engineering

The Contribution of the IOMP Women Subcommittee in the Professional Development of Women MPs Worldwide

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Introduction:
The International Organization for Medical Physics Women Subcommittee (IOMP-W) has been established to meet the growing demands of the women medical physicists for an official representation in the IOMP's governing body and to support women MPs in their professional development, advances in medical physics practice, science and technology worldwide.
Objectives:
This paper is focused on the contribution of IOMP-W in the growth of the professional and scientific development of women MPs on regional and international level, targeting an overall assessment of the women participation in major scientific events.
Results and Discussion:
An analysis of the women participation in 5 major international events organized or endorsed by the IOMP during the last 6 years has been conducted in order to assess the women role and contribution to these events. Objective criteria have been selected based on overall participation, weighted analysis of author positioning, leadership. Firm trends have been detected leading to

increased women participation and thus increasing the overall role of women for the growth of the profession.
Conclusion:
The leading role of IOMP-W and campaigns lead by the IOMP Women Subcommittee have an immense contribution to the professional world. The active participation of women MPs in various professional and scientific events has a crucial role in the future development of the profession, the dissemination of professional and scientific information, increasing the global awareness, professional diversity and thus directly influencing the quality of healthcare.
References:
[1] www.iomp.org
[2] www.iomp.org/IOMP-W

Contribution ID: 1172
SS-14 Women in Medical Physics and Biomedical Engineering

Experience working in the field of human factors engineering

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Patricia Trbovich is Associate Professor of Quality Improvement and Patient Safety in the Institute of Health Policy, Management and Evaluation and holds the Badeau Family Research Chair in Patient Safety and Quality Improvement at North York General Hospital. Patricia leads the HumanEra Team, a diverse team of human factors specialists, cognitive psychologists, and clinical engineers who understand clinical users, health technology, clinical environments and human factors principles. She holds cross appointments at the Institute of Biomaterials and Biomedical Engineering (IBBME) at the University of Toronto and the University Health Network. Patricia's areas of expertise include evaluation and improvement of safety in healthcare from a human factors perspective. Her team was recognized with the 2015 Patient Safety Award from the Association for the Advancement of Medical Instrumentation and Becton Dickinson. She collaborated with Brazilian and Spanish colleagues to build human factors teams in both countries. She is Associate Editor for the BMJ Quality and Safety journal.
Science and engineering have been traditionally seen as male-dominated occupations where women's participation is extremely low in many parts of the world. In particular, men are often found in leadership positions. Nevertheless, the representation of women in certain science and engineering jobs is increasing. In this talk, Patricia will discuss her experience working in the field of human factors engineering, reflecting on the importance of finding good mentors, the need for women to advocate for women, the power of building collaborations and international exposure.

Contribution ID: 1271
SS-14 Women in Medical Physics and Biomedical Engineering

Women for Biomedical Engineering in Cuba

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The fifth objective of the sustainable development goals supporting by World Health Organization is the gender equity, focused in six points and the fifth item include the full participation of the women in all levels of political, economic and social life. In Cuba, that's an initial goal of the government from 1959, with the improvement the sciences careers, that include engineering specialties in the Technical University of Havana "José Antonio Echevarría", from 1964. In the last decade, we have around 20 engineers (average) graduated in Biomedical Engineering, with almost a 30 percent of women, that continuous to be masters and doctors in science. There is more women that comes from similar degrees like Electro medicine and Electrical Engineer that later will work like biomedical engineers in production, health, government and educational centers. In fact, sometimes is very hard to obtain a precise statistical data but is possible to show the tendency and the improvement of women in bioengineering jobs, with emphasis in public health and scientific centers of drugs productions and clinical assays, equipment maintenance and quality assurance systems. The roll of woman increases every year, showing this mix of sensitivity, intelligence and strengthening that needs an opportunity to develop in all societies, but awfully isn`t possible in some of them.

Contribution ID: 1304

SS-14 Women in Medical Physics and Biomedical Engineering

A year of volunteering in Cambodia, a family's experience

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In November 2017, my family and I started a 12-month Australian Volunteers in International Development (AVID) assignment based in Phnom Penh, Cambodia. The objectives of AVID are to support the capacity of Host Organisations to deliver effective and sustainable development outcomes as well as to promote a positive perception of Australia in the Indo-Pacific region through the contribution of volunteers. The assignment titled "Radiotherapy Physics Trainer" is supported by the Australian Government Department of Foreign Affairs and Trade (DFAT), as part of Australia's Aid program, committed to promoting prosperity, reducing poverty and enhancing stability in the region.
My Partner Organisation in Australia is the Australasian College of Physical Scientists and Engineers in Medicine, which helps to support assignments like mine through its Asia Pacific Special Interest Group. The objectives of my assignment are to provide training to medical physicists at National Cancer Centre (NCC) at Calmette Hospital in order to develop an international standard radiation oncology program. This involves the commissioning and development of QA for a Varian 21iX, Eclipse TPS, a Varian HDR with TPS and a GE RTCT Scanner.
The long-term plan for radiation oncology provision by the NCC is to establish themselves as the foremost cancer center in Cambodia with the view to expand to 3 linacs in Phnom Penh as well as to set up regional centers for the provinces.
This presentation will provide the audience with an insight into my role as an Australian female volunteer, a medical physicist, a wife and mother of two primary aged kids. Our experiences will be shared through videos and photos as well as anecdotes about what it is like to work in a field that you love, in a country whose aims are to strengthen the quality and access to different types of healthcare.

Contribution ID: 1308

SS-14 Women in Medical Physics and Biomedical Engineering

Creating the Canadian archives of women in science and engineering

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The history of women scientists and engineers in Canada is still in its infancy. This is largely attributed to their invisibility in traditional archives which collected records of men, privileging their life and work. Another obstacle has been professional women's inclination to underestimate their accomplishments. Many women did not preserve their papers; neither did their family, friends and colleagues. There is a pressing need to provide women scientists and engineers with an accurate and inspiring understanding of the past and of the lives and accomplishments of those "who came before them". Recovering and writing the stories of these women's lives and preserving them for future generations are linked to a number of key objectives: 1) Reveal the motivations of women entering engineering and their perspectives on barriers to career advancement and retention; 2) Create a precious resource for historians writing about women in STEM; 3) Offer critical insights into the past and current status and role of women in STEM; and 4) Provide girls and young women with role models that could inspire them to pursue careers in these fields.
A two-day workshop was held in 2014 at the University of Ottawa, under the auspices of the Education and Research Institute (INWES-ERI) and the Natural Sciences & Engineering Research Council (NSERC) Regional Chairs for Women and Engineering. The meeting ended with an action plan to create a National Archive of Women Scientists and Engineers. Details of the plan and other initiatives such as the Women of Impact and the Women in Innovation projects led by the Ontario Women in Engineering Network, also involving INWES-ERI, will be discussed. Examples of materials donated to the Special Collection on Women at University of Ottawa will be presented.

Contribution ID: 1576
SS-14 Women in Medical Physics and Biomedical Engineering

Women in Medical Physics: Bangladesh

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In Medical Physics (MP) like all other professional communities, it is needed to address the gender issue seriously. Discovery of the x-rays by Roentgen and radioactive elements by Henry Becquerel, Marie and Pierre Curie make possible to use the ionizing radiation in medicine, agriculture and industry. Remembrance of Marie curie, women should come forward in MP activities to help people in health care. The contribution of women MP in education, profession and career in Bangladesh is focused in this study and a comparison is done with the survey data of the International Organization for Medical Physics (IOMP). 66 countries were participated to this IOMP survey. A total number of women medical physicists is 4807 (28%) out of 17024 medical physicists worldwide.
Considering total MP students in the three universities in Bangladesh (Gono University, University of Dhaka and Khwaja Yunus Ali University), the percentage of the female students are 30%, 20%, 10% in the B. Sc, M. Sc, and PhD programs respectively. In professional perspective 6 female medical physicists are workings in radiation oncology physics, 7 in academic, no one in diagnostic imaging. In other two areas of medical physics (Nuclear medical physics and Health physics), a good number female medical physicists are working in all nuclear medicine centers of the country under the Bangladesh Atomic Energy Commission (BAEC).
In this talk we will present the challenges and perspectives of the education and profession of female medical physicists in Bangladesh based on our recent survey in the details.

Contribution ID: 1577
SS-14 Women in Medical Physics and Biomedical Engineering

Preparing a course for female medical physicists in or aspiring to leadership roles

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Good leadership, managerial and strategic planning skills have become crucial in today's rapidly changing and highly competitive world. Leadership is of concern to all healthcare professions, but it is even more crucial for small professions such as Medical Physics. Preparing future leaders should be done in two ways: first by creating opportunities for up-and-coming leaders to interact with recognized successful leaders (who would share their experiences – 'role modelling') and secondly through a formal course on Medical Physics leadership. This presentation will provide examples of both from the author's own recent experience in leadership courses for Medical Physicists and suggest ways of making these more appropriate to the learning needs of actual or potential female Medical Physics leaders.

Contribution ID: 1584
SS-14 Women in Medical Physics and Biomedical Engineering

Engineering a successful career for women: making a difference of the future

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"Engineering a Successful Career for Women: Making a Difference of the Future"
For the past two decades in Malaysia, there has been a steady increase in the number of women engineers registered with the Institution of Engineers Malaysia (IEM) and Board of Engineers Malaysia (BEM). Education and cultural aspects have been major contributing factors towards a growing acceptance of women in engineering jobs in Malaysia. Yet, many young women engineers constantly face challenges in the workplace with regards to career growth and social impact. This paper presents how women can achieve a successful career in engineering and contribute to innovative breakthroughs in science and technology. I will describe the experiences and lessons I have gained as an engineer and academician, towards establishing the Centre for Innovation in Medical Engineering (CIME), University of Malaya (UM), through my involvement as part of the advisory panel for the Medical Device Act 2012 in Malaysia and most recently as a recipient of the Leaders in Innovation Fellowship award by the Royal Academy of Engineers (RAEng), UK. I will also share on the professional activities that I have initiated and how these activities have been able to support career development for women engineers, such as the formation of IEEE EMBS Malaysia chapter, Malaysia Society Medical Biological Engineering (MSMBE) Malaysia and a series of EMBS and MSMBE conferences organized by CIME under my leadership. Recommendations for best practices in training women to become effective leaders in innovation will also be presented in this talk.

Contribution ID: 1587
SS-14 Women in Medical Physics and Biomedical Engineering

Women in Medical Physics, professional problems and the reasons: Indian perspective

Rajni Verma, Dr. Arun Chougule

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Medical physics is touching new horizons in every possible dimension as use of Radiation in Medicine is increasing day by day. Medical Physics is an established and booming profession in India with this, role of women in Medical Physics is also increasing. But still there is a tremendous scope to enhance the role of women in Medical Physics. A survey was conducted to analyse the difficulties faced by WMP in India and reasons for it. A total of 281 WMP were included in survey from which 248 WMP have completed the survey, out of which 203 WMP are the member of Association of Medical Physicists of India (AMPI) and rest 45 are not member of AMPI yet. Out of this survey, some interesting observations have came out, maximum of them agree that they have faced gender biasing in some or other stage of their professional life. Major reasons were rigid opinion of male senior colleagues about WMP capabilities to fulfill long hours of working and late night working demanding professional commitments out of rigid cultural mindset, other main reason found was unwillingness of Hospital administration to give maternity leaves or child care leaves to young WMP so they generally deny jobs to young WMP of marriageable age. Further the most interesting observation of this survey was that twelve percent of them feel that sometimes the attitude of senior WMP's is also responsible for such rigid mindset of male Medical physicist and hospital administration as they ask for some special considerations being women but it was found that this opinion was debatable as many think that everyone either male or female needs special considerations due to personal responsibilities. The present survey attempted to provide the direction for the possible practical solutions. Detail results will be communicated in this paper.

Contribution ID: 1598

SS-14 Women in Medical Physics and Biomedical Engineering

Women in biomedical engineering and medical physics in the Czech Republic

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In last decades the effort to increase the number of women applying for studies at technical universities, and consequently for a job in the field of technology, can be seen in European countries. We have analyzed the situation in the Czech Republic and found out that there are differences in ratio of females in individual engineering disciplines. We can see a positive trend in biomedical engineering and medical physics where we have almost reached 50% of female students in bachelor and master study. However, in PhD study and in research in general the number of females is lower. Successively, it is also lower in jobs in the health care sector. They are mostly employed as ordinary employees since only the largest hospitals have separate biomedical engineering departments. However, we still have the so-called vertical segregation in employment. When it comes to comparison of positions in the companies or institutions, males are more frequently present on hierarchically higher positions. Less than 10 per cent of the top positions and about 20 per cent of high managerial positions are occupied by females in general. In engineering jobs the ratio is even lower. Recently we have analyzed and discussed the perception of women in engineering by young generation. We have asked our students for their opinion. Regarding the prejudices about women in engineering, students are aware of their existence, but they personally are not making the discrimination. This is a very positive conclusion bringing hope that the situation in engineering fields generally will change, finally resulting in gender balance. In the session we plan to discuss development of better support of women in biomedical engineering jobs during their professional career, as for example mentoring, support of part-time jobs, identifying good practice examples, etc.

Contribution ID: 1629

SS-14 Women in Medical Physics and Biomedical Engineering

Outstanding female medical physicists within the American Association of Physicists in Medicine

Melissa Martin
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The American Association of Physicists in Medicine (AAPM) has had a number of significant women medical physicists providing significant contributions to the field of medical physics in the sixty year history of the organization. Our Nobel prize winner, Rosalyn Yalow, was truly a pioneer in medical physics. Edith Quimby was instrumental in the development of brachytherapy physics. Her work is still the foundation of treatment planning for brachytherapy applications today. Ann Wright, the first female President of the AAPM in 1982, was one of the first physicists to form a consulting medical group providing very necessary medical physics services to those hospitals and imaging centers who did not have in house medical physicists. Other female presidents of the AAPM have been Mary Martel (2007), Maryellen Giger (2009), Melissa Martin (2017) and Cynthia McCollough (2019). Each of these women have been outstanding leaders and role models for all members of the AAPM, but particularly for those younger female members. Two of these leaders have been awarded the highest award of the AAPM, the William D. Coolidge Award: Edith Quimby - 1977 and Maryellen Giger - 2015. The leadership abilities of these women are now being incorporated into the Medical Physics Leadership Academy within the AAPM to help foster and develop future leaders for the medical physics profession. Details of each of these outstanding female medical physicists will be presented as examples for all attendees.

Contribution ID: 1846
SS-15 The Proposed IFMBE African Working Group

History of the Struggle to form African Federation of Biomedical Engineering

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The real struggle to form a pan-African Biomedical Engineering Group dates back to early 1990s, although a handful of national societies in biomedical engineering had existed in Africa as early as the 1970s. There was also a concerted effort by the WHO to train biomedical engineering manpower at the continental level, mostly low level in the early 1980s. This occurred across the sub-regional divide: eastern, central, northern, southern and western Africa. The first known pan African biomedical engineering society started in 1994, when the African Federation for Technology in Healthcare (AFTH) was launched by the support of the GTZ. AFTH had activities that spanned 1994 to 1999 and then went moribund. In 2003, members of the Nigerian Institute for Biomedical Engineering (NIBE) led by Kenneth Ikechukwu Nkuma-Udah spearheaded the formation of the African Union of Biomedical Engineering and Sciences (AUBES) in Ghana while some of its members were on a Medical Equipment Training with other African biomedical engineering professionals. AUBES also went moribund after two tears of activities except for its journal (African Journal of Medical Physics, Biomedical Engineering and Sciences) presence. Latest struggle for a pan African biomedical engineering group climaxed in 2015, when Anna Worm through THET organized a meeting of all national biomedical engineering societies in Africa. The meeting resolved to form an African Federation of Biomedical Engineering. A planned launch of the Federation in the 1st African Conference on Biomedical Engineering (AFROBIOMEDIC 2016) in Nigeria, 2016 was cancelled at the last minute for lack of funds. However, a smooth landing pad was provided by the IFMBE with the proposal for an African Working Group under IFMBE.

Contribution ID: 1208

SS-16 Emerging Technology in Diabetes Care: Advanced real-time diabetes monitoring systems

Improving prediction of glycaemia course after different meals – new individualized approach

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Diabetes is one of the biggest medical problems nowadays, having different forms and different mechanism of development but the ultimate result is the same – hyperglycaemia. Hyperglycaemia leads to development of chronic diabetic complications, which are the most frequent cause of worsening patient´s life quality and often shortening life expectancy. All diabetes mellitus (DM) type 1 patients and some of DM type 2 patients require full insulin substitution. Insulin is a crucial hormone of glucose homeostasis and it is not easy to adjust its dose to fit many different daily variables (different meal, physical activity, stress, environmental conditions etc.). There are two ways how to solve this problem. The ideal one is a biological approach but it is unlikely to be ready for common use in short horizon. On contrary – technical way (insulin pump therapy, sensors for measuring glucose concentration) is a reality. The most advanced device is able to give basal insulin dose automatically according to current glucose concentrations and according to trend of its change. This so-called hybrid closed loop technology can maintain very well blood glucose during night but to handle daily activities is still a problem. Patients must themselves decide regarding prandial insulin dose (bolus). They can use bolus calculator (advanced algorithm integrated into insulin pumps or smart phones) which should help to better estimate the optimal dose but the final decision is theirs. Several previous studies tried to apply various ways of entering information about meals. However, they did not consider individual response and metabolic rate. To help patients with this challenge we started to develop an application for smart phones having new features in comparison with existing applications. We concentrated on individual response to different types of meals (divided according to different glycaemic index), to physical activity and individually different basal metabolic rate.

Contribution ID: 1287

SS-16 Emerging Technology in Diabetes Care: Advanced real-time diabetes monitoring systems

Performance assessment of dry electrodes for wearable long term cardiac rhythm monitoring systems

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The use of wearable dry sensors for recording long term ECG signals is a requirement for certain studies of heart rhythm. Knowledge of the skin-electrode electrical performance of dry electrodes is necessary when seeking to improve various processing stages for signal quality enhancement. In this paper, methods for the assessment of dry skin-electrode impedance (Zse) and its modelling are presented. Measurements were carried out on selected electrode materials such as silver, stainless steel, AgCl (dry) and polyurethane. These had, Zse values between 500 kΩ and 1 MΩ within the main ECG frequency range (1 Hz – 100 Hz); in contrast to plain iron material. However, in spite of the high Zse values, open bandwidth ECG traces were of acceptable quality and stability; with dry AgCl material offering the best ECG trace performance.

Contribution ID: 1313

SS-16 Emerging Technology in Diabetes Care: Advanced real-time diabetes monitoring systems

Evaluation of the postural stability by monitoring the COP with the Pedar system in elderly patients Type 2 with Diabetic Pheripheral Neuropathy

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Diabetic Peripheral Neuropathy (DPN) is a common complication of Type 2 Diabetes Mellitus (T2DM), which decreases sensory and/or motor peripheral function in lower limbs thus affecting postural control and increasing the risk of falls. In order to determine the influence of DPN to body stability and balance, this study records the pressure distribution in standing and evaluates changes of the centre of pressure (COP) in anterior-posterior (AP) direction in 30 diabetic patients Type 2 with DPN and 30 healthy controls matched by gender, weight, height and age. The COP is the most measured parameter to assess body stability. Postural oscillations and changes in COP are interpreted as a decrease in the body control, an indicator of instability and loss of balance. For data acquisition in real time, Pedar-X pressure measurement system (Novel GmbH, Munich, Germany) with instrumented insoles was used in five test conditions in bipedal stance (open-closed eyes, straight-back head, rigid-foam surface) using Romberg Test to eliminate and/or alter the sensory systems used for balance (proprioceptive, vestibular and visual). The analysis in the time and frequency domain was performed in the five tests and COP-AP time series were used to estimate total excursion, velocity, range, root mean square (RMS) mean amplitude, maximum-minimum amplitude of sway and power spectrum density of sway. A statistically significant difference was found for all the parameters calculated between the two groups ($p<0.05$). The results confirm that DPN group postural instability in all five conditions. We suggest that DPN is the main predictor for postural instability in T2DM group which has been reflected in significant oscillation and variation of the COP-AP.

Contribution ID: 1341

SS-16 Emerging Technology in Diabetes Care: Advanced real-time diabetes monitoring systems

Prandial insulin dose calculation based on the meal contents monitoring in patients with diabetes

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Calculating insulin doses compensating the increased demand of the body for this hormone is one of the most challenging tasks that the person with type 1 diabetes (T1DM) must carry out a few times each day. Expert systems supporting patient's decision on prandial insulin dose calculation, called automatic bolus calculators (ABC), have been available for the last 20 years. Results of a few clinical trials demonstrated that the use of ABC may improve the treatment outcomes. However, to use ABC the nutritional value of the meal has to be estimated. Persons with T1DM need to remember such information or use nutritional databases available on the Internet, or implemented within ABC. Manual input of the meal contents into the ABC is troublesome and time consuming. Thus, there are attempts to develop automatic or semi-automatic methods of the meal contents estimation, which should be easier in daily use.
The first approach is to use the image analysis techniques to estimate contents of the meal based on its mono- or stereoscopic digital pictures. Such systems usually require that color and size markers are photographed together with the meal. They can properly recognize from several

dozen to several hundred distinctive dishes. The second approach is to monitor activities related to meal consumption, e.g. hand movements, chewing or swallowing. However, they require application of on-body sensors (e.g. accelerometers, microphones, electroglottographic or EMG sensors) and suffer from low specificity. The third approach uses the automatic speech recognition and the text analysis methods to convert the verbal description of meal, which is provided by the patient, into estimates of their contents. In such systems the meal description is subjective. However, results of their ambulatory and hospital applications indicate that they are useful and accurate enough. All three approaches will be discussed in detail during the presentation.

Contribution ID: 1588

SS-17 Necessity to Establish Healthcare Engineering Directorate for Enhancing Quality of Patient Care in lower middle income countries

A hybrid module to produce clinical engineering professional for the hospital in under developing countries

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In recent years, it has found that underdeveloped countries could not use the healthcare technology properly due to a huge shortage of clinical engineering professionals (CEP). As a result, quality of patient care of developing countries likes Bangladesh, Bhutan, Nepal, Myanmar, and Pakistan, etc are not properly satisfied. On the divergent, long time and huge budget are needed to produce clinical engineering professionals. The main objective of this paper is to specify the basic education, skills, experiences, responsibility of CEP for the hospital in the under developing countries to ensure the safe health care delivery to the patients and to reduce the entire health care service cost by applying engineering principle. We evaluate the educational qualifications and skills level of present Electro- Medical Engineers (EME) in the healthcare system of these countries on healthcare technology management and their experiences will compare with clinical engineering professionals. We make a statement and find out the lacking of present EME. Accordingly, we submit a hybrid module for EMEs to produce them as clinical engineering professionals. Moreover, in this module, we design additional course and duration for B. Sc. in EEE/BME/ME/ CSE/ medical physicists or other equivalent graduates to produce them as clinical engineers. In this regards, we collect data from under developing, developing and developed countries. Our proposal will be enhanced to assist to develop academic module of public and private universities to produce clinical engineering professionals. We firmly believe that it will be possible to produce huge numbers of CEPs through our proposed module and this profession brings excellent outcomes for health care delivery in the hospitals presently which is seemed to be an unpleasant condition.

Contribution ID: 1590

SS-17 Necessity to Establish Healthcare Engineering Directorate for Enhancing Quality of Patient Care in lower middle income countries

Necessity of affiliation with global clinical engineering association to grow awareness among healthcare stakeholders in Bangladesh

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In recent years, it has found that healthcare system comes under the spotlight of healthcare technology. Healthcare stakeholders are now self-motivated to apply healthcare technology by clinical engineering in developed and developing countries whereas lower-middle-income countries like Bangladesh could not yet make conception due lack of clinical engineering or biomedical interpretation to the healthcare system. Present Electro-Medical Engineers (EMEs) have been continuing breakdown maintenance work with a shorter training and they could not enhance their qualifications and skills in other phases of healthcare technology. As a result, the incomplete knowledgeable EMEs could not operate healthcare technology properly as well as they could not motivate the necessity of healthcare technology for the healthcare system. After Global Clinical Engineering 2017 day long program enhances the ideas of healthcare stakeholders in Bangladesh. In this research, we submit a proposal through clinical engineering association for making an excellent affiliation to motivate present healthcare stakeholders in Bangladesh. In the proposed method, we have collected data of healthcare technology management with and without clinical engineering and the study result will be shared and presented to healthcare technology stakeholders for appropriate application of healthcare technology. The global clinical engineering (GCE) association for healthcare technology provides feature discussions with members of the CE community, highlights associations functions, poster and oral that showing off various CE roles and functions for growing awareness among people. The GCE association helps to remember each corner of healthcare, patient safety, health technology management, equipment management and repair, and the role of each clinical engineer. This association reflects the thoughts and views of healthcare personnel and a closeness of their connection, friendship, and feelings for one another not only in Bangladesh but globally. Thus the present healthcare stakeholders learn and become motivated to enhance healthcare technology in the healthcare system in Bangladesh.

Contribution ID: 1593

SS-17 Necessity to Establish Healthcare Engineering Directorate for Enhancing Quality of Patient Care in lower middle income countries

Role of Clinical Engineers in Radiological Equipment

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A Clinical Engineer is a professional who supports and advances patient care by applying engineering and management skills to healthcare technology. Clinical Engineer is the responsible person for the safe and effective application of medical technology in the hospital. He plays the leading role beginning from procurement of appropriate equipment; inspection, maintenance and repair; regulatory compliance and all other related technical issues.
In a radiological department, the clinical engineer bears a leading role in management of medical devices such as X-ray radiography/fluoroscopy, mammography, computed tomography (CT), ultrasound and magnetic resonance imaging (MRI) during their entire life time. Therefore clinical engineers have become deeply involved in image quality improvement and risk management especially radiation protection activities. He also has additional tasks related to radiation protection issues as radiation protection officer:
-Supervision of the installation by vendor

-Acceptance testing
- License/ Notification for operation from/to the regulatory authority
- Supervision of the official expert examinations (before going to operation and then repeat in every 5 years)
- Quality control and Constancy testing (QC)
- Radiation protection course for doctors, technicians and nurses

In this overview, we will present the present situation of the radiological equipment management and radiation protection activities in some representative radiological hospitals in Bangladesh and compare with Germany.

Contribution ID: 1594

SS-17 Necessity to Establish Healthcare Engineering Directorate for Enhancing Quality of Patient Care in lower middle income countries

Clinical Engineering: Patient Risk Factors Involve with Medical Devices

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Patient safety is a major challenge in the healthcare facilities of low and middle income countries that requires advanced knowledge and adequate skills in various areas, including human factors and systems engineering. The most common medical device errors were: leakage of current, lack of calibration before use, less standardization data, wrong drug and wrong administration time. The most commonly reported causes for these errors were: failure to follow checking procedures, written miscommunication, transcription errors, prescriptions misfiled and calculation errors. Another important cause of these errors is the absent of BME/CE/BMET/CET professionals in hospitals of Bangladesh. A number of suggestions shall be proposed in order to avoid failure of medical devices in government and private hospitals. These include a) following up rules made by the authorities to ensure that BME/CE/BMET/CET are recruited at each hospital, b) increasing documentation of malfunctioning devices and adverse events c) nurses and physicians taking part in the procurement process along with BME/CE professionals d) establishing a Biomedical/Clinical Engineering Department at all hospitals e) organizing workshops for health care workers f) developing biomedical products adapted for multiple time use and with less need for calibration g) providing more education for health care workers in infection control, management of specific devices, solutions to common technical problems, patient safety and user safety, for example using Information and Communication Technology tools (audio and audiovisual material) and discussion platforms as well as h) constructing an internet forum for consultation on the above mentioned subjects for technicians. Those recommendations and practices will be able to develop and implement the sophisticated systems that are necessary to improve healthcare work systems and processes for patient safety by reducing the medical device errors.
Key words: Clinical Engineering, patient safety, private hospitals, public hospitals, medical devices.

Contribution ID: 951

SS-18 Potential breakthrough points of emission tomography on brain exploration

Multimodal PET-MEG approach to study the correlations between molecular mechanisms and brain network changes in neurodegenerative diseases: toward the preclinical diagnosis

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The deposition of abnormal proteins (beta-amyloid, tau and alfa-synuclein) is a common feature shared by all neurodegenerative diseases (NDDs). It is well-established that pathophysiological processes ultimately leading to neurodegeneration start decades before clinical presentation
In the last decade the brain has been modelled as a network and approaching NDDs through network studies is one of the current frontiers of neurosciences.
As a consequence, there is a need for early and non-invasive biomarkers to detect both the biomolecular process (accumulation of specific protein/s) and the possible modifications of interaction of different brain areas (network) that underlies the cognitive impairment.
Magnetoencephalograpy (MEG) detects the synchronized activity of an assembly of neurons. MEG is a powerful tool to study functional connectivity and to describe the features of neural networks. However, a significant limitation of MEG is that it does not provide any insights on the biological nature of the pathological events that affect the brain network.
Positron Emission Tomography (PET) has been successfully applied in studying NDDs. Recently, PET ligands that provide a basis for assessing proteins accumulation have been developed.
In recent years, neuroimaging techniques have become reliable in studying the brain function in health and disease. Each of these approaches is subject to limitations that are intrinsically linked to the nature of the method, and to the specific biological phenomena that each of them detects. More recently, to overcome the limitations of individual modalities, multimodal neuroimaging, referred to as the summation of information from different neuroimaging modalities, bears promise to overcome the limitations of each single modality alone.
The integration of MEG data, providing insights on the network features, with PET data, providing evidence on the molecular bases of loss of function, could represent an extraordinary improvement in understanding the pathogenesis, performing early diagnosis and, ultimately, test new therapies of NDDs.

Contribution ID: 965

SS-18 Potential breakthrough points of emission tomography on brain exploration

An Automatic Semi-Quantitative Analysis Software System of SPECT-TRODAT Images for Idiopathic Parkinsonism Diagnosis

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Early and correct diagnosis of Idiopathic Parkinsonism is extremely important medical identification for aging people. Tc-99m TRODAT is a contrast agent that has been developed and produced in Taiwan for brain dopamine imaging, and the imaging cost is covered by local health insurance system. The SPECT-TRODAT studies have been applied in clinical examination and try to benefit patients based on the development of biotechnology and medicine industry in the world. Currently, one of the key issues is how to effectively provide a functional imaging software analysis system as a medical device to solve the problem of poor SPECT-TRODAT imaging resolution and to be conveniently used by the physicians. This presentation introduces a new developed analysis software system with automated image processing technology for analyzing the SPECT images when TRODAT tracer was applied to show dopamine imagine in evaluating the number of striatal dopamine neurons in the brain. Subsequently, semi-quantitative automatic analysis results were provided for physicians to clinically diagnose whether the patient’s syndrome of the motor neurological disorders affected by degradation of dopamine neurons or not. The applied SPECT-

TRODA imaging software analysis system is expected to effectively assist early diagnosis of Idiopathic Parkinsonism.

Contribution ID: 1039

SS-18 Potential breakthrough points of emission tomography on brain exploration

The research, development and application of preclinical all-digital PET

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The Trans-PET® BioCaliburn® systems are the preclinical all-digital positron emission tomography (PET) systems introduced by the Raycan Technology Co., Ltd (Suzhou, China). Since the invention of MVT (multi-voltage threshold) digital data-acquisition (DAQ) technique pioneered by the Huazhong University of Science and Technology (HUST) and the University of Chicago, the basic detector modules (BDMs) had been developed by HUST, which were the basic components of the Trans-PET® BioCaliburn® systems. Moreover, the systems have been built in three models: LH, SH and SH2, which are different in the structures from the various combinations of BDMs for different scanning purposes. Among them, the LH contains twelve BDMs and offers the largest transaxial field-of-view (TFOV) of 13.0 cm and the shortest axial field-of-view (AFOV) of 5.3 cm, while the SH has the smallest TFOV (6.5 cm) and shortest AFOV with six BDMs, and the SH2 presents the smallest TFOV but the longest AFOV (10.6 cm) with twelve BDMs. Based on these models (mainly on the LH), thousands of rodents have been scanned for the basic researches of tumor, neuroscience, cardiovascular, metabolism and so on. So far, a dozen important application papers with application of Trans-PET have been published, and we expect the all-digital PET technology to provide more help to basic researches in the future.

Contribution ID: 1065

SS-18 Potential breakthrough points of emission tomography on brain exploration

A turn-key solution for PET scanner using DexScanner E102

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Recently, developing a PET system by digitizing a scintillation pulse at the earliest possible stage attracts substantial interests. In such a PET system, all the information are processed and transferred digitally. This could avoid the performance degeneration due to the analog noise and bandwidth limitation, it could also leverage the fast developing computer industry. Previously, our group proposed a Multi-Voltage Threshold (MVT) method for directly sampling the scintillation pulse. It takes the timing samples of a pulse when it crossing the pre-set thresholds. This method could be implemented by using several voltage comparator and timing to digital convertors (TDCs). Using this method, we developed a digital PET detector named DexScanner E102. It directly outputs the resulted digital scintillation pulse by a Giga-bit Ethernet connector via the UDP protocol. The timing, energy, positon information picking up, coincidence discrimination and image reconstruction could all be implemented in a computer by software. Thus, a PET scanner could setup by connecting several DexScanner E102s to a computer and developing a feasible digital signal processing (DSP) software. In this work, we present such a solution using DexScanner E102. In the solution several DexScanner E102s are arranged according to the aimed geometry of the PET scanner. The yielded digital scintillation pulse from different detectors are then

convergecast by using a network switch and then storage/processed in a computer. All the detectors are synchronized by a global clock. Besides, an API function library is also provided for digital scintillation pulse collection, storing and analysing in the solution. According to this solution, a PET system for a dedicated application could be setup by developing a software in a computer.

Contribution ID: 1417

SS-11 Context-driven BME interventions in Limited Resources Settings

Collaborative solutions for safe design of needs based medical devices

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“Open source Medical Technologies” means sharing the design, documentation, source-code, ideas and blueprints, as well as results and collected data, with other professional medical device designers. Accessibility, sustainability, lower costs are some of the potential advantages. Reliability, documentation, quality, funding are threats that alarm policymakers and clinicians and may prevent their embracing such technologies. Indeed, “Open Source Medical Technologies” requires a careful reflection, also considering the opportunity offered by new fabrication technologies and sharing services.
Medical technologies designed following collaborative methods and respecting internationally recognized standards and the formal regulatory processes can however be a solution for improving the efficiency of healthcare services in developed countries as well as for providing access to better medical treatments in the poorest ones. Here we describe the UBORA e-infrastructure, as a fundamental tool for empowering novel collaborative design strategies in the biomedical field and for sharing innovative medical devices developed with open-source criteria, and open it to collaborators pursuing the democratization of medical technology.
With the help of expert mentors and supervisors, UBORA takes engineers through a development process which starts with needs assessment, device classification, resource identification and safety assessment conforming to EU regulations. This collaborative (and innovative) e-infrastructure may be also of help for promoting impacts and for finding new ways of funding research translation to market and, in the case of biodevices, for helping reach patients in a more efficient, safe and rapid way. Crowd-funding is also implemented within UBORA together with other sponsorship options, including patrons funding specific projects or public/private organisms deciding to fund research and development activities in a concrete medical area, as part of their social responsibility strategy. UBORA also exploits the teaching-learning potential of web infrastructures to achieve the democratization of medical technology.

Contribution ID: 1853

SS-18 Potential breakthrough points of emission tomography on brain exploration

Novel Image fusion techniques for a multimodal digital PET approach

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Positron Emission Tomography (PET) and Magnetoencephalography (MEG) allow to investigate different,
but physio pathologically strictly correlated, phenomena. Therefore, the integration of the two approaches

will lead to the identification of the molecular mechanisms related to precocious topological modifications
of brain connectivity in NDDs with relative diagnostic and therapeutic recurrences.
Currently the two methods, although able to provide precious information, are affected by limitations. PET,
mostly by the usage of the FDG marker, show a condition mainly related to hypometabolism (and indirectly
to atrophy) and then evidence a pretty advanced state of the disease. MEG, analogously to functional RM
(fRMI), is an extraordinary useful element for the brain connectivity study in normal and pathological
conditions. However, this method is not able to give any information related to the molecular reasons of
the connectivity alterations. Another, important, limitation of the two methods is the imitated spatial resolution.
Regarding the limited spatial resolution, we will present the recent results of a digital brain PET helmet with a higher spatial resolution and sensibility compared with the other devices on the market and of a MEG system based on smaller magnetic field detector (SQUID) relative to the ones used in current assembly. On the basis of such new design, we will present novel image fusion techniques for the integration of the data, obtained through the two methods. Particularly, we will present a set of parameters of clinical interest from PET and
MEG images and we will introduce a data integration according to the techniques of morphologic data
fusion, wavelet, and neuronal networks with an implementation of the sensibility regarding the specified clinical parameters of interest.

Contribution ID: 867

SS-19 The status of Bioengineering, Biomedical Engineering and Clinical Engineering Education in Latin America. “ Curriculum, Accreditation, Innovation and Research”

Accreditation of Biomedical Engineering careers in Latin America: quality standards, quality practice, quality outcomes

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In 1991 the MERCOSUR Education Sector created the Meeting of Ministers of Education of the member countries of MERCOSUR (MER) as the entity responsible for the coordination of education policies in the region. In June of 1998, in Buenos Aires, the MER approved the Memorandum of Understanding on the Implementation of an Experimental Mechanism of Accreditation of Careers for the Recognition of University Degrees in the MERCOSUR Countries. Advisory Commissions on Agriculture, Engineering and Medicine, produced the documents "Dimensions, Components, Criteria and Indicators for the Accreditation of MERCOSUR" in their respective areas but recently in November 2006, the Meeting of Ministers of Education approved the Operational Plan for the creation of the System of Accreditation of University Careers of MERCOSUR (ARCU-SUR).
It was adopted, as a general criterion, to establish dimensions divided into components and for each component to establish the criteria, the indicators and the respective sources of information. The components, dimensions and criteria adopted have been: Institutional context, Academic project, University population and Infrastructure
Both in the national and regional accreditation processes, it was necessary to deepen the debate on the conceptions of quality in higher education, defining more precisely its dimensions, criteria

and indicators, its methodological approaches to evaluation and accreditation and the strategies for its assurance and permanent improvement.
Nowadays after 10 years working in accreditation in Latin America, the restructuring process of higher education underway in Europe, starting with the so-called Bologna Declaration, constitutes an interesting alternative. Its objectives of increasing the comparability, compatibility, transparency and flexibility of higher education systems coincide with the concerns and interests already raised in various Latin American countries and with the proposals on quality assessment and accreditation exposed.

Contribution ID: 1016

SS-19 The status of Bioengineering, Biomedical Engineering and Clinical Engineering Education in Latin America. “ Curriculum, Accreditation, Innovation and Research”

Innovative biosensor of circulating breast cancer cells; a potential tool in latin America oncology rooms

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The detection of circulating tumoral cells represents the posibility for therapy monitoring as well as prevent mestasis in oncology patients. Portable and economical technologies are requiered in most of the oncology rooms of third level latin America hospitals. In this work an innovative biosensor of circulating breast cancer cells on the basis of bioimpedance spectroscopy measurements assisted with magnetic nanoparticles is presented. The technical proposal involves a microfluidic system for cancer cells separation by inmunomagnetic technique and its detection by multifrequency bioimpedance measurements. An experimental proof of concept to detect a typical breast cancer cell line was developed to evaluate the sensitivity of the system. The results shown the technical proposal feasiblity as portable, inexpensive and non-invasive biosensor of circulating tumoral cells, as well as its technical feasibility for implementation in oncology rooms of latin America third level hospitals.

Contribution ID: 1312

SS-19 The status of Bioengineering, Biomedical Engineering and Clinical Engineering Education in Latin America. “ Curriculum, Accreditation, Innovation and Research”

The First Latin American Joint Summer School “Emerging Technologies to Support Health Care and Independent Living”

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The joint summer school was organized by IFMBE and CORAL with the support of IEEE/EMBS as a new academic strategical action to promote BME in Latin American region. The Electronics Department of Pontificia Universidad Javeriana from Bogota, Colombia with the support of its Extension Program and the Joint International Academic Committee from CORAL -IFMBE societies designed and implemented the academic program. Twenty three potential young

researcher students with different academic backgrounds on Biomedical Engineering, Electronic Engineering, Computer Science Engineering, Biophysics, Mechanical Engineering, and Medicine, from Ecuador, Peru, Colombia, Argentina, Costa Rica and Mexico were exposed to diverse global topics on emerging technologies for the elderly people for independent living. The topic was approached from different prospective from a range of international lecturers from Europe, Asia and America.
The main aims of the summer school were to introduce participants to emerging technologies and their applications to assist clinical specialists in the diagnosis, treatment, physical rehabilitation and follow-up of older adults for active old age and to identify the active social role of the engineer from the field of Biomedical engineering in collaboration with professionals in health care. Special attention was paid to innovation and development of self-care technologies and independence of the elderly.
Different active learning strategies were implemented such as seminars, workshops, technical visits to the industry, IoT lab, biosignal simulation lab, thinking innovation workshops and social networking and cultural meetings. A main project was assigned to the students during the course, based on a real study case of an elderly person with poor health and possible cardiac arrhythmia. Based on the case, the students interacted in four international and multidisciplinary teams in order to develop a simple and innovative solution to assist that elderly person.

Contribution ID: 1456

SS-19 The status of Bioengineering, Biomedical Engineering and Clinical Engineering Education in Latin America. “ Curriculum, Accreditation, Innovation and Research”

How to Motivate young Students to Pursue a Research Thesis on Mathematical Medicine.

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Since 2012, Mathematical Medicine was established as research topic at the Center for Research and Development of Digital Technology (CITEDI) which belong to Instituto Politécnico Nacional. This area is focused on analyze the cancer dynamics and the immunologic system. The academic impact of this topic is 14 papers in high impact journals, 4 graduated PhD students and 3 graduated MsC student. As social benefit, this research can be used to control cancer, however, it is important that students get interested to contribute in this topic. Recently, it has been seen that even the relevance of the topic just a few students has involve. Manly the students in our location are interested in electronics and computers. For this reason, in April 2017 was held at CITEDI the School of Mathematical Medicine: Dynamic Systems Applied to Cancer Models were 42 undergraduate students attended and were motivated to pursue a research thesis on Mathematical Medicine. Currently, only 3 students are doing their research thesis at CITEDI. For this reason is important to foster young engineer students to continue their careers into this research are to prevent and control cancer.

Contribution ID: 1468

SS-19 The status of Bioengineering, Biomedical Engineering and Clinical Engineering Education in Latin America. “ Curriculum, Accreditation, Innovation and Research”

The new model of health care in Mexico as an opportunity for the incorporation of Clinical Engineering

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The new model of health care in Mexico, aims to provide universal coverage to all Mexicans, in addition to improving the quality of medical services; This has meant that the financing mechanisms of public hospitals are restructured, linking their budget to a system of accreditation and hospital certifications.
This new model of healtcare is opening an opportunity for Mexican clinical engineering to integrate more strongly into the health system, incorporating and contributing to hospital certifications. It is important to note the impact of having clinical engineers in the implementation, monitoring, control or supervision, as well as the opportunity to generate indicators and information from the Mexican health system.

Contribution ID: 1554
SS-24 Global Credentialing in Clinical Engineering

Creation of Global Clearing House for Credentialing in CE and HTM

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Profession matures when its community of practitioners assumes the responsibility and accountability, based on extended education and experience, to demonstrate their competence. Credentialing program allows such practitioners to demonstrate their competency and knowledge through qualification program. While there are no standardized requirements for credentialing - public declaration of individual’s competency in their profession, has been adopted by many fields including engineering, jurisprudence, accounting, architecture, and medicine. Communities of healthcare providers adopted credentialing as declaration of their competencies to the public they serve including physicians, dentists, psychologists, nurses, and pharmacists.
Clinical engineers, members of the healthcare industry, should also demonstrate their qualifications through public declaration of their competency and knowledge. Recent survey shows that some national credentialing program in the clinical engineering field do exist however there is no international registry or global organization that track, register, or assist further development of national credentialing programs in clinical engineering.
This presentation describes proposal for IFMBE/Clinical Engineering Division to serve as nonpartisan global administrative focal point representing international interests who advocate compliance with minimum set of guidelines. These guidelines consist of body of knowledge (BOK), public safety, healthcare outcomes, technology management, financial impact, communications, standards and regulatory issues and professional ethics.
Like function of financial institutions’ clearing house this proposal seeks to establish a level playing field among similarly situated national credentialing programs that track, register and further assist development of new national programs for certification of clinical engineering practitioners, both engineers and engineering technicians.
The global clearing house will be administered by body of certified CE practitioners within the IFMBE/CED structure ensuring transparency and accountability through publication of annual reports. It will provide for national program review and auditing thus promoting lifelong maintenance of competencies, skills, and ethical behavior and recognition for the role of CE within healthcare.

Contribution ID: 1578
SS-24 Global Credentialing in Clinical Engineering

The case for accredited undergraduate programs in Clinical Engineering

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US biomedical engineering (BME) undergraduate programs are advancing rapidly, producing practitioners for academia, industry, and health-care professions as academics, engineers, physicians, and other professionals devoted to knowledge creation, medical device design, and healthcare delivery. A few BME undergraduates work in hospitals, but they often lack experience in clinical environments. "A Clinical Engineer (CE) is a professional who supports and advances patient care by applying engineering, economics, communication and managerial skills to healthcare technology" (Global Clinical Engineering Summit in Hangzhou, China 2015). The American Hospital Association, reports there are 5,724 US hospitals with 914,513 staffed beds. ~250,000 deaths occur in US hospitals each year due to Medical Error! Could CEs reduce hospital deaths due to Medical Errors? It is estimated that ~3,700 BMETs and ~1,200 US CEs are needed today. There are ~100 accredited BME undergraduate US programs, but no undergraduate programs offering CE degrees. Only one MS BME program creates CEs and eight accredited US BME technology programs (BMETs) exist. The Defense Health Agency's BMET Program provides training for US Service men and women. CEs play critical and expanding roles in health technology management and assessment. Recently, CEs are positioned to be involved in integrating medical devices into electronic health records (EHRs). CEs can "help drive changes in clinical workflows at health organizations: planning, policies, acquisition, management, strategies, investments, risk, design of clinical environments and others. This is accomplished through the interoperability of devices and EHRs so that care everywhere (inpatient, clinic-based and mobile health) profoundly allows redesign of care delivery." Sloane et al. suggests that the profession needs practitioners with new skill-sets - both for emerging graduates and people at all stages of their careers. We consider now the realm of knowledge required of CEs to be successful in clinical environments offered through accredited CE undergraduate programs.

Contribution ID: 1601
SS-24 Global Credentialing in Clinical Engineering

(Inter)national credentialing as an essential thing in clinical engineering

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Credentialing is an umbrella term used for different approval processes including accreditation, certification, licensure and registration. It's defined as an attestation of qualification, competence, or authority of professionals issued to individuals by a third party with an authority to do so. Since clinical engineers, as a subset of biomedical engineers, are considered health professionals, similar career paths and opportunities at (inter)national levels should be provided for clinical engineering practitioners (CEPs) as for all other health professionals.
Although full regulation of each health profession is achievable primarily by national legislation, usual international credentialing models for health professionals provided by international authorities should be nevertheless provided for CEPs as well. Namely, in many countries neither appropriate study/training programs nor local/national/regional credentialing boards has been established, and CEPs from such countries face difficulties in providing necessary qualification evidence when they seek employment or improvement of their professional status.

Grandfathering of qualified and experienced individuals has been a common practice at the beginning of regulation of each profession, in order to get first mentors and members of credentialing boards for younger colleagues supposed to undergone more formal and structured training and/or examination thereafter. The examination is usually in the form of written and/or oral tests based on given bibliographic references, for all candidates who officially applied after the fulfillment of eligibility criteria, the submission of required documentation and the payment of defined fee.
Biomedicine and healthcare challenges in the 21st century demand regulation of all health professions worldwide, so professional credentialing should be among the global priorities. After years of running contextual credentialing projects, the International Federation for Medical and Biological Engineering with its Clinical Engineering Division should finally provide its own credentialing model for all interested CEPs, in order to facilitate harmonization, standardization, visibility and mobility in clinical engineering.

Contribution ID: 1701
SS-24 Global Credentialing in Clinical Engineering

Clinical engineer as a creative partner of medical team

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Clinical engineering is an important part of health care and its meaning is growing together with the quick development of medical equipment and its application in medical procedures. The role of clinical engineers was evaluated throughout the years and gained new aspects. They primary tasks were supervising service and maintenance, patient safety, evaluation and planning the purchase of medical equipment, providing technical support in the everyday practice to the clinical staff with regard to the medical devices and their use.
Increasing complexity of medical equipment, broadening of medical applications, and widening of the knowledge base needed for its functions resulted in the need for specialized profession. Understanding the concept on advanced level as well as the technology of medical equipment itself requires knowledge from other fields and a different point of view. Therefore, participation of clinical engineers in medical procedures and aiding in the interpretation of measurements taken by medical devices is required. This became a very important role of clinical engineer. The knowledge and understanding of advanced application of the laws of physics and mathematical knowledge, as well as engineering activities is applied to the interpretation of the results of medical examinations. In particular, the participation of an engineer is required in examinations involving techniques of different modalities, for example, simultaneous imaging synchronized with electrophysiological recordings. Collaboration of clinical engineers with medical teams in everyday practice is an important factor of creating new ideas and supporting development in medicine.

Contribution ID: 672

Evidence-Based contributions of Clinical Engineers to improving global patients' outcomes

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Health Technology (HT) is vital to health; dependence of health, rehabilitation, and wellness programs on HT for the delivery of their services has never been greater. Therefore, it essential for

HT to be managed in the most optimal way, for better response to the burden of diseases and resource utilization.
Professionals called Clinical Engineers (CEs) are critical members of the healthcare team, and are responsible for HT management. But is their role recognized? To answer, our global society studied available published evidence.
The 1st Global CE Summit, under IFMBE/CED, was organized (in 2015) to determine the common international challenges to the CE profession. At the 2nd Global CE Summit (2017), these challenges were reviewed and updated. Attendees adopted resolutions seeking to address the most pertinent barriers: (1) lack of professional recognition and influence, and (2) lack of sufficient education and training for entering the field and for ongoing professional development.
The Summits' action plans included first, data collection identifying CE contributions and unique qualifications to improvement of world health and wellness through an international call for evidence-based submissions. And to address the second issue, an international survey of Body of Practice (BOP) and Body of Knowledge (BOK) was initiated.
In 2016, there were 150 responses from 90 countries that qualified as evidence-based CE contributions. Results were tabulated into categories (Innovation, Improved Access, Health Systems, HT Management (HTM), Safety & Quality, and e-Technology) and were submitted to WHO's World Health Assembly (http://global.icehtmc.com/publication/healthteachnology). In 2017, 250 additional stories from 35 more countries were identified– now 400 total from 125 countries. A key to success in each story is early engagement of CE expertise. These evidence-based success stories document benefits from HT, and present complex systems that must be effectively managed for their optimal clinical and business impact to be realized.

Contribution ID: 1531

SS-25 Evidence-Based Contributions of Clinical Engineers to Improving Global Patients' Outcomes

Europe's best CE Success Story: The Italian Clinical Engineers Association AIIC

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The Italian Clinical Engineers Association (Associazione Italiana Ingegneri Clinici, AIIC) was founded in 1993 with two main goals:
- To spread and advance scientific, technical and organizational knowledge in Clinical Engineering
- To represent the professional interests of Clinical Engineers and promote the establishment of clinical engineering services in health institutions for the governance of medical technologies
Reflecting the changes in the professional environment, in 2005 the association approved its new bylaws, opening the membership to engineers from the manufacturers, as well as to students, and even non-engineers that share the purposes and principles of the association.
In addition to its governance bodies, for each italian region one or more delegates are appointed to coordinate the efforts and initiatives locally; moreover, several working groups have been created to address specific topics of interest.
The association has grown a lot in the last decade and has now more than 1700 members from hospitals, service companies and universities covering the whole nation.
A relevant effort of the association is dedicated to the development of international collaborations. AIIC is affiliated to the International Federation of Medical and Biological Engineering (IFMBE) with an active role in the Clinical Engineering Division (CED), and has regular relationships with other associations and institutions. As a strategic goal for Europe, AIIC aims at creating a network of European clinical engineering societies, sharing a common legal framework and challenges.
AIIC organizes many workshops, training events and meetings during the year, and the main appointment is the national congress, that involves the whole clinical engineering community (more

than 1000 registered participants attended this year in Genova), with a huge participation of the industry (more than 80 exhibitors present each year), other scientific societies, and representatives from local and national institutions.

Contribution ID: 1545

SS-25 Evidence-Based Contributions of Clinical Engineers to Improving Global Patients' Outcomes

Successful application of social media, Colombian clinical enginering regional nodes changing the practice

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One significant challenge in the clinical engineering (CE) practice in Colombia is the lack of knowledge sharing among clinical engineers in the private and public sectors. An innovative approach implemented for engineers to be more efficient in their jobs was to leverage the power of social media (SM).
A large number of engineers are millennials; this generation has a predilection for sharing information and is accustomed to using SM tools. The alignments of these factors lead to a group of people getting together and creating communication groups.
It started in 2013 with a local group and the motivation to share information and knowledge in a fast way without any restriction of costs and accessibility promoted the creation of a national network now called Clinical Engineers Regional Nodes (CERN).
CERN are informal and spontaneous organizations. They have broken hierarchical structures paradigms of information accessibility and real time networking. Consequently, CERN are becoming a benchmarking model process for CE.
Currently CERN are autonomous in 6 regions. They cover 40% of the national territory, with 250 members from different stakeholder groups. They meet frequently and are in permanent contact through SM.
CERN key success factors are: the identification of a common situation for the region, the identification of motivated leaders, and the direct communication with government about the real needs of CE in Colombia. The main breakthrough was to build trust and credibility among the groups. This opened communication among participants and led to the removal of geographical barriers.
The CERN in short time has achieved the standardization of processes and methodologies, and the participation in tests to validate MoH products.
Colombian CERN are successfully contributing to better Health Technology Management decisions, access to education, and excellent visibility for CE.

Contribution ID: 1560

SS-25 Evidence-Based Contributions of Clinical Engineers to Improving Global Patients' Outcomes

Global CE Success Stories: Overview of 400 from 125 Countries

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Health Technology (HT) is vital to health; dependence of health, rehabilitation, and wellness programs on HT for the delivery of their services has never been greater. Therefore, it essential that competent and trained professionals manage it in the most optimal way. Trained Clinical Engineers (CEs) are appropriately responsible for HT management and fulfill a critical role as members of the healthcare team that focuses on availability of safe and effective technologies to facilitate intended outcomes. But is their role recognized? This presentation will share the conclusions after two years of examination of published evidence.
Following the international congress on CE and HT management in Hangzhou, China in 2015, a task force consisting of senior certified CEs from IFMBE/CED issued a global call for submissions of evidence-supported case studies for CE contributions to the improvement of delivery of healthcare services or patient outcomes. In 2016, of the submitted studies, an aggregate of 150 responses from 90 countries was examined and found qualified as evidence-based CE contributions http://global.icehtmc.com/publication/healthteachnology. Results were rated and tabulated into categories (Innovation, Improved Access, Health Systems, HT Management, Safety & Quality, and e-Technology), incorporated into document http://global.icehtmc.com/publication/globalsuccess and submitted to WHO's World Health Assembly that May.
We decided to expand our review in 2017, as submissions and publications continued, to include within our examination review published data that was presented and published at IFMBE sponsored events. Our examination methodology identified 250 additional stories from 35 more countries – now raising the total over two years to 400 publications from 125 countries. These CE success stories point to improved outcomes benefited from HT, and present overall complex integrated systems that must be effectively managed for their optimal and safe clinical and business impact to be realized. Clinical outcomes also benefit from better recognition for the CE role in healthcare.

Contribution ID: 1616

SS-25 Evidence-Based Contributions of Clinical Engineers to Improving Global Patients' Outcomes

African Success Story: Healthcare Technology Management (HTM) Programme at the University of Cape Town, South Africa

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The Healthcare Technology Management (HTM) Programme at the University of Cape Town was launched in 1999 in response to well-documented existing and anticipated future challenges in the African Region. The Postgraduate Diploma (PGD) became the flagship capacity-building qualification with a total of more than 200 students from 14 African countries in the years to 2015, with the following characteristics:
1. It recognised the complex nature of the HTM space: first formulated as the PGD in Clinical Engineering, it was soon renamed as the PGD in HTM.
2. Although most students were Clinical Engineering (CE) practitioners, all classes included health professionals from other disciplines (e.g. nursing, radiography, clinical technology, architecture, etc.); this allowed for consideration of real-world/multiple perspectives.
3. Most CE practitioners were not engineers but technicians; to this end, a Recognition of Prior Learning (RPL) framework was developed and applied to the processing of applicants, and many non-degreed individual BMETs were accepted into the programme.
4. The vast majority of students were full-time employees of public sector institutions (typically ministries of health - both national and state/provincial) and hence a block-release model was used.

5. The programme in its execution attempted to meet the diverse needs of students in their respective environments so that they could become fully empowered in those specific contexts; this was achieved primarily through the applied research project that followed the coursework.
6. With time, the scope of the HTM PGD programme expanded to include medical device innovation, airborne infection control, health-related information systems, hospital engineering practice and health facility design, in addition to generic project management and technology assessment.
7. Valuable multi-stakeholder networks were established, e.g. AFTH, WHO.
The successes of the programme were partly countered by failures in implementing (i) a distance-learning option and (ii) a web-based International Centre for Health Technology Management (ICHTM).

Contribution ID: 1552
SS-26 Application of EM Field in Medical Diagnostics

MTM sensors for microwave non-invasive blood glucose monitoring

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In our previous paper, a metamaterial and microstrip transmission line sensors for non-invasive blood glucose level monitoring were designed. In this paper two different models of dielectric properties of blood glucose solutions are used to evaluate sensors' sensitivity by means of numerical simulations. Model A is adopted from professional literature and
the model B was created by our group using information about dielectric properties of blood plasma-glucose solutions, recently published dielectric properties of red blood cell cytoplasm-glucose solutions and an electromagnetic mixing formula. Both sensors shows smaller sensitivity for the model B than for the model A. Due to non-linear dependency of dielectric properties on glucose concentration predicted by model B a lower sensitivity for high glucose concentrations was observed. The metamaterial sensor shows more than 10-times higher sensitivity than the microstrip sensor.

Contribution ID: 1565
SS-26 Application of EM Field in Medical Diagnostics

High-water content phantom for microwave imaging and microwave hyperthermia

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The main goal of this contribution is the investigation, design, and evaluation of an agar-based high-water content phantom for microwave imaging and hyperthermia. The contribution attempts to specify preparing procedure to get the most uniform results and describes the problems during the fabrication of the phantom, the effect of the size of the particles and degassing.
Growing interest in using electromagnetic energy at microwave frequencies for medical imaging, tumor detections, and tumor therapies, increases the need for tissue-mimicking phantoms. They are appropriate for testing and optimizing designed microwave imaging or hyperthermia systems.

Many different phantoms in many forms have been proposed to simulate electrical properties of biological tissue, although not all of them are inexpensive and easily fabricated.
In this contribution were compared electrical properties of agar phantoms with different compositions of honey, grape sugar and polyethylene powder for lowering the relative part of the complex permittivity over the frequency range of 10 MHz to 2995 MHz. Proposed phantom also consists of agar powder, deionized water, sodium chloride and TX-151.
In the contribution, the effect of the size of PE powder particles to electrical properties (40-48 micrometers, Gauss distribution of sizes up to 100 micrometers) was evaluated. Effect of degassing the samples under vacuum is presented. Relative permittivity and specific conductivity of the phantom were measured using open-ended probe kit SPEAG DAK-12 in conjunction with a VNA Keysight FieldFox. Long-term stability of parameters was examined. The relative permittivity was decreased to the value under 60 at frequency 434 MHz for muscle phantom with available equipment and fabrication (with 13.23 % PE powder, 40-48 micrometers).

Contribution ID: 1568
SS-26 Application of EM Field in Medical Diagnostics

Processing of standard MR images prior execution of the MR-based electrical properties tomography (MREPT) method.

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Recently a new method for mapping of dielectric parameters of body tissues in-vivo has been introduced. Magnetic resonance-based electrical properties tomography (MREPT), uses information of the RF magnetic field distribution (B1+) during MRI scanning, and computes electrical properties relative permittivity and electrical conductivity via the Helmholtz equation. Recent progress in the area has reported satisfactory results using approximate values of the field B1+ extracted from standard MRI sequences, boosting the method into a more realistic clinical environment. An experiment was conducted in order to certify the validity of the method. It was learnt that MRI images could not be used to implement the method just as they come out from the scanner, certain pre-processing steps need to be done to correct certain ailments in the images like noise or phase shifting. Recent publications on the topic report encouraging results and give a detailed explanation on the theory in which the method is based. However, little or none explanation is given to the processing to which the standard MRI images need to undergo in order for the method to be correctly implemented. In this document, only a brief explanation of the done experiment will be given, for emphasis will be put on processing and corrections that needed to be applied to the retrieved MRI images so it was possible to arrive to the results that are here reported. The aim of this work is to use the authors' experience to provide the interested of more information if they wish to recreate already published and reported experiments on the topic.

Contribution ID: 1574
SS-26 Application of EM Field in Medical Diagnostics

Prototype of simplified microwave imaging system for brain stroke follow up

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Stroke is the second most common non – traumatic cause of mortality in the world and can be distinguish on ischemic or hemorrhagic in general. Time plays key role in diagnosis of stroke and

its shortening is main goal for successful treatment. One way how to short a time between onset of stroke and its detection / classification is to use microwave imaging (MWI) method. At ELEDIA @ CTU laboratory in Prague a simplified prototype of MWI system which is suitable for stroke detection testing was developed. The system was designed as octagonal container with dimensions of average human head surrounded by eight bow tie antennas. The container was filled by homogeneous liquid phantom with average dielectric parameters of human head. Inside the head phantom was possible to place cylinders (stroke phantoms) of different diameters and on different positions. Stroke phantoms were prepared as liquid with higher as well as lower dielectric parameters than head phantom. Assuming that exists difference between dielectric parameters of head phantom and stroke phantoms, measured data was reconstructed by existing algorithm based on the differential microwave imaging and Born approximation approach. Reconstructed changes of dielectric parameters correlated with absolute changes measured by dielectric probe as well as the position where stroke phantoms were placed. Sensitivity of reconstruction method depended on the stroke diameter as well as on difference between dielectric parameters of stroke phantoms and head phantom. Data and results obtained by first MWI system prototype are valuable for research of next generations of MWI systems where for example new antenna elements need to be designed as well as dry realistic heterogeneous phantom of human head.

Contribution ID: 1575
SS-26 Application of EM Field in Medical Diagnostics

Samples of dry head tissues phantoms for microwave brain stroke classification

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Microwave Imaging (MWI) is new perspective non-harmful method for diagnosis of state of human tissues. In compare with current conventional imaging techniques, MWI systems could be relative cheap, fast and portable devices which use non-ionizing microwave radiation. Research in applications of microwaves in medicine is focused mainly on two areas. This areas are timely breast cancer detection and brain stroke follow up, its classification respectively. For testing and validating of MWI method phantoms of human tissues are used. At ELEDIA @ CTU laboratory in Prague a simplified prototype of MWI system for brain stroke follow up was developed. For purpose of testing this system a dry heterogeneous human head phantom needs to be design and fabricate. According to state of the art in field of phantoms design new materials was chosen. Mixture of polyurethane rubber (PU), graphite powder (G), carbon black powder (CB) and acetone (A) could be ideal combination for fabrication of dry human head tissues phantoms. Series with different weight percentage of mixtures of PU-G, PU-CB and PU-G-CB as cylindrical samples was prepared. For those samples which viscosity was too high an acetone was added. Dielectric parameters of fabricated samples were measured by DAK 12 dielectric probe in frequency range from 1 MHz to 3 GHz where 1 GHz is region of interest. Each sample was measured ten times and combined type C uncertainty was calculated. Results of this measurements was compared with results available from literature. The goal of this contribution is to choose samples those dielectric parameters are similar or equal to dielectric parameters of human head tissues. Based on this choice realistic dry human head phantom is going to be design and fabricate in the future work.

Contribution ID: 1731
SS-26 Application of EM Field in Medical Diagnostics

Methods for Diagnostics and Therapy of the Orofacial Pain

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In this paper, description of steps necessary for computation of the induced distribution of electric field intensity in patients' brain during repetitive transcranial magnetic stimulation of a real patients suffering orofacial pain as well as some results are presented. The patients were stimulated with the Magstim rapid2 stimulator and the 70 mm coil. The location of the area in brain to be stimulated was obtained using functional MRI and was used for the coil navigation ANT neuro Visor2TM system. Numerical simulations were used to assess the quality of treatment as well as to identify systematic or accidental errors due to the inaccuracies accompanying the process. For computation of electromagnetic field distribution during rTMS the numerical simulator Sim4life was used. To create precise numerical model, it was necessary to capture position of the stimulating coil and the patient using 3D scanning. Results of photogrammetry and laser scanning will be discussed. To obtain the anatomical patient's data, the Siemens Magnetom Prisma 3T scanner (64 channels coil), using T1 sagittal multiplanar reconstruction CONNECTOM @0.7 mm3, was selected. For segmentation the iSEG segmentation tool which is compatible with Sim4Life and images DICOM format was used. To expedite the time consuming process of creation 3D dielectric model of real patient the program MARS (Morphologically and Anatomically accuRate Segmentation) was used to separate different tissues. After performing a numerical calculation of the distribution and intensity of the electric field, the results were evaluated in terms of the total volume (determined by fMRI), which was stimulated by an electrical intensity higher than 80 V/m. These data were further correlated with data evaluated the success of the treatment. Based on this, it is possible to state how large the volume of the brain and the intensity of the electric field needs to be to make the treatment successful.

Contribution ID: 653
SS-28 Clinical Engineering Innovation Leading to Improved Clinical Outcomes

Machines Perfusion: new technologies for increasing organ's availability

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Introduction & background: Waiting lists for organ transplantation represent a critical issue for healthcare system in the entire world. According to some estimates around 120.000 people were in organ waiting lists in the U.S.[1], while more than 9.000 are registered in waiting lists in Italy in 2016 [2]. Although great results were achieved in the organization of transplants and in medical techiniques, the continuously raising demand doesn't meet the availability of organs.
Methods: A recent technical development in transplantation is the Machines Perfusion (MPs). MPs are organ specific and stand-alone systems composed in the simplest case by a pump, a circuit and an organ repository.
Organ perfusion guarantees a better condition conservation that can extend ischemia time of the explanted organ. Moreover, the organ-specific perfusion solution can improve the reconditioning of organ that in other case would be rejected for the transplant procedure. The main technical characteristics of MPs for a first classification are: flow modality (continuous or pulsatile), temperature (hypotermic or normotermic) and the transportability (fixed or mobile systems).
Kidney, liver and lung are the most diffuse and developed MPs nowadays, while those for pancreas and hearth are less spread.

Conclusions: Through the monitoring of the main parameters given by MPs, the operator has some evidences for an early assessment of the organ that can early detect organ failure. Moreover the extended ischemia time and the organ reconditioning could help in the reorganization of the complicated and unpredictable transplant process.

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Contribution ID: 1540

SS-28 Clinical Engineering Innovation Leading to Improved Clinical Outcomes

Development of a novel self-calibration thermometer using low melting-point metal

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A sensor with self-calibration function is ideal and many attemptswere made in various fields, such as visual sensor, inertial sensor, and so on. In the field of body temperature measurement, semiconductor type thermistor has been widely used. However, in thermistor, the problem of so-called “aging” do exists. Despite of this, commercially available thermometers are calibrated only once before put on the market. This means, to precisely measure body temperature, recalibration is indispensable. To solve this problem, we have been trying to develop a novel self-calibration thermometer.

As a temperature standard, we utilized Gallium (Ga) metal because of its stable melting temperature (29.7646 deg.Celsius). Ga has been used for calibrating various types of thermometers. However all of those are bulky instruments and impossible to install into a tiny thermometer head.

To realizing a self-calibrating thermometer, we newly designed a Ga metal coated thermistor. For makeing a thin Ga layer onto the surface of glass bead head (o.d.: 1.5mm, length: 2mm) of a thermistor (NXFT15XH103FA2B050, Murata Manufacturing.), 5N Ga (Sigma-Aldrich) was melted and dip coated. Then, to protect the Ga layer, polyurethane was dip coated and air dried.

This prototype thermometer was inserted in the axilla of a healthy adult and expected results shown below were obtained; The thermistor output was gradually increased from room temperature until it reached to about 29.5 deg. Celsius. Then, the output became almost flat for about 30-50 seconds, and increased again and reached to about 35 deg. Celsius. The experiment was repeated several time and reproducibility was quite good. Using this flat region, we can easily calibrate the thermistor, and this re-calibration could be performed every measurement with “automatic” manner. We are now planning to blush up this prototype sensor by incorporating a micro capsulation technique of Ga.

Contribution ID: 1567

SS-28 Clinical Engineering Innovation Leading to Improved Clinical Outcomes

Global Clinical Engineering Innovation, An Overview

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Health Technology (HT) is vital to health care and wellness programs. The dependence on HT services and the expectation for novel approaches has never been greater. Patients, payers, and administrators are demanding innovative HT and optimal services. Clinical Engineers (CEs) are critical members of the healthcare team, and are responsible for current and emerging strategies for HT management. But is their role recognized? To answer, IFMBE CED studied published evidence.
There are now 400 stories from 125 countries that qualify as evidence-based CE contributions. The subset of innovation stories are examined to see how innovation approaches, business models, and solutions can be shared. These stories also demonstrate significant benefits, and should encourage other CEs to embrace innovation as part of their work and a path to enhance recognition within the health care team. Examples: Simulation/Modeling, Remote Patient and Personal Health Monitoring, HT Policy for Industry, Mother Child Health, Emergency Care and Diagnostics.
Innovation is in the current priority list of most health care organizations. Focusing in this aspect is of high value to clinical engineers. The 1st Global CE Summit, under IFMBE/CED, was organized (in 2015) to determine the common international challenges to the CE profession. At the 2nd Global CE Summit (2017), these challenges were reviewed and updated. Attendees agreed to address the most pertinent barriers: lack of professional recognition and influence, and lack of sufficient education and training for entering the field and for professional development.
The action plans included data collection identifying CE contributions with evidence-based improvement to world health and wellness. These Innovation success stories are a result of that data collection effort, and outline different approaches for capturing and transferring this kind of work to many other CEs around the world, to both address recognition and influence challenges, as well as ongoing professional development work.

Contribution ID: 1615
SS-28 Clinical Engineering Innovation Leading to Improved Clinical Outcomes

Rapid manufacturing and virtual prototyping of pre-surgery aids

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Progressive development of rapid manufacturing and virtual prototyping have a significant influence not only in the industry and transport, but also in the medicine. Presurgical support and preparation of a surgeon with use of these technologies, especially in complex cases, can help prepare more precise plan of surgery and perform a simulated operation. The aim of these studies was to develop a methodology and manufacture an anatomical model of a kidney with a tumour, using rapid manufacturing technologies and virtual prototyping techniques. The model was a part of a presurgical support, allowing a doctor to become acquainted with an organ and a tumour and was also used for a simulative operation of partial nephrectomy. Due to the fact that model has two functions (preoperative planning and simulative operation), an important part during the production process was to consult procedures like cutting or suturing. Combination between technology of 3D printing and vacuum casting and silicon usage allowed to create a model, which imitates living tissues, especially the renal cortex and tumour. Transparency, which is a property of both models –

physical and virtual – also plays a relevant role. Transparency helps surgeons in precise planning before operation. Doctors can familiarize themselves with arrangement of internal structures and pathologically altered areas. The collected information and tests performed with a cooperating hospital helped evaluation of created models, their usefulness and future implementation possibilities

Contribution ID: 1727

SS-28 Clinical Engineering Innovation Leading to Improved Clinical Outcomes

Creation of a global health innovation registry is critical to improve design, promote collaborations, and ensure system lifecycle economies

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Currently there is no single source of information about healthcare innovations that is comprehensive, authoritative, affordable, and capable of evolving with rapidly emerging healthcare technologies and services. The complex scope of healthcare innovations currently exceeds the capacity of even the most mature institutions to manage and integrate efficiently across multiple clinical professions and often competing economic sectors. As healthcare now expands exponentially beyond hospital-centric services, innovations now range from nanoscale therapies to EMRs, to point-of-care diagnostics, to ubiquitous telehealth monitoring, disaster management, and behavioral health management of populations -- all mediated by IT systems costing billions of dollars and requiring years of planning. This session will propose the creation of a global health innovation registry, based on a semantic web data platform, to identify and classify emerging innovations, identify design gaps, and promote formation of complementary, multi-disciplinary research teams to ensure successful end-to-end designs, with Clinical Engineers as key stakeholders.
The absence of a global health innovation registry creates an enormous burden of institutional ignorance, uncertainty, risk, and inefficiency for managing the lifecycle of medical devices and services. Hospitals are not adequately prepared to track and assess the growing flood of innovations; design flaws are often discovered after deployment, putting lives at risk and costing millions to repair, recall, or replace. This burden could be greatly reduced by promoting more comprehensive and methodical stakeholder involvement at the design stage, encompassing the entire lifecycle of devices, services, and interdependencies. A one-stop, state-of-art Registry will be a global convening hub – a shared service enabling innovators across the functional lifecycle of a device/service to locate each other and collaborate on complementary design solutions. This “convergent innovation” tool will give Clinical Engineers a powerful new tool to monitor and influence innovations, reduce waste and rework, promote interoperability, and lower total cost of ownership.

Contribution ID: 1893

SS-28 Clinical Engineering Innovation Leading to Improved Clinical Outcomes

Partial findings of the clinical engineering body of knowledge & body of practice survey

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Clinical Engineering has been fundamental to health care for decades, providing expertise in the interaction between medical devices and the health care system. Because the skills and activities required from clinical engineers around the world are not homogeneous, the Clinical Engineering

Division at IFMBE decided to promote a global survey to identify the body of knowledge and body of practices they adopt. The survey was aimed at collecting data about employers and professional status, background knowledge, activity responsibilities, and the time spent in the multiple classes of activities. Survey results suggest the profession is still associated to certain traditional characteristics, such as the predominance of professionals with background in electrical, electronic, or mechanical engineering and the prevalence of hospitals and clinics as employers. The questionnaire seems adequate to reveal which skills and activities are considered the most relevant by clinical engineers, but more responses are required before a solid Body of Knowledge and Body of Practice can be defined.

Contribution ID: 1770

SS-29 Eliminating global Medical Physics disparities

Resuscitating quality radiotherapy service in a resource challenge environment – National Hospital Abuja (NHA – Nigeria) as a case study

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NHA pioneered the use of medical linear accelerator (Linac) in the West Africa sub-region in the year 2000. A lot of experience was garnered over the nearly two decades of deployment of this equipment but also technology seems to have even move at a faster pace. Several challenges were encountered amidst the treatment of numerous patients that have benefited from this initiative before obsolescence of the facility sets in.
On December 1st 2017, NHA commenced treatment of cancer patients with a Synergy Platform 80 leaves (MLC) linear accelerator (Linac) with a wide bore CT Simulator, a Monaco Treatment Planning System (TPS) and a Mosaiq (Record and Verify System – RVS) with a whole lot of new dosimetry and quality assurance (QA) tools (Daily QA3, IVD, robust 1D and 3D water-tanks, etc.) thus, blazing the trail in the sub-region as the first infirmary to deploy this relatively new and state of the art facility yet again.
Over 100 patients (mixed cases and pathologies) have been planned and treated in the first few weeks of ‘going clinical’ with a concomitant curative and palliative intent which will certainly improve in the next months and years thus, bringing the necessary and requisite succor to the teeming population of patients that daily yearns for the provision of this service thereby closing the gap and global disparities which has been the focus of FAMPO, GHCCS and MEPHIDA in the African continent.
Keywords: NHA, Synergy Platform, Linac, MLC, CT-Sim, TPS, RVS, QA3, IVD.

Contribution ID: 1919

SS-29 Eliminating global Medical Physics disparities

Medical Physics for World Benefit: A Global Collaborative and Partnering Organization

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Medical Physics for World Benefit (MPWB) is a young, not-for-profit organization that was developed in North America in recognition of the limited human resource availability and insufficient training opportunities for medical physicists in low-to-middle income countries (LMICs). Its mission is to support activities which will yield effective and safe use of physics and technologies in medicine through advising, training, demonstrating and/or participating in medical physics-related activities, especially in LMICs. Operationally, its emphasis is on “partnering” with

the goal of having individuals and/or educational or healthcare institutions in both LMICs and high-income countries (HICs) work together to meet well-defined needs. Practically, it also seeks to work collaboratively with other organizations wishing to provide similar support including, but not limited to, Physicien Médical Sans Frontières (PMSF), the International Atomic Energy Agency (IAEA), the Canadian Organization of Medical Physicists (COMP), the American Association of Medical Physicists (AAPM), and the IOMP. Various projects are in progress, most of which relate to training and mentoring. One example project that is in progress is the development of an Open Syllabus for Medical Physics Residents. This project seeks to link the detailed list of topics in the IAEA Clinical Training documents to the best on-line materials available. The Open Syllabus will be posted on the MPWB website and made available to any training program around the globe. MPWB is a membership-driven organization for individuals who have a passion for reducing global health disparities, especially as related to medical physics. Its vision, mission and values are summarized on its website (www.mpwb.org) along with links to newsletters and other relevant activities.

Contribution ID: 1924
SS-29 Eliminating global Medical Physics disparities

Medical Physics Program in Bangladesh

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The cooperation in the field of Medical Physics between Bangladesh and Germany has a long tradition. Since 2000 this cooperation is based on the cornerstones of the
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- University of Heidelberg and German Cancer Research Center (DKFZ)
- University of Heidelberg, Mannheim Faculty, Mannheim Medical Center, Dept. Radiation Oncology
- German Academic Exchange Service (DAAD)

In the years 2003-2006, nineteen students and teachers were educated and trained at DKFZ and Heidelberg University Hospital, based on a first DAAD scholarship program.
The DAAD Pagel project 2014-2017, as a cooperation between Gono University and the University of Heidelberg, Mannheim Faculty, Mannheim Medical Center, Dept. Radiation Oncology has allowed establishing foundations for a senior level in Medical physics in Bangladesh. As outcome of this phase, 4 students attended the International Master Course in Medical Physics in Mannheim and 8 students participated in Medical Physics workshops. 8 graduated Medical Physicists completed 3 month practical trainings at different hospitals in Germany and 5 PhD students completed the experimental parts of their PhD thesis.
A prerequisite of the planned DAAD Pagel project phase 2018-2021 is the intense use of resources and local operation, independent from Germany.
This shall be achieved by supporting the international co-operations of Gono University with other institutions throughout the South Asian region (India, China, Nepal, Bhutan, Myanmar, Sri Lanka) and the development of a South Asian Regional Centre for Medical Physics and Cancer Research (SRCMPCR). This center will be considered a hub for training and residency program of medical physicists.

Contribution ID: 1925
SS-29 Eliminating global Medical Physics disparities

Parts unknown: global health experiences

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Purpose: Recently there has been a major upsurge in global health interest by Medical Physicists, coinciding with an equal upsurge in international travel. Whether for global health, international collaborations, cross cultural educational purposes, medical missions, professional development, or NGO partnership developments, many first time and repeat travellers are embarking on exciting journeys to parts unknown. The purpose of this work was to document the best, and worst moments of those who have had the global health experience, and provide recommendations for Medical Physicists and others interested in global health.
Method: We interviewed over 20 individuals who have travelled to Africa for global health work or missions over the past 20 years. We analysed the good, bad and ugly moments of these travellers and their recommendations for those planning to travel to Africa for global health work
Results: From pre-departure plans through travel and return (or re-entry), the life-transforming experiences of international travel intersect at multiple levels: global health, vibrant cultures, local economies and ecologies, partnership building, among others. The worst moments included, ill-health, cultural and systemic barriers, and crime. The best moments included: impact of their work, cultural experience, organic food, and awards. Recommendations included: learning the language and cultures, respect, adequate pre-travel preparation, humility, and flexibility.
Conclusions: This work provides an analysis of global health experiences that could prepare any medical physicist planning to embark on global health or international travel. Specific experiences in different African countries are discussed

Contribution ID: 1927
SS-29 Eliminating global Medical Physics disparities

Experience of Setting up an International Medical Physics Graduate program with online learning component in Tanzania

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A "Regional Workshop to Raise Awareness on Medical Physicist Roles in Ensuring Safety in Medical Imaging" was held in Dar es Salaam, Tanzania November 26-28, 2014. The workshop brought together Medical Physicists, representatives of Ministries of Health from 23 African countries, as well as international experts from Europe and the United States. At the end of the workshop, representatives from the ministries of health recognized and better appreciated the urgent need to address the problem of shortage of Medical Physicists in African countries. One of the recommendations that came out of this workshop was that the assessment of the national training needs related to medical physics and introduction of academic and clinical training programs, where necessary and justified. In order to build capacity we must develop a strategy over the next 5-10 years which can sustain long term growth.
A course on "Quality Assurance of Radiation Therapy" was held at Ocean Road Cancer Institute in Dar es Salaam, Tanzania spring 2016. Building on our current partnership we are strengthening our engagement by providing a roadmap for physics training. Our long-term goal is to develop a USA/Africa Radiation Oncology Core (ROC), with both practical (PROC) and virtual (IROC) components, dedicated to research/education training in Radiation oncology in East Africa. It also provides desperately needed quality assurance tools for patient safety and research collaborations for cancer control. We want to establish a regional center of engagement with East Africa to

significantly increase research/education capacity, ensure radiation/patient safety and build research/education capacity to address an ongoing silent crises which is undoubtedly causing significant loss of life and disability in Africa. This core program will provide a hub for Radiation Oncology research/education in east Africa; benefiting students/researchers from neighboring countries like Kenya, Uganda, Burundi, Malawi, Zambia DRC, Rwanda, South Sudan and Central Africa Republic.

Contribution ID: 1937
SS-29 Eliminating global Medical Physics disparities

Medical physicist in diaspora for africa (mephida e.v)

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Low and middle-income countries have only 5% resources but account for up to 80% global cancer burden, with patients mostly diagnosed with cancer at their late stages. Radiotherapy, which has been identified to benefit up to 50% of cancer patients with either a curative or palliative end-point, remains inaccessible to over 90% of patients in low-income settings. This uneven distribution of treatment access results from lack of infrastructural and financial resources, trained medical and technical professionals and/or programs, geopolitical and economic instabilities, and of approaches to assure sustainability once the service is available. In order to tackle these issues profoundly, cultural and behavioural barriers must be broken to enable practicable cancer preventive measures through lifestyle as well as encouraging early diagnosis and participation in screening and immunization programs. Medical physicists in diaspora for Africa (MephidA e.V.) is a non-profit NGO aimed at turning the brain-drain to brain-gain by benefiting from the diversity of the professions of its members made of experts in medical physics, radiation oncology, information technology, journalism, etc. Our activities encompass:
- Organizing and distributing donated medical equipment in adherence with WHO recommendations.
- Consulting in establishing radiotherapy departments by promoting up-to-standard treatment delivery techniques and
the use of innovative electric power solutions such as solar energy.
- Use of information communication techniques (ICTs) to facilitate tele-diagnosis, education and training.
- Reconnecting and assisting professionals trained abroad to return and deliver cancer care in Africa.
- Collaborating with partners and stakeholders to catalyze cancer care via basic training in forums, as well as developing
and establishing accredited teaching courses to train professionals at high educational institutions.
As co-organizers of the Global Health Catalyst Summit in Harvard, we identify the event as a unique platform to gain partners in the quest towards closing disparities in cancer access world-wide.

Contribution ID: 851
SS-30 Recent advances in EEG signal processing

Estimating the spatial frequency response of realistic head models

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It is known from the literature that the human head, considered as a volume conductor, possess spatial low-pass filter characteristics [1]. An exact analysis and quantification of these low-pass filter characteristics of the human head is extremely helpful for the estimation of the necessary number of sensors for spatial sampling, the design of spatial filters and the compressed representation of EEG data.
A previously used approach to quantify the low-pass filter characteristics of the head is based on the combination of spherical head models. Forward simulations in such volume conductor models generated the potential distribution. Spherical Harmonics were used for the analysis of the spatial spectrum of the potential distribution [1]. However, spherical head models are only a rough approximation of the real geometry of the head.
Recently, a new approach for spatial harmonic analysis (SPHARA) was introduced that extends the classical spatial Fourier analysis to systems with non-uniformly positioned sensors, such as EEG sensor systems [2]. Thus, the spatial low-pass filter characteristics can be examined in realistic head models for the first time.
The suitability of the new SPHARA based method could be demonstrated by comparisons with the Spherical Harmonics approach applied to spherical head models. Subsequently, realistic BEM head models are analyzed using the new SPHARA approach. For these realistic BEM models, the spatial frequency response was quantified.
[1] Srinivasan, R. et al.: Estimating the Spatial Nyquist of the Human EEG. Behavior Research Methods, Instruments, & Computers 30(1), 8–19 (1998)
[2] Graichen, U. et al.: SPHARA - A Generalized Spatial Fourier Analysis for Multi-Sensor Systems with Non-Uniformly Arranged Sensors: Application to EEG. PLoS ONE 10 (2015)

Contribution ID: 1521
SS-30 Recent advances in EEG signal processing

An automatic ICA-based fingerprint method for rejecting physiological artefacts in EEG recordings: validation in cued and sports science EEG data

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Physiological contamination of EEG data is an on-going problem especially in applications involving motion (such as sports). Automatic artifact detection methods have been developed, but their effectiveness and efficiency across EEG platforms and research settings remain open questions. Our method automatically detects the most common types of physiological artifacts affecting EEG datasets.
EEG data are first decomposed into independent components (ICs) using ICA. Non-linear support vector machine (SVM) classifiers are trained to automatically classify each IC as artifactual or non-artifactual. The former are removed and artifact-free EEG data are reconstructed. The SVM classifiers are trained and cross-validated using EEG datasets containing multiple cued artefacts. To ensure generalizability of each classifier (one for artefact type), these datasets were acquired from diverse types of EEG electrode arrays, and the number of separated ICs was varied. ICs classification was based on 14 features (forming the IC fingerprint) spanning the spatial, temporal, spectral, and statistical properties of the ICs. Using all possible combinations of these features we determined the best combination to classify eyeblinks, eye movements, myogenic artifacts. We evaluated the performance of the classifiers in 12 EEG datasets acquired during sports cycling endurance tasks.
Method's performance was assessed with the percentage of correctly classified ICs out of all ICs in the testing datasets. The mean percentage of correctly classified ICs approached 100 for eyeblinks (mean > 99.9%, SD < 0.001), was 93.8% for eye movements (SD = 0.02), was 96.2% for myogenic artefacts (SD = 0.02). In sports cycling, correct classification was 99.4% for eyeblinks,

98.6% for eye movements, 92.8% for myogenic artefacts. Results indicate that our method correctly identifies physiological artifacts in data acquired from multiple EEG systems and also in challenging settings such as sports settings.

Contribution ID: 1603

SS-30 Recent advances in EEG signal processing

Influence of parameter choice on the analysis of highly resolved brain networks

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The detection of directed interactions within networks derived from spatially highly resolved data (such as fMRI) has been a challenging task for the last years. Conventional approaches suffer from the problem that the high resolution encounters a high number of network nodes, leading to problems concerning computational capacities and interpretability of results. This is commonly solved either by restricting the highly resolved networks to a small number of representative nodes of interest (such as fMRI voxels), or by concentrating on several relevant regions of interest (such as brain areas). Recently, the combination of multivariate autoregressive (MVAR) models and parallel factor (PARAFAC) analysis has been proposed to overcome these problems. Simulation studies have demonstrated the ability of this new approach to provide correct results; resting state fMRI data have successfully been used to offer a first proof of principle for the application in practice.

What has not been clarified so far is the question of an appropriate choice of analysis parameters. The combination of MVAR and PARAFAC involves a cascade of analysis steps, entailing a number of parameters that have to be chosen carefully. These parameters include, for example, the order of the MVAR model and the number of factors for the PARAFAC decomposition.

Until now, the impact of these parameters on the resulting derived networks is not clear. In this work, we fill this gap by examining the influence and reciprocal effects of all these parameters on the resulting networks. Simulated data with known underlying ground truth structure are generated in order to evaluate the correctness of results in dependence on the parameter choice. Resting state fMRI data of 154 healthy subjects are used to assess the influence of the involved parameters in the clinical application.

Contribution ID: 1606

SS-30 Recent advances in EEG signal processing

An electrophysiological approach for objective measurement of ocular stray light – a proof of principle

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Purpose: Psychophysical measurements are common used to examine the perception of ocular stray light. Nevertheless, these measurements are still a subjective representation due to their principle. This work aims to transfer a psychophysical method into an electrophysiological measurement setup to determine ocular stray light in an objective way.

Methods: Ocular stray light was measured using steady-state visual evoked potential (ssVEP) in three healthy subjects (1m, 2w, 28-35 years, binocular). Stray light emulating filters (Black Pro Mist 2) were used for simulating the effect of cataracts to validate the results for increased scattered light conditions. Based on the direct compensation method (van den Berg 1986), the stimuli consisting a test field (r=2°) with a luminance adjustable compensation light surrounded by a ring shaped stray light source (r=5-10°) which are flickering in counter phase (f=7.5 Hz). The stimuli were presented for 15 brightness levels of the compensation light (0.9 cd/m2-6.2 cd/m2). The ssVEPs from occipital zero were transformed by Fourier analysis. The magnitude at the stimulus frequency and its harmonics were plotted against the measured brightness levels of the compensation light. Two linear functions were fitted to the resulted curve to determine a robust minimum which correlates with the amount of stray light perception as we assume. Furthermore, ocular stray light was measured with the C-Quant (gold standard). In order to compare, all results were converted to the stray light parameter log(s).
Results: The detected amount of stray light of the ssVEP measurement without stray light emulating filters was in the range of log(s)=0.74-0.88 (C-Quant: log(s)=0.8-0.83). Under the use of filters, the log(s) increased to log(s)=1.22-1.28 (C-Quant: log(s)=1.2-1.21).
Conclusion: The electrophysiological approach has the ability to measure ocular stray light for normal and increased stray light conditions in an objective way. Further investigations are necessary to validate this principle.

Contribution ID: 1608

SS-30 Recent advances in EEG signal processing

Eye state classification from EEG recordings using machine learning algorithms

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Abstract: Nowadays, the developments in electroencephalography (EEG) support medical and non-medical applications, even outside the hospitals. For instance, permanent monitoring of mental and cognitive states can contribute to avoid critical and potentially dangerous situations in daily human activities like e.g., car driving. Furthermore, a key application for EEG carried out at home is the real-time classification of mental states. We compared different machine learning algorithms for the classification of eye states based on EEG recordings. Namely, we tested 23 classifiers from the WEKA (Waikato Environment for Knowledge Analysis) specialized machine learning toolkit. All classifiers were evaluated in terms of three factors, including (i) classification accuracy, (ii) time of classification for new (i.e., unseen) cases, and (iii) time required for training the classifier. In addition, the complexity of selected algorithms was discussed. Each classifier was tested on data acquired from 27 volunteers. Furthermore, the data was analyzed using two separate approaches – called sample-wise and segment-wise – used in combination with raw and pre-filtered data. It was proved that ten out of all 23 tested classifiers fulfilled the determined requirements of high classification accuracy and short time of classification, and can be denoted as applicable for real-time EEG eye state classification. Precisely, we found that it is possible to predict eye states using EEG recordings with an accuracy from about 96% to over 99% in a real-time system. On the other hand, we showed that there is no best, universal method of classifying EEG eye states in all volunteers. Thus, we conclude that the best algorithm should be chosen application-specific, using the optimal classification accuracy in combination with time of classification as the criterion.

Key words: EEG, brain-computer-interface, eye state, classification, machine learning, decision rules, decision trees, WEKA

Contribution ID: 1797

SS-30 Recent advances in EEG signal processing

Advanced concepts to quantify information dynamics in physiological systems: non-linear interaction analysis of and between EEG and cardiovascular/cardiorespiratory data

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The detection and quantification of directed interactions are of highest interest in terms of quantifying information dynamics in physiological systems. Measures to define directed interactions are often based on the concept of Granger Causality. Contrary, the new approach of Convergent Cross Mapping (CCM) defines directed interactions between time series in terms of non-linear stability. Aim of our study is to demonstrate potentials, limitations and essential extensions of the original CCM approach in the context of highly relevant clinical data including EEG as well as cardiovascular/cardiorespiratory data.
Basic idea of nonlinear CCM is to test for causation between time series X and Y by looking at the correspondence between so-called shadow manifolds constructed from lagged coordinates of the time series values of X and Y. The (bivariate) causality concept of CCM is that when X drives Y, then it is possible to estimate X from Y, but not Y from X. Extensions to adapt time-varying causal interactions can be achieved by using a sliding window of an appropriate data length, a frequency-selective quantification of CCM is possible by adapting empirical mode decomposition. Furthermore, statistical methods like the use of surrogate data and/or the adaptation of bootstrapping approaches are necessary. Practical applications of CCM are demonstrated for different clinical applications by investigating different physiological systems. Adaptations of CCM approach are achieved by an appropriate use of time-variance, frequency-selectivity and/or topology. EEG and/or heart rate of children with temporal lobe epilepsy before, during and after seizure and EEG and/or heart rate as well as cardiovascular/cardiorespiratory data of patient with schizophrenia during resting state period are analyzed and statistically evaluated.
In summary, adapted CCM approaches are able to reveal time-dependent, frequency-selective and/or topological views of complex nonlinear interactions in physiological systems thereby providing deeper insights into and further understanding of underlying complex physiological networks.

Contribution ID: 1573

SS-31 Embedded Sensor Systems for Health – health technology applications at home and at work

Breath alcohol detection

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The research objective of the investigation is to demonstrate the present status of passive in-vehicle driver breath alcohol detection and highlighting the necessary conditions for large scale

implementation of such a system. Completely passive detection has remained a challenge mainly because of the requirements on signal resolution combined with the constraints of vehicle integration. The work is part of the DADSS (driver alcohol detection system for safety) program aiming at massive deployment of alcohol sensing systems which could potentially save thousands of lives annually.
The sensor principle relies upon simultaneous measurement of alcohol vapor and carbon dioxide at a distance from the human subjects' mouth. Previous work has shown encouraging results using the methodology. The present investigation includes improvement of sensor performance in terms of resolution and integration of improved sensors into the steering column and the drivers' door of a vehicle. Human subjects and artificially produced gas pulses were used to evaluate the installations in a laboratory environment. Initial testing using the installations in a real-world environment has also been performed.
The performed investigation showed several options for sensor integration. The laboratory experiments showed improved sensor performance enabling reliable measurements at greater distances. The increased performance also showed feasibility of passive driver breath alcohol detection using the present system. The statement was also strengthened by the data collected during the initial real-world testing.
The work on nonintrusive breath alcohol detection has already generated a new product line called SESAME Connect for workplace screening, which is highly relevant to the ESS-H Health at Work profile.
The work concludes that improved sensor performance enables completely passive detection of driver breath alcohol. If required, the sniffer function with alcohol detection capability can be combined with a subsequent, highly accurate breath test to confirm the driver's legal status using the same sensor device.

Contribution ID: 1581

SS-31 Embedded Sensor Systems for Health – health technology applications at home and at work

Embedded Sensor Systems for Health

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Embedded Sensor Systems for Health (ESS-H) is a research profile at Mälardalen University in Sweden, developing embedded sensor systems for health technology applications. The research addresses several important issues: to provide sensor systems for health monitoring at home, to provide sensor systems for health monitoring at work, to provide safe and secure infrastructure and software testing methods for physiological data management in both the previous mentioned areas.
One of the overall aims for sensor systems for health monitoring at home is to
enable health trend monitoring in home environment, and being able to detect early deterioration of a patient. Sensor systems, signal processing algorithms and decision support algorithms for selected use cases have been developed. Examples of activities and use cases are: Intelligent phonocardiography, Real-time tracking of working memory from EEG, Continous monitoring of COPD patients, Microwave methods for locating brain and breast inhomogeneities, Wireless monitoring and automatic fall detection for elderly people at home, Health promoting technology and physical activity, from the user's perspective, Signal Processing of embedded motion analysis system, Surface EMG signal processing removing ECG interferences and decoding hand movements.
Within the area of sensor systems for health monitoring at work, the application cases are: High performance breath analysis, Human detection with ultra wide band radar, and Wireless wearable measurement system based on pedobarography.

Work on development of safe and secure infrastructure and software testing methods are important for an embedded sensor system aimed for health monitoring, both in home and in work applications. Patent data must be sent and received in a safe and secure manner, also fulfilling the integrity criteria. And an embedded system is partly controlled by the integrated software. Thus, the requirements of testing the software is crucial.

Contribution ID: 1582

SS-31 Embedded Sensor Systems for Health – health technology applications at home and at work

Electromyography signal analysis: electrocardiogram artifact removal and classifying hand movements

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Electromyography (EMG) is a non-invasive tool that has been widely used in the pattern recognition applications for classifying different limb movements. In EMG pattern recognition the challenge still lies in different stages (i.e. preprocessing, feature extraction and classification). One of the challenges is in the preprocessing stage. When surface EMG signal is recorded, noise from different sources significantly affects the signal and makes its analysis unreliable. The EMG signals recorded from upper trunk muscles are strongly corrupted by the electrical artifacts generated by heart (electrocardiogram (ECG)). In the state of the art different approaches have been proposed to remove ECG from EMG but there is still room for improvement. In the current study, four efficient methods (artificial neural network-wavelet, adaptive neuro-fuzzy inference system-wavelet, adaptive subtraction and automated wavelet-independent component analysis) have been proposed to effectively remove ECG interferences from surface EMG signals. Another challenge in this area is in the feature extraction and classification stages. Different EMG-based algorithms have been proposed in the state of the art and most of them obtained high recognition rates. However, in different studies different methodologies have been used to investigate these algorithms; therefore, it is difficult to compare their results. In addition, most of the algorithms have been evaluated offline and it is still unknown whether they will perform well in clinical applications. To address this challenge, in this study we have evaluated the offline performance of different recognition algorithms to classify different hand gestures. As a result selected feature sets and configurations have been proposed to improve the recognition accuracy. To develop more accurate recognition system, an online test will also be performed.

Contribution ID: 1583

SS-31 Embedded Sensor Systems for Health – health technology applications at home and at work

Overview of microwave based diagnostics for breast tumours and strokes

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Microwave imaging was introduced in the 1980’s; the object was submerged in a microwave-absorbing liquid – bolus – for avoiding interferences as well as reducing direct coupling between antennas. The advantages compared with X-ray mammography are still: non-hazardous (weak) irradiation, “seeing” closer to the rib, and above all an improved discrimination of internal inhomogeneities. The general disadvantages still are a need for a compromise between the spatial resolution and the depth below the surface of a large object which can be investigated, and a need for complicated computations for achieving a tomographic image.

In general, microwave systems are susceptible to external interferences, since the signal attenuation by the object is typically high, typically necessitating the use of boluses of variable extent.
Multiple, quite simple antennas at a distance from the object under test (OUT), pioneered by the Meany group, are submerged in a large microwave-absorbing bath and works for breasts. Another system developed by EM Tensor, Austria, uses multiple special antennas closely contacting the skull. Both these systems are quite expensive and require comprehensive computation resources
A quite low number of fixed or moveable special polarised antenna applicators in near contact to the OUT, by our group at MDH, provides unique sensitivities by particular considerations of diffraction physics. Software records the applicator positions and signals, for essentially direct readout. The system type may become the least expensive.
R&D has been going on for about 30 years, but the related mathematics is evolving and computation capacity is increasing, as is also microwave technology and use of advanced microwave physics. In this multidisciplinary evolution, simple or communication-type antennas have been used much, leading to too weak focus on the microwave physics for transmitter/receiver designs and also on diffraction, modes, surface and arch-trapped waves.

Contribution ID: 1585

SS-31 Embedded Sensor Systems for Health – health technology applications at home and at work

Cooperation between academia and industry within embedded sensor systems

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Embedded Sensor Systems for Health (ESS-H) is a research profile at Mälardalen University in Sweden, developing embedded sensor systems for health technology applications. The research is performed in close collaboration between academia, healthcare organisations, and industry.
The need of small, embedded sensor systems enabling monitoring of health trends, in home, at work and in other situations, is increasing, both considering changes in demography, with an increasing elderly population, and an increasing need of monitoring people at work due to more complex working situations. The problem encompasses several important issues: to provide sensor systems for health monitoring at home, to provide sensor systems for health monitoring at work, to provide safe and secure communication infrastructures, and software testing methods for physiological data management.
Ten companies are official partners of the ESS-H research profile, facilitating research result transfer to innovation and product development. Hospitals and care organisations are active as partners and problem owners, academia work on the technical challenges, and the companies work on innovations and product development.
The expertise and role of the companies in the consortium vary: one company has expertise in electromagnetic compatibility and offer the rest of the consortium expert advice and access to their EMC test lab. Another company performs research and development of alcohol measurements in vehicles and at work places. Yet another company develops and provides software for motion monitoring and fall detection, another company provides human motion capture systems and signal processing algorithms for motion recognition. Other company interests include human detection in mining environments, a remote controlled telecommunication platform, a robot assistance eating robot, and a system used when prescribing medicine, checking possible interactions with other prescribed medicines. Several of the companies also have an employee enrolled as an industrial PhD student at Mälardalen University, thus bringing research competence into the company.

Contribution ID: 1591
SS-31 Embedded Sensor Systems for Health – health technology applications at home and at work

ECG measurements using embedded sensor systems

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Since the end of the nineteenth century, when the first electrocardiograms (ECGs) were recorded, many advances in the theory and practice of electrocardiography have happened. Even though there have been different attempts to record cardiac electrical activity from body surface, among which the vectorcardiography systems have been the most influential, the 12-lead ECG has become the sole standard in clinical practice. For the measurements in remote setting, on patients outside hospitals in their normal daily activities, Holter monitors are routinely used, featuring a subset of the 12-lead ECG set. This practice has been lasting for decades. Recently however the so called patch ECG monitors have appeared, which have the potential to advance the current clinical practices, especially in remote settings. Single patch ECG monitor is composed of two electrodes at a distance of approximately 5 cm, which are used to obtain a differential ECG lead. The patch monitors contain a battery, electronics needed to digitalize the signal, and are often able to transmit the signal wirelessly in real time to a smartphone, tablet or a computer, and from there even to the Cloud. Compared to Holter monitors, the patch monitors most often provide just one lead, but have a number of advantages, among which easiness to use and long recording periods, are perhaps those most contributing to their increasing popularity and better compliance. Decision support algorithms are currently being developed that can even combine patch ECGs with other physiological parameters monitored in remote setting, for the purpose of estimating patient status and detecting life threatening events. Additionally, a reliable respiration rate can be estimated from ECGs produced by patch monitors, which reduces a need for separate respiratory sensors.

Contribution ID: 1602
SS-31 Embedded Sensor Systems for Health – health technology applications at home and at work

Reliable communication for remote monitoring using embedded sensor systems

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According to the Eurostat population projection, by 2030 just in the European Union, the percentage of elderly people will increase with 6.1%, compared to 2008. At the same time, we are facing the problem of birth rates that are below the level needed for a sustained population. This results in a growing need for healthcare, and reduces the ability to financially support it. This calls for less expensive solutions in healthcare that will utilize the benefits of modern technology, providing distance monitoring of elderly, and avoiding hospitalization when it is possible.
Technical advances in physiological sensing devices and wireless connectivity provided by the Internet of Things (IoT) empowered by low-power wireless sensors can enable dramatic changes in the ways health monitoring and remote healthcare will be performed in the future. However, for such changes to take place, the enabling technologies must be employed with the well-being of the patient in focus, since neither individuals nor society would accept IoT solutions that mismatch the standards of current best practice in healthcare.
Reliable IoT communication infrastructure for health monitoring systems can enable new possibilities to patients, especially to those not ill enough to be admitted to a hospital. By providing low-cost solutions to in-home monitoring, IoT can enable monitoring of such patients, enabling

early detection health deterioration, allowing for earlier responses and treatment. In order for in-home monitored patients to feel safe and secure when staying at their homes, the IoT solutions used must guarantee safety and security at a more technical level.
Within the ESS-H research profile, we have implemented a heterogeneous IoT infrastructure to employ various physiological and environmental sensors equipped with different radios such as Bluetooth, BLE, and 802.15.4. The idea is to provide a health monitoring system, where different technologies in terms of hardware and software are employed.

Contribution ID: 1726

SS-31 Embedded Sensor Systems for Health – health technology applications at home and at work

Extraction of diagnostic information from phonocardiographic signal using time-growing neural network

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This paper presents an original method for extracting medical information from a heart sound recording, so called Phonocardiograic (PCG) signal. The extracted information is employed by a binary classifier to distinguish between stenosis and regurgitation murmurs. The method is based on using our original neural network, the Time-Growing Neural Network (TGNN), in an innovative way. Children with an obstruction on their semilunar valve are considered as the patient group (PG) against a reference group (RG) of children with a regurgitation in their atrioventricular valve. PCG signals were collected from 55 children, 25/30 from the PG/RG, who referred to the Children Medical Center of Tehran University. The study was conducted according to the guidelines of Good Clinical Practices and the Declaration of Helsinki. Informed consents were obtained for all the patients prior to the data acquisition. The accuracy and sensitivity of the method was estimated to be 85 and 80% respectively, exhibiting a very good performance to be used as a part of decision support system. Such a decision support system can improve the screening accuracy in primary healthcare centers, thanks to the innovative use of TGNN.

Contribution ID: 1570

SS-32 Support of Movement Rehabilitation by Functional Electrical Stimulation: current options and limitations in the interplay of advanced technology and physiological reality

Influences of control mode and stimulus shape variation on motor unit recruitment in non-invasive neuromuscular stimulation

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Neuromuscular electrical stimulation (NMES) is an established technique to maintain and restore function, and assess the neuromuscular system. Transcutaneous NMES can non-invasively depolarize nerve fibers by inducing an artificial voltage field. The field depends on different parameters like stimulus pulse shape and intensity, and electrode setup. From those, the first one is often underestimated by the users since a higher intensity can compensate the use of non-optimal pulse shapes. However, it is known that higher intensities are linked to higher discomfort,

skin irritation, and burns. Here, we discuss the effects of stimulus shape in basic control modes—current- and voltage-controlled—and the influence of interphase intervals (IPI) on biphasic pulses.
We found that, due to the skin-electrode interface properties, a significant difference between the control modes is that during voltage-controlled stimulation a large current peak is injected at the beginning of each phase. This current peak can be 10-fold the amount required by current-controlled stimulation to elicit the same contraction (biphasic pulses of 1ms per phase). This cause that, during voltage-controlled stimulation, most of the motor units are recruited within the current peak, and extending the pulse width beyond 150µs produce negligible effects. This differs from current-controlled stimulation, where the pulse width plays a major role during all the tested durations (50-1000µs).
The use of IPIs, on the other hand, can help to improve the contraction levels. We show how to optimize the interval to prevent that the action potentials—triggered by the first phase—from being suppressed by the contiguous compensating phase that produces a hyperpolarize field, which prevents action potentials to propagate and, therefore, reduces the number of recruited motor units.
In conclusion, we present data that can help to better design NMES application with lower electrical charge and, therefore, improvement in sensation and skin problems.

Contribution ID: 1829

SS-32 Support of Movement Rehabilitation by Functional Electrical Stimulation: current options and limitations in the interplay of advanced technology and physiological reality

The EEG-controlled MoreGrasp neuroprosthesis for individuals with spinal cord injury - decoding of single limb movements and closed-loop grasp control

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Neuroprostheses based on functional electrical stimulation (FES) can restore lost functions in people with high spinal cord injury (SCI). The feasibility of EEG-based brain-computer interfaces (BCIs) for grasp neuroprosthesis control by motor imagery was already shown. However, intuitive BCI-control is still missing. Due to the limitations of noninvasive BCI systems for real-time control closed-loop grasp pattern control is needed. The EU-project MoreGrasp (H2020-643955) aims at the realization of both.
In two high-resolution EEG studies with 15 able-bodied subjects each, the decoding classification accuracy of 6 single joint movements of the same arm and of 3 different grasp types of the same hand were investigated analyzing motor-related cortical potentials (MRCPs) in a narrow 0.3 to 3 Hz band.
Following the protocol of these 2 studies, classification of 2 subsets of movements with 5 participants with high cervical SCI was performed.
Two sets of multi-pad FES electrodes were developed: 1) a stackable screening electrode matrix consisting of 15 (5 x 3, HxW, 6.3 x 3.8 cm) electrodes (diam. 7mm) made of conductive silicone, and 2) a personalized textile forearm sleeve with up to 4 electrode matrices and two inertial measurement units (IMUs) for wrist rotation angle measurement.
The 1st study revealed a classification accuracy of 37% (chance level 16.7%), with classifier sources mainly in premotor and primary motor areas. The 2nd study showed that grasps can be decoded from MRCP features (binary classification of 74% grasp vs. grasp). Experiments with SCI showed a classification accuracy of 53 % (subset 1) and 57 % (subset 2).

Multi-pad test results of 3 able-bodied subjects and 1 end user with SCI reveal that not only quantification of denervation is possible, but also robust electrode positions for palmar or lateral grasps and electrode switching strategies during wrist rotations for a stable grasp force can be defined.

Contribution ID: 1842

SS-32 Support of Movement Rehabilitation by Functional Electrical Stimulation: current options and limitations in the interplay of advanced technology and physiological reality

Implantable microelectrodes - opportunites and challanges with respect to selectivity, stability and reliabilty

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Miniaturized electrode arrays for electrical stimulation in neural implants have to be stable, functional and reliable over the life-time of the implant, which is at best at least as long as the life time of the recipient. While cardiac pacemaker and cochlear implant electrodes stay stable for long time due to well established materials and precision mechanics manufacturing, more complex implants with higher channel count and integration density requires different technologies as well as materials. It is not only the dimension of thin-film metals that is more demanding than the one of solid electrode sheets in cochlear implants, cardiac, spinal cord and brain pacemakers but also the fact that surface effects predominate and promote corrosion mechanisms that are hardly seen in the established applications. In addition, adhesion of metals and polymer insulation is of utmost importance for device longevity and reliability. How can these challenges be combined with the target specifications for high spatial selectivity and the possibility of current steering when using multipolar stimulation paradigms ? This presentation combines material sciences foundations with requirements of electrical stimulation in movement rehabilitation to discuss opportunites and challenges in development of miniaturized electrode arrays. Examples include delivery of sensory feedback via stimulation of afferent fibers in the peripheral nervous system and recording of neural signals from the central nervous system as input parameter in brain-computer-interface applications to control movement of either artificial or paralyzed limbs. Results from preclinical as well as from human clinical trials are presented to discuss material-tissue interactions and microsystem stability in chronic implantation scenarios and the influence of these findings to spatial selectivity that is needed for sophisticated movement rehabilitation by functional electrical stimulation.

Contribution ID: 1843

SS-32 Support of Movement Rehabilitation by Functional Electrical Stimulation: current options and limitations in the interplay of advanced technology and physiological reality

Spinal cord stimulation, a versatile tool for assessment and intervention to modify spasticity and to augment movement

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In case of cervical or thoracic spinal cord injury (SCI) in humans, the nervous structures below the level of injury are mostly intact. Nevertheless, it is unclear if the excitability of the remaining

networks can be modified, which is the premise of many therapeutic interventions. In this study, therefore, the excitability of the lumbosacral spinal network was tested by a transcutaneous spinal cord stimulation (tSCS) in the presence or absence of conditioning afferent input. In our case, tSCS generates a sensory input to the lumbosacral spinal cord by depolarizing large posterior root nerves.
We studied five subjects with a motor complete chronic SCI (C5 to T8 level). For tSCS, a surface electrode was placed over the T11-T12 vertebrae and referenced to a pair of paraumbilical electrodes. For electrical stimulation, 2x1-ms biphasic rectangular pulses were delivered at the rate of 10–30 pps or 50–80 pps with and without conditioning by passive single-joint, or multi-joint movements. Surface electrodes were used to record myoelectrical responses from the major leg muscles.
The conditioning input produced either facilitation or no change in the lumbosacral excitability when tested by tSCS at 10–30 Hz; however, the effect varied across different muscles even in the same subject. On the other hand, the same conditioning input produced a clear suppression of the tSCS at frequencies above 50 Hz which was consistent in all subjects.
These preliminary results suggest that afferent input can alter the excitability of the lumbosacral network, but the consistency and direction of change depend on the state of central excitability set-up by the rate of tSCS. This methodology may prove useful for better understanding of the pathophysiology of SCI and assessment of interventions aimed at restoration of functional movement.

Contribution ID: 1844

SS-32 Support of Movement Rehabilitation by Functional Electrical Stimulation: current options and limitations in the interplay of advanced technology and physiological reality

Introductory remarks on interaction of FES technology with physiological interface conditions

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Functional Electrical Stimulation (FES) can provide many supportive options for movement rehabilitation. On one hand, it is underrepresented in clinical practice, though it's value for assessment, therapy and health economy have been clearly demonstrated, on the other hand it is too often overrated in scientific and popular publications, which can lead to false hope, disappointment and skepticism among patients and healthcare professionals, and impedes adequate consideration in rehabilitation protocols.
This special session aims in sketching the actual possibilities and limitations as well as an outline on realistic developments towards the foreseeable future. Continuous progress in technical developments tends to refine specificity of interaction with nerve and muscle structures, nevertheless control of selective functions down to atraumatic single fiber activation seems not in sight with current possibilities. But in close synergy of engineering, physiology and clinical expertise a lot can already be accomplished and recognition of individualized physiological conditions in patients with movement disorders has become a key for significant progress in therapeutic outcome.
Basic conditions for interaction of technology and physiology as well as representative examples for restoration of paralyzed movement functions in the upper and lower extremity are addressed, with strong emphasis to what is presently realistic and adequately beneficial for clinical application. Also, an outlook on foreseeable innovations and long-term visions will be included.

Contribution ID: 1855

SS-32 Support of Movement Rehabilitation by Functional Electrical Stimulation: current options and limitations in the interplay of advanced technology and physiological reality

Assistive and Therapeutic Effects a of Non-Invasive Neuroprostheses for Drop-Foot Correction

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Non-invasive transcuteanous neuroprostheses for drop-foot correction have shown to be as effective in improving gait parameters as ankle-foot orthoses, but allowing active and more natural movement of the ankle joint.
We conducted a pilot study to investigate assistive and therapeutic effects of a multi-channel drop-foot system that allows gait correction by stimulation of ever-sion/inversion balanced ankle dorsi- and plantar-flexion.
In 20 FES sessions a multi-channel drop-foot system was applied by the therapists to four sub-acute to chronic patients (at least three months post stroke). The study was carried out in the Clinic for rehabilitation ˝Dr Miroslav Zotović˝, Belgrade, Serbia. Each subject re-ceived 30 min therapy sessions, five times a week during four weeks, supervised by a physiotherapist. Prior the first session a baseline assessment was carried out and repeated after 10 sessions and again after concluding the study after 20 sessions. Gait spe-cific the foot trajectories and kinematic data were recorded with inertial sensors placed on the insets of both legs and the 10m walking test was performed.
Ethical approval for this study was obtained from local ethic committee.
Both observed gait parameters ROM and gait velocity showed assistive and therapeutic effects of the FES system.
Without FES, an increase of 38% in walking speed after 20 training sessions could be measured.
With FES at baseline the gait velocitiy could be increased by 17% (assistive gain) and remained 17.5% at the end of the training.
Subjectively, the therapist observed and reported im-provements during the therapy resulting in more natural like and confident walking, with and without stimulation.
With this preliminary test we concluded that we can expect superior improvements of gait functions than could be shown so far by one channel FES drop-foot systems.

Contribution ID: 1891
SS-33 The role of Biomedical Engineering technology in Traditional Chinese Medicine

Observation on the therapeutic effect of treating neuropathic pain after surgical operation on brachial plexus injury by tuina

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Introduction
Brachial plexus injury refers to any damage to the brachial plexus, a set of nerves that conducts signals from the spinal cord, which is housed in the spinal canal of the vertebral column (or spine), to the shoulder, arm and hand.
Objective
Observe the therapeutic effect of Tuina treatment on neuropathic pain after surgical operation on brachial plexus injury.
Design

Randomized controlled trial.
Setting
Huashan Hospital affiliated to Fudan University, Shanghai, China
Method and Materials
Divide 52 cases with neuropathic pain after surgical operation on brachial plexus injury into Tuina treatment group and routine lone physical factor therapy control group randomly. Both treatment were applied from Monday to Friday. Two weeks were designed to be one course of treatment and two courses were needed in this study. A brief McGill Pain Questionnaire was used in this study to compare the effects before the course, after the first course as well as after the second course. The data were input into SPSS 13.0 to have the relevant analysis.
Results
50 cases finished the whole course treatment while 2 cases lost. After the courses of treatment, the PRI emotional degree, the PPI and VAS scores were found to have statistical differences ($p<0.05$) between the groups. After the first course of treatment, all the scores of the treatment group had statistical differences ($p<0.05$). After the second course of treatment, the number of positive words, VAS and PPI scores had statistical differences ($p<0.05$) compared with the first course, while the other scores had no statistical differences($p>0.05$)
Conclusion
Tuina plus routine physical factors therapy was more effective than that of lone routine physical factors in treating neuropathic pain after surgical operation on brachial plexus injury.

Contribution ID: 1569
SS-34 Integrated Precision Medicine Technologies

A multimodal machine learning approach to omics-based risk stratification in coronary artery disease

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The purpose of this study is to design and develop a machine learning-based model effectively integrating multiple categories of biological data towards precise risk stratification in coronary artery disease (CAD). A multiclass classification problem was defined based on an established risk score of coronary atherosclerosis combining markers of stenosis severity, plaque location and composition, as assessed by computed tomography angiography. A multimodal architecture approach was selected whose generalization capability, with respect to CAD stratification, is currently evaluated. The skeleton and individual modules of the integrative model (merging mechanisms, machine learning algorithms, metric learning, regularization, feature extraction) were implemented in R. First, the following feature classes (or views) were defined: (View 1) demographics, (View 2) clinical data, risk factors, symptoms, (View 3) molecular variables (i.e. biohumoral, inflammatory markers and lipids profile), (View 4) gene expression data, (View 5) exposome, and (View 6) monocytes. The multimodal architecture consists of two processing layers which are defined according to late or intermediate data integration strategies. Late data integration consists in the construction of: (i) an ensemble of decision tree-based prediction models (i.e. random forests, boosted decision trees) for each data view, whose individual decisions are effectively merged using simple mechanisms (e.g. weighted voting), or (ii) a multimodal deep neural network comprising appropriate deep learning subnetworks for each separate data view and, unifying their output into higher network layers. Intermediate data integration is based on multiple kernel learning. Kernel matrices are computed for each data view, and then they are combined, through a parametric linear function, in order to generate the final kernel matrix. Kernel-based classification (i.e. support vector machine, relevance vector machine) is subsequently applied to predict CAD risk stratification. Finally, early integration schemes, which concatenate all features into a single vector, accompanied by appropriate feature selection algorithms were implemented for comparison purposes.

Contribution ID: 1571

SS-34 Integrated Precision Medicine Technologies

Precision medicine with in-silico and in-vitro models of patient cells

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Precision medicine emerges from integration of a number of novel technologies and data they produce. For precision diagnostics and for predicting drug responses we need new models from gene regulation to cellular and organ functions. Human induced pluripotent stem cells (hIPSC) derived from e.g., patient blood cells provide means to produce most cell types and thus provide means to get patient own cells for in vitro disease models and for drug testing. New technologies are needed to assess the cell functions in-vitro. In addition we can also utilize computational models to mimic the patient or population cellular functions in silico.

We have developed novel methods based on electrophysiological sensing as well as 2D and 3D bioimaging to assess the stem cell based constructs. For example, we have developed imaging methods to assess functions of hIPSC cardiac cell with simultaneous assessment of electrophysiology as well as mechanobiology in vitro. Further, we have developed in-silico models of various cellular function including multi-cell-type neuronal networks and in-silico population models of the hIPSC cardiomyocytes providing us ionic current level hIPSC derived cardiomyocyte electrophysiology. We have shown that these computational models can also represent pathological patient phenotype cells with specific mutations, e.g., long QT syndrome, showing that the pathological condition of the patient observed in cardiac scale is seen in-vitro and can also be modelled in-silico. Our result highlight the importance of population of in-silico models providing large scale simulation of a variation of patient cells with different phenotypes or population of cells with varying genotypes. In-vitro models provide precision validation with testing the actual patient cells.

Our results demonstrate the power of stem cell technology for precision medicine. With integration of novel engineering expertise from multimodal sensing, imaging and computational modelling, we have shown their power on studying diseases and for pre-screening of compounds.

Contribution ID: 1572

SS-34 Integrated Precision Medicine Technologies

Radiogenomics in the era of precision medicine

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This talk highlights the potential of exploiting radiogenomics approaches in the era of precision medicine. It provides a brief overview of selected studies that have been conducted under the precision medicine initiative in the U.S.A, exploiting the joint processing of imaging, genomics, and clinical data. More precisely, quantitative imaging studies that have been performed for breast invasive carcinoma and glioblastoma, describing key technologies and outcomes, while highlighting future directions.

Precision medicine aspires to leverage new knowledge emanating from heterogeneous genomic, environmental, and clinical data analysis, facilitating increased understanding of disease progression, treatment efficacy, and prevention, towards developing new, personalized therapies and interventions. Such a radical shift in clinical care practice dictates fundamental advances that range from new big data analytics tools development and precision medicine research groups formation, to standardization of acquisition and sharing of research data and patients' electronic health records (EHR), as well as significant patient involvement and establishment of supportive policies.
In response to the ever increasing scientific community demands for heterogeneous multi-level data sharing, The Cancer Imaging Archive (TCIA) in the U.S.A is building a publicly accessible database, providing clinical diagnostic images matched to genomically analyzed tissue subjects of The Cancer Genome Atlas (TCGA). The Cancer Imaging Program (CIP) TCGA Radiology Initiative (http://www.cancerimagingarchive.net/), aspiring to establish new frontiers on connecting cancer phenotypes to genotypes exploiting radiogenomic approaches, currently supports six TCIA research groups investigating different cancer types.
In this talk, a brief overview of novel retrospective studies that were carried out by two of these groups is presented, namely for (i) Invasive Lobular Carcinoma (ILC), the 2nd most frequently diagnosed invasive breast cancer (between 10%-15% of all cases), and (ii) Glioblastoma (GBM), the most lethal brain cancer type, associated with low median overall survival rates.

Contribution ID: 1589
SS-34 Integrated Precision Medicine Technologies

Unusual aspects of precision medicine: the role of personalised, long-term recordings of seniors' daily activities

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The notion of studying aspects of elderly health through the introduction of home or remote monitoring as well as intervening with technologies have been introduced long ago. Almost a decade ago, we also proposed the application of neuroscience methodologies (functional brain imaging and connectomics of brain resting states) to study the effectiveness of such interventions like for instance exergame-blended cognitive and physical training. Multi-faceted evaluations were used to produce evidence of the resulting health impact. This has been practiced against the usual mode of conducting user friendliness/technology acceptance studies with limited sample sizes and limited validity. For example, our emphasis was thrown on studying detailed signatures of in-game metrics during the training sessions of an elderly individual, or long-term recordings of daily activity attributes (e.g. average daily walking speed, TV channels watched, or other frailty or continuous behavioural indicators). All the above have helped in realising new (cognitive and frailty) assessment tools which will have the power of being ecologically valid as they place within daily, non-clinical environments. Further refinement, adaptation and personalization of such systems is, however, needed. Continuous real-life feedback, via behavioural sensor indicators, could be the key towards precise, truly individualized treatment regimens for the elderly. This may well account for a new notion of public health informatics. Moreover, the availability of big amounts of such daily data facilitate precise and personalised measurements of one's health and can easily overcome the need for genetic information that is the usual attribute of precision medicine. Combining those with other information parts of "ordinary" public health may also enable precision public health, focused on individuals on one end or on the other, defocused on public aspects only, whenever and wherever needed. Fusing these ideas with information regarding environmental health opens-up new avenues of the so called exposomics-led precision medicine.

Contribution ID: 1592
SS-34 Integrated Precision Medicine Technologies

Precision medicine in the 21st Century: why public health informatics will play an increasing role in disease prevention

Luis Kun
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Through a holistic view of healthcare, and the lenses of multidisciplines and interdisciplines, a roadmap is provided which includes a "required cyber ecosystem" that could be used, for individuals with Non-Communicable and Communicable Diseases. As people live longer, thanks to advancements and discoveries both in science and technology, the chronic conditions group is becoming larger every day. In the US, by 2030, the group of individuals over 65 years of age, will double. If we consider that as we age, our healthcare costs increase, and that our last year of life is the most expensive one, the question will be: how can we afford those costs?
he premises of a healthcare transformation, were based on health (versus disease), and some of its major components related to the prevention of disease and minimizing risks. Environmental health (i.e. air quality, drinking water quality, etc.) as well as our: homes (i.e., materials used for construction, paint, pipes, insulation, etc.), neighborhoods, waste, highways, and medical system available, as well as our behaviors, mental health, life style, stress, diet and nutrition, food and medication safety, exercise, education, vaccinations, are key. Public Health and Environmental Health Informatics are driving factors for such a vision, where the objectives are: improve quality of life and decrease the costs of the healthcare system.
The Lancet Commission on pollution and health on a report on October 19, 2017, concluded that Pollution is the largest environmental cause of disease and premature death in the world today. It is responsible for an estimated 9 million premature deaths in 2015, three times more deaths than from AIDS, tuberculosis, and malaria combined. The biggest failures of current electronic systems (globally), is that they lack the integration of a variety of relevant data and information, that could greatly improve the so called "precision medicine" effort.

Contribution ID: 1600
SS-34 Integrated Precision Medicine Technologies

Integrated Precision Medicine Technologies

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Throughout human history light has played an important role in medicine. New optical technologies, many involving light emitting diodes, laser diodes, lasers, fibre optics or nanotechnologies, providing sensitive and compact electronic like devices, are revolutionising many fields. Applications of new optical technologies to medicine might be described as in an adolescent stage, where their power and potential can be recognised but are still developing rapidly, and much is yet to come. Such technologies, so far, have been used extensively for monitoring, diagnostic, prognostic or therapeutic purposes. The focus of this presentation will be mainly in the application of optics in the development of medical sensors. The talk will cover examples of application areas including real-time physiological and biochemical monitoring using optical techniques and spectral analysis. Mathematical modelling of optical propagation in tissue, as well as signal-processing techniques developed or adapted specifically for extraction of biomedical information arising from optical techniques also lie within the scope of the presentation.

Contribution ID: 1625

SS-35 Radiation exposure monitoring and tracking

Patient radiation exposure and dose tracking: An overview

Madan Rehani
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Tracking of medical exposures of patients has been receiving increasing attention in recent years. This has resulted in industry responding to the need. The availability of dose management systems is resulting in huge amount of information which can be usefully utilized. Most efforts have been directed at deriving trends in mean, median radiation doses, quality control actions and assessment of diagnostic reference levels (DRLs). Unfortunately, little attention has been paid to cumulative radiation doses to patients. Our experience in recent years has demonstrated how tracking of procedure and doses of individual patient has resulted in strengthening the process of justification and optimization (https://www.ncbi.nlm.nih.gov/pubmed/23521446). Our new focus is now on cumulative doses to individual patients. The data collected shows hundreds of patients with cumulative doses of over 100 mSv and some in the range of 500-900 mSv. We have segregated patients in the category of malignant and non-malignant and in different age groups: 0-30; 31-50 and over 50 years. Although majority of the patients with higher doses are in upper age groups of >50 and have malignant condition, there are 1-5% situations where patients are in lower age group (0-30 years) and we have now identified patients who have non-malignant conditions and have obtained radiation doses above 100 mSv in age group 0-30 years. This calls for guideline development for achieving appropriateness to enhance patient protection. The talk will review the current situation of the field by giving a global overview, analyze available literature and results from selected institutions and provide avenues for further research and development in this challenging field.

Contribution ID: 1632

SS-35 Radiation exposure monitoring and tracking

Using patient dose monitoring for optimization in diagnostic radiology

Jenia Vassileva
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International standards and guidelines express the need for medical facilities to monitor patient radiation doses for the imaging procedures they perform. Collected data from different patients, modalities, and units are combined and processed to perform relevant dose analysis, with the aim to ensure that imaging exams are well optimized, so the required diagnostic information is obtained with the lowest possible exposure dose to patients. Collection and analysis of dose related data can be performed either using electronic automatic systems or manually. In both cases data collection needs to be standardized, and data quality ensured at all steps. An exposure monitoring system should allow for recording and collecting of the proper modality specific measurable dose quantities. The level of completeness for patient exposure data should take into account the final scope of the data collection, e.g.: establishing typical dose values at the facility, and/or diagnostic reference levels (DRLs) and using them for optimization of clinical protocols, or for temporal tracking of changes, or estimation of patient-centric dose/risk quantities like organ doses. These data will form the basis for optimization of clinical protocols, for monitoring operations and trends in the clinical practice, tracking over time, and as result, improving the clinical practice and patient safety. A program for exposure monitoring can be created at the level of one imaging system, but its effectiveness would gain if all systems in a particular hospital are connected, thus allowing for inter-system comparison, and optimization and standardization of their performance. The next level is to connect systems in a group of hospitals in a region, country, or different countries, which would allow for establishing DRLs, benchmarking and comparison. This talk will be based on a consensus of a group of experts working on the IAEA coordinated international guidelines for patient radiation exposure monitoring in medical imaging.

Contribution ID: 1636
SS-35 Radiation exposure monitoring and tracking

Slovakian experience in tracking of patient's radiation doses

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In Slovakia with 5,4 milion populations, a central system was established in 2013 wherein doses from CT, mammography, fluoroscopy, radiography and nuclear medicine machines are transmitted through automatic monitoring system of patients.(DQC)
Currently we have data of 2,4 milion patients. This is nationwide set up covering hundred machines. The effective dose of patients calculated by DQC system is available. We report here patients with high cumulative doses.
The patients were classified into different age groups, namely three for children (10/15/18 years) and three for adult (30/50/>50 years). Of this the distribution of patients with more than 100 mSv effective dose is thousands.
Besides age group, we focused on finding the diagnosis and identified patients with >100 mSv cumulative dose but having non-malignant disease. This provides useful information for policy planning for radiation protection of patients.

Contribution ID: 1640
SS-35 Radiation exposure monitoring and tracking

IT means for automatic patient exposure data monitoring

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Nowadays, thanks to the digital technology used in medical imaging, various ways of collecting dose data are available. The information is communicated using specific standards (i.e. DICOM), such as the non-image information object definitions. These objects are carrying information about equipment output and do not provide any information on patient dose. Although they can include some of the information needed to estimate patient dose, unfortunately this information is not complete. Moreover some more recent modality (e.g. CBCT) are not covered by the present standard. For this reason the DICOM WG-28 (Physics Strategy) is currently working on a revision of the RDSR to include the missing information.
Furthermore none of these objects includes a template for patient-specific dose data to be recorded after estimation. For this reason a new DICOM object, the Patient Radiation Dose Structured Report (P-RDSR) has been added to the standard in 2017, in order to include some of the information lacking in the RDSR necessary for estimating patient-specific dose and to provide the archival tool to record the results of any dose estimation as well as the methodology used to achieve this estimate.
DICOM standard is vital to provide a common syntax and semantics for information exchange. Essentially, DICOM provides "tools" and "technologies". However, DICOM standard alone is insufficient: it may be open to interpretation, and some information remains optional, preventing a common implementation that guarantees interoperability for all the use cases and applications. There is a need for specifications about how to apply the standards to particular real world

scenarios. These specifications are provided by IHE (Integrating the Healthcare Enterprise) through the development of the so-called “profiles”.
This talk will review the existing DICOM objects and IHE profiles used to monitor patient exposure, highlighting pros and cons and introducing to the future developments.

Contribution ID: 1630
SS-36 Radiation protection of women in childbearing age

Status of radiation protection in pregnancy and breastfeeding

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Around one million of patients in childbearing age benefit every day from medical radiological procedures, and some of them might be pregnant or breastfeeding. The radiation risks during pregnancy depend on the dose to embryo/ fetus and gestation age. Because of insufficient knowledge, some physicians recommend termination of pregnancy following X-ray or CT, or do not perform imaging procedure on pregnant patient, that may put the women at risk. Imaging departments should minimize the risk through making checks on the pregnancy status of female patients of childbearing age, and perform proper justification and optimization. If it happened that a patient realised that she was pregnant only after the procedure, a medical physicist should estimate the foetal dose and provide advise. The second group that requires special attention are breastfeeding patients who need nuclear medicine procedures. Depending on the radiopharmaceutical and administered activity, advice should be provided for the period of suspension of breastfeeding based on the evidence-based guidelines provided by the ICRP and IAEA. The third group are female workers. Results from the IAEA global survey on radiation protection of female workers, answered by 182 professionals from 61 countries, demonstrated big variations in policies, procedures and practices among different countries and departments. There are many aspects to be considered in the proper management of protection of female patients and staff, including risk assessment, optimization of protection, proper dosimetry as well as ethical aspects. Review of the requirements of the International BSS (IAEA, 2014) for justification and optimization of radiation exposure of female patients and staff members will be presented. Practical guidelines, training and information resources are provided by the IAEA for helping countries and increasing knowledge of health professionals, all available through the dedicated website on radiation protection of patients (https://rpop.iaea.org). Summary of these resources will be presented.

Contribution ID: 1633
SS-36 Radiation protection of women in childbearing age

Managing pregnant and lactating patients and staff in nuclear medicine

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Before a woman of childbearing age is examined or treated with radiopharmaceuticals, it is important to find out whether she is pregnant, breastfeeding or caring for an infant. If pregnancy or breastfeeding has been confirmed, it is important to examine if the nuclear medicine procedure can be postponed or if there are alternatives not involving ionising radiation. For diagnostic investigations, pregnancy is not an absolute contraindication and may in many situations provide essential diagnostic information. Dose estimates are available for various stages of pregnancy and for a large number of radiopharmaceuticals. Nevertheless, there are considerable uncertainties

about how much activity may cross the placenta barrier and about the biokinetics in the foetus. A pregnant woman should not undergo therapeutic nuclear medicine procedures unless there are implications to save her life. If the procedure has to be performed, the possible foetal radiation dose should be calculated and the risk for malformations and childhood cancer estimated and shared with the patient. Many radiopharmaceuticals are excreted through the breast milk of nursing mothers. For radiopharmaceuticals used for diagnostic procedures, breast feeding interruption schedules are recommended keeping the effective dose to the infant under 1 mSv. Before start of therapy with radiopharmaceuticals, breast feeding has to be stopped.
For members of the staff, the protection principle is to ensure the same level of protection for the foetus and child as for the general public, which means dose constraint of 1 mSv to a foetus during the remaining time of pregnancy after it is known/declared and a yearly dose constraint of 1 mSv to a breast-fed child. Each facility needs to review external and internal exposure to plan protection measures and issue their own guidelines and rules. Information to the staff about the necessity of declaring pregnancy or breastfeeding is of fundamental importance.

Contribution ID: 1635
SS-36 Radiation protection of women in childbearing age

Foetal dosimetry in medical imaging

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Foetal dose estimation in medical imaging is possible by using normalized dose data published in the literature or software packages that allow calculation of dose. A method has been developed to estimate foetal dose for pregnant patients who had previously undergone abdominal and pelvic CT examination (Radiology 2008, 249, 220-227). The authors provide a linear equation for the estimation of dose. A methodology has been created for the accurate estimation of foetal dose from CT examinations performed on pregnant patients during the first weeks of gestation (Radiology 2010, 257, 483-489). This period of early pregnancy is particularly important because the unborn child is considered to be more sensitive to radiation than during the second and the third trimester. A two-variable equation provides a relationship among normalized conceptus dose, body perimeter and skin-to-conceptus-distance. A general-purpose Monte Carlo simulation code and mathematical phantoms simulating pregnancy during all trimesters of gestation were used to provide normalized dose data for foetal dose estimation from any CT examination performed in the trunk of the pregnant patient (Medical Physics 2010, 37, 6411-6420). Foetal dose calculation from nuclear medicine procedures is possible using tabulated normalized data (mGy/MBq). NCRP report 128 provides doses (mGy/MBq)to the unborn child following injection of Tc-99m labelled radiopharmaceuticals commonly used in young women. CoDE (Conceptus Dose Estimation) online software tool allows a) calculation of foetal radiation dose and associated risk from X-ray examinations performed on the expectant mother and b) anticipation of foetal dose for the pregnant employee who participates in fluoroscopically-guided interventional procedures. CoDE is available free of charge. For more information please visit embryodose.med.uoc.gr

Contribution ID: 1641
SS-36 Radiation protection of women in childbearing age

Protecting pregnant workers in interventional radiology

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Radiation protection in medical imaging is important to ensure staff are safe guarded from any risks due to unwanted radiation exposures. This becomes even more critical for pregnant staff. One area of medical imaging that requiring direct patient contact or present around the patient during procedure are the interventional procedures. During interventional procedure, radiation protection of staff, especially women in childbearing age is highly important.
This presentation will discuss in more details the type of radiation exposures a typical imaging staff encounters. Among the different type of radiation exposure, scatter radiation depends on a variety of factors and are of main concerns to staff working around patients during interventional procedures. The presentation will discuss how such radiation exposures be mitigated and what additional steps should childbearing women staff need to take in order to ensure radiation protection. Regulatory limits for regular and pregnant staff working in a radiation environment will be discussed.
Rationale methods to minimize radiation exposure for childbearing women staff will be discussed in this presentation along with demystifying myths about radiation exposures.

Contribution ID: 1911
SS-37 Medical Physics for World Benefit: A Volunteer Organization in Support of Medical Physics in Challenging Environments

Current Status of Medical Physics for World Benefit (MPWB)

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While a young organization, MPWB is now established as a viable and valued partner among organizations whose aim is advancing Medical Physics and its application to Global Heath.
As part of this, we:
1. Established MPWB as charitable organizations in the US and in Canada since December 2016.
2. Attracted more than 150 volunteer members and created a database of expertise, availability and language capabilities to serve in a variety of projects.
3. Engaged in collaborative efforts with organizations dealing with Medical Physics, such as the AAPM, COMP, IAEA and others.
4. Collaborate with more general International Cancer outreach and Physician organizations, such as the International Cancer Experts Corp (ICEC), the Global Health Catalyst and others.
5. Increased awareness of colleagues in LMICs about our activities as complementary to those of other organizations at various international events.
Illustrations of these will be presented.

Contribution ID: 1914
SS-37 Medical Physics for World Benefit: A Volunteer Organization in Support of Medical Physics in Challenging Environments

How can you participate in MPWB activities?

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The underlying principle of Medical Physics for World Benefit (MPWB) is partnership. MPWB acts as a mediator between between medical physicists in places that lack certain expertise and MPWB members that have and are willing to share that expertise. MPWB is engaged in the projects to provide advice, guidance, support and/or direct training for medical physics-related technologies, especially those related to radiation medicine, including (1) the design of such technologies and related facilities, (2) the acquisition/purchase of such technologies, (3) the commissioning of such technologies, (4) the development and/or review of quality assurance/quality control programs, and (5) the development and/or review of safety-related activities, especially those related to ionizing radiation. The presentation will review different MPWB projects as examples of partnership projects, provide guidance how to get engaged with existing or future projects, as well as with other MPWB activities. In addition, we will review how medical physicists in need can apply for assistance from MPWB.

Contribution ID: 1915
SS-37 Medical Physics for World Benefit: A Volunteer Organization in Support of Medical Physics in Challenging Environments

Open syllabus for medical physics residents

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One of the major challenges in the training Medical Physicists in developing nations is access to high quality and timely educational medical physics resources. Achieving competency in medical physics practice must include exposure and mastery of medical physics standards of practices, most of which are encapsulated in curricula defined in important credentialing bodies such as CAMPEP, IAEA and EFOMP. There are many reputable on-line and freely accessible educational resources which help facilitate these educational needs, but a generalized hierarchical syllabus which directly links core competencies enlisted in the IAEA medical physics training curriculum with online educational resources is difficult to find. The goal of this project is to develop a generalized freely accessible syllabus that consists of common core-learning objectives from various medical physics educational curricula specifically geared towards developing countries: The Open Syllabus Project. Underlying the project is the principle that MPWB works in partnership with national and international organizations. This syllabus is to be a 'living document' that is flexible enough to adapt to the latest best-practices and available technologies, yet practical enough such that it could be delivered within the time-frame of a typical medical physics residency.

Contribution ID: 1920
SS-37 Medical Physics for World Benefit: A Volunteer Organization in Support of Medical Physics in Challenging Environments

Why Medical Physics for World Benefit (MPWB)?

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In 2011, the UN issued a resolution explicitly stating that the rising burden of non-communicable disease "constitutes one of the major challenges for development in the 21st century, which undermines social and economic development throughout the world and threatens the achievement of internationally agreed development goals." One of the major diseases affected by this trend is cancer. A report published in Lancet Oncology in September 2015 describes the growing concern about the need for cancer treatment and the potential health and economic benefits if appropriate treatment would be available. It outlines that radiation therapy is a fundamental component of effective cancer management and that the infrastructure requirements for radiation therapy include the training of highly skilled professionals. Medical Physicists are a critical component to radiation therapy since they are not only involved in the computerized treatment planning of individual patients but they are also involved in all the steps associated with facility design, radiation technology acceptance testing, commissioning, quality assurance and all aspects of radiation safety. The projection is that an additional 22,000 Medical Physicists will be needed in LMICs between now and 2035 in support of radiation therapy. In addition, similar requirements for Medical Physics support exist in allied areas such as Diagnostic Imaging Physics and Health Physics. Thus, there is a tremendous need for education and training of Medical Physicists, especially in LMIC settings. At the same time, it is recognized that Medical Physics education and training infrastructure is minimal in LMIC contexts. Thus, Medical Physics for World Benefit (MPWB, www.mpwb.org) was created as a not-for profit, charitable organization in both the US and Canada with a Mission of supporting activities which will yield effective and safe use of physics and technologies in medicine through advising, training, demonstrating and/or participating in medical physics-related activities, especially in LMICs.

Contribution ID: 1337

MRI physics for the non-specialist: understanding the basics to appreciate current advances

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MRI uses signals generated by nuclear magnetic resonance (NMR) of hydrogen nuclei (protons) in water. The signal frequency depends on the strength of the magnetic field, typically 1.5 tesla (NMR frequency 64 MHz) or 3.0 T (NMR frequency 128 MHz. Three spatial-encoding methods are employed, all of which use the concept of the magnetic field gradient. By sending electrical current (hundreds of amperes) through a gradient coil, an extra magnetic field is produced, the strength of which varies linearly with position inside the scanner bore. The scanner includes three independent gradient coils, generating magnetic field gradients along the principal axes X, Y and Z. In frequency-encoding, the NMR signal is recorded while a field gradient is applied. Since the magnetic field varies with position along the gradient direction, the NMR resonant frequency (also called the Larmor frequency) is a function of position, so the detected signal contains a range of frequencies; analysing the frequency content generates a one-dimensional projection of the water-distribution within the patient. The technique called phase-encoding is employed in the second in-plane dimension; here, the gradient is pulsed on and off prior to measurement of the signal, altering the phase of the NMR signal as a function of position. Finally, the slice itself is defined using selective-excitation, in which the excitation 90-degree radiofrequency pulse is specially-shaped and is applied in the presence of a field gradient perpendicular to the slice plane (e.g. along Z for a transaxial X-Y slice). In order to generate data for an NxN image, the pulse sequence is usually applied N times, varying the phase-encode gradient amplitude with each repetition. A two-dimensional Fourier transform of the raw data matrix (the “k-space” data) yields the MR image, which can be encoded with the disease-dependent NMR parameters (T1, T2, diffusion etc.) to aid diagnosis.

Contribution ID: 1354

Electronic devices can motivate patients during rehabilitation

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Physical therapy or physiotherapy aims to remediate impairments and to improve functioning. The main phases of physiotherapy are: functional assessment, setting up the therapeutic plan and physical intervention. The rehabilitation is more effective if the patient is motivated.
The following electronic devices were developed at the Department of Measurement and Information Systems, Budapest University of Technology and Economics to aid rehabilitation: passive marker based analyzer of movement (PAM), a smart Nine-Hole Peg Tester and an input position and rotation sensor to Huple®, a special hemisphere-like tool for the habilitation of children with birth injuries.
PAM is a 2D analyzer, able to determine the x-y coordinates of passive markers moving basically in a plane. Finger tapping, tremor of the face, hand- and arm tremor and balance were tested. The recordings make possible the objective evaluation of patients' actual state, an important feedback for their therapy.
The Nine-Hole Peg Test requires the tested person to pick nine pegs up from the holder and place them in the holes in the board in arbitrary order and then remove the pegs. The smart Nine-Hole Peg Tester features light emitting diodes, thus guided tests with different difficulties can be performed. Patients can use the smart device without supervision. Certain patients enjoyed the guided tests and were keen on improving their results. This increased the efficiency of their rehabilitation.
Gézengúz Foundation for Children with Birth Injuries uses the patented hemisphere-like tool, Huple®, to improve the balance ability of children with disability. Attaching an integrated 3D orientation sensor, x-IMU to Huple® allows the objective assessment of the actual movement control of the child sitting in it. An interface was developed to Huple® thus children can control simple PC games by tilting the hemisphere. As a result, they are motivated, they playfully improve their balancing ability.

Contribution ID: 1360

Technologies supporting diagnostics and therapy of diabetes with special attention to tele-homecare and the artificial pancreas

Piotr Ladyzynski
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Diabetes is one of the most challenging medical problems worldwide. The tutorial will review technologies, which are used to support diagnostics, monitoring and treatment of diabetes. It will cover the state of the art and recent developments in: (1) the intermittent and continuous glucose monitoring, (2) the glycated hemoglobin A1c monitoring and interpretation, (3) the subcutaneous insulin infusion using the conventional portable pumps, patch pumps and implantable pumps, (4) the alternative routes of insulin delivery, (5) decision support systems in the intensive insulin therapy, (6) the tele-homecare support of the diabetes treatment applying eHelath and mHealth systems, and (7) the artificial pancreas systems, including electromechanical, biological, bioartificial and biochemical solutions.

Contribution ID: 1366

Neurodynamic functional brain imaging using magnetoecephalography

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Magnetoencephalography (MEG) uses SQUID-based sensors to measure extremely weak extracranial magnetic fields generated by spontaneous and evoked neuronal activity of the human brain. As one of the major functional brain imaging methods MEG allows real time monitoring of sensory and cognitive processes. A range of spatio-temporal localization methods and approaches have been developed which allow most detailed insight into topology and cortical neurodynamics of the activated dynamical neural networks subserving perceptual and cognitive processing of the working brain in health and disease. Due to its non-invasive and non-contact nature as well as the fact that MEG does not exposes subjects to any fields or substances it can be safely used throughout the life-span. The tutorial will provide introduction to MEG instrumentation for newborns, children, and adults, noise cancellation hardware and software solutions, most recent advances in the development of novel sensor technologies, present briefly experimental design, review major analysis approaches and provide an overview of MEG basic and clinical studies, some of which represent unique contributions of MEG to human brain studies.

Contribution ID: 1367

Novel digital signal processing tools in cardiac electrophysiology

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In recent years, electrocardiogram (ECG) recorders are available and widely used in clinical practice. Last decade brought a number of other applications such as experimental cardiology, sport medicine, rehabilitation engineering, automotive, smart cities, biometrics, well-being and smart ageing. In this areas, ECG recorders are usually built in a compact form so that users can wear them without much of obstruction in the routine activities, or the recorders are embedded in larger systems. Wearable ECG recorders are becoming very popular because of their low cost, long term recording capability and ease of use. Embedded ECG recorders aim to track heart activity of the user by wireless way to recognize an individual or check his/her current physical or mental health status. Since a huge volume of ECG data is generated in the mentioned applications, automated methods are preferred for analysis of the heart signals. The ECG data may be composed of single-channel or multiple-channel depending upon the type and configuration of the ECG recorder producing ECG signals, heart activity signals or heart rate variability signals. This includes single-lead and multiple-lead wired recorders, video cameras, touchless fingerprint and palm/hand biometric sensors, smart wireless sensor recorders, and others. Methods of data analysis are also different to deal with data and interference accordingly. A wide range of time-frequency methods, optimal filters, deep-learning approaches, ultra low computational complexity algorithms, support vector machines methods, and many others are used for data cleaning, signal classification and feature extraction.

Contribution ID: 1437

Establishment of clinical DRLs: The European experience

John Damilakis
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Dose reference levels (DRLs) have proven to be an effective tool for optimisation of protection in medical exposures of patients. The new Euroepan Union ‘Basic Safety Standards’ states that ‘Member States shall ensure the establishment, regular review and use of diagnostic reference levels for radiodiagnostic examinations, having regard to the recommended European diagnostic reference levels where available, and when appropriate, for interventional radiology procedures, and the availability of guidance for this purpose’. Clinical indications dictate the main parameters that affect patient dose from CT such as scanning length, collimation and number of phases. Therefore DRLs should be specified for a given clinical indication. Although many national radiation

protection authorities have established DRLs for anatomical areas only a few have defined a limited number of DRLs for different clinical indications, so far.
The European Commission (EC) launched the ‘European study on clinical diagnostic reference levels for x-ray medical imaging’ (acronym: EUCLID) project to provide up-to-date clinical DRLs. The main objectives of the project are to a) conduct a European survey to collect data needed for the establishment of DRLs for the most important, from the radiation protection perspective, x-ray imaging tasks in Europe and b) specify up-to-date DRLs for these clinical tasks. Moreover, a workshop will be organized to disseminate and discuss the results of this project with Member States and the relevant national, European and international stakeholders and to identify the need for further national and local actions on establishing, updating and using DRLs.

Contribution ID: 1469

Interactions of Electromagnetic Fields with Biological Systems

JAN VRBA
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Tutorial is focused on description of interactions of electromagnetic (EM) fields with biological systems, mainly from the point of view of physics. Approach to research of biological effects of EM fields (both thermal and non-thermal) will be presented. Usually special exposure chambers are being used for this kind of research. Basic requirement for these exposure chambers in general is a precise dosimetry that allows to evaluate biological effects of EM field even in case of long term EM exposures of small animals that can move freely during the experiments. Basic known results of this research (i.e. both positive and negative biological effects of EM field) will be discussed here. From it it then will result how the positive biological effects can be used in the area of applications of EM fields in medicine and biology. In details will be described the use of microwave technology for cancer treatment by hyperthermia. Principles of new type hyperthermia applicators (e.g. based on MTM technology, etc.) will be mentioned. Last but not least, prospective use of microwave technology for medical diagnostics, e.g. microwave differential tomography, will be given. Part of this presentation will be a description of a special exposure chamber for the research of the biological effects of the EM field at a frequency of 900 MHz, one of mobile phone frequencies. We will present here the results of biological experiments in which the effect of EM field on free radical formation in selected organs of mice was investigated. This is based on a comparison of the level of free radicals in mice actually exposed by EM field to the free radicals level in the control group.

Contribution ID: 1510

Biological Cells and Tissues in Electric Fields

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Today, biological cells and tissues are exposed to electric fields in order to induce certain biological effect - for instance, the electroporation of cell membranes. The exposure is, however, often unintentional coming from numberless electrical devices. In this tutorial we present basic methodology for modeling and understanding the electrical response of biological cell and tissue to harmonic and pulsed electric fields of various intensities and frequencies. The focus is on short-term electrical and thermal response of tissue to high intensity pulsed electric field used in electrochemotherapy and electro gene therapy. The methodology is based on basic concepts of electromagnetic theory.

Contribution ID: 1516

How to pick up an X-ray image: from celluloid to digital Flat-Panel Detectors

Olaf Doessel
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The tutorial will briefly lead through history of X-ray imaging devices (celluloid, image storage foils, image intensifier). Then the most important technologies of today are described ending with the Flat-Panel Detector (FPD). Quality measures like Modulation Transfer Function MTF and Detective Quantum Efficiency DQE are explained. Finally new trends are reported: dual energy detectors and direct conversion detectors.

Contribution ID: 1517

Biosignal Analysis - demonstrated with Intracardiac Electrograms

Olaf Doessel
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The classical steps of biosignal analysis are: preprocessing, feature extraction, annotation and visualization. Sometimes classification tasks are included. The lecture will explain important methods of biosignal analysis using the example of signals measured with multichannel catheters inside the human atria. Signal sections with activity will be separated from signals without activity, ventricular far fields will be identified and compensated, the local activation time (LOT) will be detected, complex fractionated atrial electrograms (CFAE) will be classified, the cycle length (CL) and the dominant frequency (DF) and the conduction velocity (CV) will be reconstructed. The detection of the instantaneous phase, phase maps and phase singularities is a speciality of atrial signals, aiming at reliable rotor identification.

Contribution ID: 1518

Hybrid imaging technology: Looking back and moving forward

Habib Zaidi
Medical Imaging & Information Sciences, Geneva University Hospital, Geneva, Switzerland

Early diagnosis and therapy increasingly operate at the cellular, molecular or even at the genetic level. As diagnostic techniques transition from the systems to the molecular level, the role of multimodality molecular imaging becomes increasingly important. Positron emission tomography (PET), x-ray computed tomography (CT) and magnetic resonance imaging (MRI) are powerful techniques for in vivo imaging. The inability of PET to provide anatomical information is a major limitation of standalone PET systems. Combining PET and CT proved to be clinically relevant and successfully reduced this limitation by providing the anatomical information required for localization of metabolic abnormalities. However, this technology still lacks the excellent soft-tissue contrast provided by MRI. Standalone MRI systems reveal structure and function, but cannot provide insight into the physiology and/or the pathology at the molecular level. The combination of PET and MRI, enabling truly simultaneous acquisition, bridges the gap between molecular and systems diagnosis. MRI and PET offer richly complementary functionality and sensitivity; fusion into a combined system offering simultaneous acquisition will capitalize the strengths of each, providing a hybrid technology that is greatly superior to the sum of its parts. However, the technology suffers from a number of drawbacks that will be discussed in this talk.
This talk also reflects the tremendous increase in interest in hybrid imaging technology as both clinical and research tool in the past decade. It offers a brief overview of the historical development

of this modality from basic principles to various steps required for obtaining quantitatively accurate data from dedicated standalone PET and combined PET/CT and PET/MR systems. Future opportunities and the challenges facing the adoption of multimodality imaging technologies and their role in biomedical research will also be addressed.

Contribution ID: 1525

Quality assurance and control in CT.

Virginia Tsapaki
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Computed Tomography (CT) scanners are widely known for their use in diagnostic, interventional radiology and fluoroscopy practice. The last years they are also utilized in radiotherapy for . They are equipped with a vast variety of different technology, setup and technical protocols; thus the choices of the medical personnel in charge to practice are numerous. Due to the extended range of almost every parameter of each protocol (kV, mA, rotation time, pitch, filters, reconstruction algorithms, etc.), the radiation dose can vary extremely. Depending on the clinical needs and the technical protocols applied in each CT department, patient radiation dose differs, even for the same clinical indication, anatomical region, technical protocol and sometimes even for the same CT unit. Furthermore, high rates of repeated CT scans in certain cases are reported in the international literature as for example the trauma patients with additional hospital charges and additional radiation exposure. Due to the aforementioned reasons, the urge to monitor, optimize and generally review medical practices in CT units has risen significantly. Furthermore periodical evaluation of all CT parameters enables the end users to control the performance of the CT scanner at all times.
All these clearly point to the critical need for ongoing quality control (QC) and quality assurance (QC). The related educational course lecture will present an extensive review of the latest routine QC tests, based on the most recent publications, starting from more simple tests that can be easily performed by a radiographer or other qualified health professional to the more complex ones that must be executed and analysed by a medical physicist or a medical physics expert.

Contribution ID: 1535

The radiobiology of particle radiotherapy

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Rapid advances in our understanding of radiation responses, at the cellular, tissue and whole body levels have been driven by the advent of new technological approaches for radiation delivery, including the increasing use of ion beam therapies. These take advantage of the Bragg curve to allow more optimized delivery of dose. Alongside this physical advantage there ae also significant biological advantages with increasing radiation quality or linear energy transfer (LET). For protons, the routinely utilized clinical approach is to correct for increased biological effectiveness using a constant Relative Biological Effectiveness (RBE) value of 1.1. However it is well appreciated that this represents a broad average and overlooks the steep rise of Linear Energy Transfer (LET) at the distal end of the Spread-Out Bragg Peak (SOBP). Multiple cellular studies, examining a range of endpoints, have clearly shown this strong physical dependency on LET. This is also dependent on well understood radiobiological parameters such as the alpha/beta values underpinning survival responses, oxygen status and the impact of fractionation.
Despite this dependency on physical parameters, even when taking a panel of cells representing different molecular phenotypes of a particular cancer, there can also be a wide variation in proton

RBE, independent of LET. In the drive towards precision medicine it is clear that this will have consequences for individual tumor responses particularly for protons. Further detailed studies evaluating a range of endpoints both in vitro and in vivo to quantify RBE along the full range of the Bragg curve may facilitate the optimization and further exploitation of the potential benefits of proton therapy and indeed other ions. In the longer term, appropriate parameters for individual tumours and normal tissues need to be defined which will allow biological-based treatment optimisation for particle therapies.

Contribution ID: 1536

Technologies to capture real world use of assistive devices

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There is a bewildering range of devices now available to assist functional movement for those with physical impairments. Many of the devices on the market have limited evidence of efficacy, making the selection of the appropriate device for a given patient difficult. The clinical studies of efficacy which have been published, generally focus on parameters which can easily be measured in the lab or clinic, sometimes combined with self-report or interview feedback from the user. Very few studies report objective data on how, where and when the devices are actually used in everyday life. The lecture will first discuss why capturing data on real world usage of assistive devices is of potentially significant value to researchers, manufacturers and clinicians. A number of case studies will then be presented, focusing on real world monitoring of prostheses, walking aids and wheelchairs. Finally, a discussion of how such approaches could be used to better evidence the effectiveness of assistive devices, as well as some of the challenges such technologies raise, will be presented.

Contribution ID: 1541

Developing clinically oriented physics learning outcomes for healthcare professionals: a multi-stakeholder consensus based approach

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Policy statements describing the role of the Medical Physicist include the duty of teaching medical and healthcare professionals at both universities and hospitals. In the case of ionising radiations this is often a legal obligation of the Medical Physicist; in Europe this legal obligation is in fact enshrined in EU directives (2013/59/EURATOM, Article 83(2)(h)). Unfortunately little educational research has been carried out by Medical Physicists regarding their role in the education of medical and healthcare professionals with the result that sometimes learning outcomes are far removed from the day-to-day clinical learning needs of these professions. In 2005, the EFOMP council set up a Special Interest Group (SIG) to develop this aspect of the role of the Medical Physicist. This session will explain the background to the project, summarise the research achievements of the SIG and explain a curriculum model developed by the SIG involving a multi-stakeholder consensus based approach. This model is structured enough for systematic curriculum development yet generic enough to be applicable to all medical and health care professions whilst being easily modifiable to national and local needs. Finally we will describe the research results of a practical application of the model for the development of physics learning outcomes as part of a continuous professional development programme for MRI radiographers.

Contribution ID: 1542

Advanced Implantable Cardiac Devices Settings and Patient Troubleshooting

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To the implantable cardiac devices belong now the pacemakers, implantable defibrillators and subcutaneous defibrillators. The aim of this tutorial is to show the possibilities of the recent programmable features within these devices and their using in practice. The troubleshooting part of the tutorial provides the overview of most common issues to solve in the clinical practice, like supporting/elimination of own patient rhythm, individual need of pacing, environment and electromagnetic disturbance. The technical standardization requirement will also be covered.
For dual chamber pacemakers, the timing of ventricular pacing, realized by AV delay parameter, is fundamental. It can be either fix or dynamic, incorporated the specific algo-rithms for AV delay extension. As the ventricular filling phase influences the patient hemo-dynamics, and an abundance of ventricular paced beats should be avoided, this parameter is critical.
For implantable defibrillators, the optimization of tachycardia detection process is of primary importance. False-positive shocks are quite often in the praxis. Therefore the trends of patient rhythm should be evaluated during ambulatory follow-ups and detection settings adjusted appropriately. Detection zones, sensing threshold, duration, morphological algo-rithms – all these parameters will be discussed in details. The similar situation is for subcuta-neous defibrillators, where however the settings have no so many options.
All implantable cardiac devices settings should be individualized. This educational course helps to better understanding of advanced settings.

Contribution ID: 1547

QA Metrics: A Scientific Approach to Quality Improvement

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Medical physicists spend a lot of time "doing QA", but we often look at the results as just pass or fail. This non-quantitative methodology is often our way of meeting professional standards such as task group reports from the American Association of Physicists in Medicine or other professional societies. However, there is little data to show the impact of following these prescriptive guidelines. By setting quantitative quality metrics we can scientifically measure the impact of our work and quantify improvements. The easiest approach is to take routine work that is already being performed and make it the study for improvement. For example, institutions that use an incident learning system could quantify reported incidents before and after a practice change. To begin, a prospective plan of study must be created and a metric created; the additional work is minimal and the benefit can be significant. Essentially, this is applying the scientific method to the routine QA we currently do each and every day. In addition to evaluating the impact of our work, it can help justify our contributions to hospital administrators and regulators, provide data for change of practice, or substantiate need for new and improved equipment. Transitioning from a non-quantitative methodology into a scientific, qualitative one is a process every scientist should be excited about doing.

Contribution ID: 1550

Spatio-temporal aspects of DNA damage and repair upon action of ionizing radiations of different types

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Repair of DNA damage is a necessary prerequisite for life. Biochemical pathways responsible for DNA damage signaling and repair thus attracted extensive attention in previous years. However, less understood remain spatio-temporal aspects of DNA damage response upon action of different radiation types. In present lecture, we will focus on induction, repair and misrepair of DNA double strand breaks (DSB) as the most serious DNA damages induced by ionizing radiation; we will discuss how physical parameters of ionizing radiation, like frequently studied linear energy transfer (LET), influence microdosimetric characteristics of DSB damage, with important consequences on DSB repair and misrepair. We are going to show that although LET represents an important determinant of microdosimetric characteristics of DSB damage, even particles with similar LET can dramatically differ in spatio-temporal distribution of DSBs and, consequently, biological effects. Moreover, we will explain how different types of ionizing radiation interacts with chromatin domains of different structure. This also has to be taken into consideration when biological effects of individual radiation types are compared. In this context, we will introduce primary DSB clusters, which especially appear due to highly localized energy deposition and chromatin fragmentation after high-LET irradiation, and secondary DSB clusters, which arise as a byproduct of DSB repair processes after irradiation of all types. Both primary and secondary DSB clusters can result to formation of chromosomal aberrations, the process that is further dependent on cell nuclei organization and chromatin structure of higher-order. We will explain how these findings together support the “breakage-first” and “position-first” hypotheses of the mechanism of chromosomal aberrations formation, respectively. To summarize, relationships between physical characteristics of different radiation types, higher-order chromatin structure, DSB induction and repair, DSB misrepair, and cell killing by radiation will be discussed

Contribution ID: 1556

How NOT to write a manuscript that cannot be published

Karel Roubik
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Recently, the number of journals publishing papers related to biomedical engineering is expanding including the “predatory journals”. The well-established “traditional” journals can be easily distinguished from these low-level journals. The main principle of the high-quality journals is to publish only well-written, technically sound papers with a good structure and clear content. Publishers of the best biomedical journals created a set of rules how a good quality paper should be written and other journals have been using these rules as well. Furthermore, strict rules have been followed concerning studies involving human subjects, including the obligatory registration of these studies in a recognized public registry. The lecture analyzes the current requirements of the best biomedical journals and gives the potential authors recommendations how to avoid problems that might be so serious that the high quality journals would refuse the manuscript.

Contribution ID: 1609

Image filters in nuclear medicine

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Image quality in nuclear medicine is limited by several physical factors, including attenuation and scatter inside the patient, inherent noise, and location-dependent resolution (blurring). Some of these effects may be at least partially compensated by applying suitable image filters.
In this talk, after outlining the nature of the degrading phenomena mentioned above, we shall explain how to represent signals and noise in the frequency domain, and how filters can be characterized there. The special aspects of planar gamma camera images as well as the role of filters in reconstruction will be addressed. We shall outline the basic approaches to define and optimize image quality by the selection of appropriate parameters for image processing steps, especially filters, putting emphasis on the practical challenges of nuclear medicine.
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Contribution ID: 1626

Numerical solving of ordinary differential equations in MATLAB/ or OCTAVE, with focus on neuronal simulation

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Tutorial deals with numerical solving differential equations, specifically ordinary differential equations, ODE, where the variable is integrated typically in time, t, in environments of MATLAB and its free companion, OCTAVE.
Other inputs, which have to be specified: Initial conditions, the range of values of the integrated variable, and initial variable difference and initial output tolerance to be used as initial precision of the solution.
MATLAB contains several ODE solvers (integrators), "ode23, ode45, ode113, ode23tb" and others. The solvers are MATLAB/ OCTAVE functions in libraries (under MS Windows, or Unix, respectively, can be found at):
C:\Program_Files\MATLAB\R2008a\toolbox\matlab\funfun\
/opt/matlab/toolbox/matlab/funfun
My demos can be accessed on web at: nemo.lf1.cuni.cz/mlab/ftp/tutorial, or onyx.lf1.cuni.cz/mlab/ftp/tutorial
Most current versions of MATLAB contain only solvers with adaptive, i. e. variable step size. They use Runge-Kutta methods, Adams method, and others. The simplest Euler method is not amongst them. We can plot the solution, obtain phase plots or using the event location property. In MATLAB libraries, there is no solver with the fixed step, to my knowledge.
Several years ago I have written my own ODE solver with the fixed step size, using Runge-Kutta and Euler methods. Then I also wrote my own version of "odeplot", which plots the solution, since at that time, when I was writing these, it was not available.
When simulating models of neurons by dynamic ODE, it is advantageous to solve complicated and nonlinear equations, like the Hodgkin-Huxley equations, and others, with the use of fixed time step

and simultaneously plot the solutions and captured specific events (like action potentials, or synaptic potentials). With these techniques we can construct curve of firing frequency response of neurons to the level of DC current.

Contribution ID: 1627

Event related potentials: principles and practice

Jan Kremláček
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The tutorial will introduce registration and analysis of the electrical activity of the brain associated with visual stimuli. In the first part, the principles of registration together with their clinical and experimental use (e.g. in brain computer interface) will be presented. In the second part, a live registration of sensory and cognitive potentials (ERPs) will be conducted among interested course participants. Registered data will be available on-line for a simple immediate ERP analysis. The tutorial should give an overview of ERP strengths and weaknesses for a future project build by the course participant.

Contribution ID: 1628

Introduction to equation-based modeling and simulation with Modelica and OpenModelica with focus on physiology modeling using Physiolibrary - Part 1

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The development of models of human physiology was facilitated by a new generation of simulation environments using Modelica language. Fundamental innovation of Modelica language is the possibility to describe individual parts of the model as a system of equations directly describing the behavior of that part and not the algorithm of solving of these equations (see http://physiome.cz/modelica.pdf).
This tutorial gives an introduction to the Modelica language, the OpenModelica environment, and an overview of modeling and simulation in a number of application areas.
The tutorial will show acausal approach of modeling physiological system using Physiolibrary, an open-source library for biomedical modeling, which allows presenting complex models composed from different domains in comprehensible and maintainable form. Together with participants, models will be constructed of cardiovascular system, chemical reactions, body thermal transfer, osmotic phenomenon and integrative approach. Attendees should bring their own computers to participate in the hands-on sections of the tutorial.
Based on participants previous knowledge, tutorial may be extended to introduction of model-based dynamic optimization with OpenModelica including goal functions, constraints, convergence and other advanced features of OpenModelica. Bring your laptop for exercises.
First part of tutorial will introduce acausal and object oriented Modelica language using an open-source tool OpenModelica (www.openmodelica.org) and a commercial tool Dymola. Attendees can install the open-source OpenModelica tool in advance before the tutorial.
The second part of the tutorial will consist of hands-on sections that will demonstrate building selected models of 1) cardiovascular system dynamics – using hydraulic domain. 2) common biochemical reactions – using chemical domain. 3) body thermal transfers with blood flow using thermal domain 4) liquid volume of the penetrating solution in intracellular space, extracellular

space, interstitial space, blood plasma or cerebrospinal fluid using osmotic domain 5) integrative approach which connects these domains together.

Contribution ID: 1639

Super-resolution microscopy: principles and applications

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Over the past decade, STORM and STED microscopes produced by the major optics companies became commercially available and super-resolution microscopy transformed from somewhat a specialty to actual applicable tool for biological and biomedical research. Imaging of subcellular structures with unprecedented resolution can shed light on the cause and development of a pathological condition. It came as no surprise that the great potential impact of super-resolution fluorescence microscopy was recognized by the Royal Swedish Academy of Sciences and the Nobel prize in Chemistry was awarded for its development in 2014. In this course, the fundamentals of fluorescence microscopy will be presented, followed by the principles of several derived super-resolution imaging techniques such as Near-field Scanning Optical Microscopy, Stochastic Optical Reconstruction Microscopy, and Stimulated Emission Depletion Microscopy.

Contribution ID: 1645

Modern approaches to diagnosis of hearing disorders

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Contemporary state of art in the field of audiology is based on examination of the hearing function and its disorders with different audiological methods comprising tympanometry, tone audiometry, speech audiometry, oto-acoustic emissions as well as several other audiological tests and objective audiometry based on recording of evoked potentials. In the tutorial speakers will describe in detail all these methods and will inform about the recent improvement of these methods taking into account the fact that with the continuous prolongation of the human life becomes more and more important proper diagnosis of presbycusis. In addition information will be given about the use of modern MRI methods such as functional magnetic resonance, MR morphometry, diffusion tensor imaging and MR spectroscopy in the investigation of hearing disorders. These methods are at present time predominantly used in the research but in the future they could be used routinely in the diagnosis of hearing impairment.

Contribution ID: 1654

Particle Therapy

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There is at the moment a rapid increase in the number of Particle Therapy (PT) centres across the world. From being an exotic modality at a few research laboratories for very few patients, the accessibility of PT will soon reach a level where most large cancer centres will be able to offer PT to patients with suitable indications. As a consequence, the radiotherapy community, including those without access to PT, must increase their level of knowledge of all aspects of PT to ensure that the patient selection is done in the most optimal way in order to offer the best possible treatment to those patients who will benefit the most.
In this lecture the basic rationale for PT will be given, primarily for proton therapy but also to some extent for heavier ions such as therapy with Carbon ions. The technology of beam production and delivery will be discussed as well as an overview of radiobiological aspects of PT.
The clinical advantages in terms of dose distributions for some indications will be touched upon but also possible challenges such as robustness and uncertainties. The specific aspects of dosimetry and QA in scanned proton beams will be discussed and finally an outlook will be given for the years to come, including interesting technological achievements that may affect the PT of tomorrow.

Contribution ID: 1732

Dosimetry audits in radiotherapy

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Dosimetry audit plays an important role in the development and safety of radiotherapy. National and large scale audits are able to set, maintain and improve standards, as well as having the potential to identify issues which may cause harm to patients. They can support implementation of complex techniques and can facilitate awareness and understanding of any issues which may exist by benchmarking centres with similar equipment. Undertaking regular external audit motivates centres to modernise and develop techniques and provides assurance, not only that radiotherapy is planned and delivered accurately, but that the patient dose delivered is as prescribed. This lecture will give an overview of different types of dosimetry audit, highlighting their advantages and disadvantages. A summary of audit results will be given, with an overview of methodologies employed and lessons learnt. Recent and forthcoming more complex audits will be considered, including future needs such as proton therapy and other advanced techniques such as 4D radiotherapy delivery and verification, stereotactic radiotherapy and MR linacs. The work of the main quality assurance and auditing bodies will be discussed, including how they are working together to streamline audit.

Contribution ID: 1760

Modelling radiation effects beyond single-cell level

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Dedicated models of tissue responses to radiation depict the sigmoidal dose-effect relationship of tumor control and normal tissue complication probabilities (TCP and NTCP) in radiotherapy [1]. Refining simple tools like the logistic or Poisson models, current descriptive and mechanistic approaches account for non-uniform dose distributions, hierarchical tissue organization, and effects of fractionation. Cellular automaton models represent individual cells and underlying processes such as cell growth and loss or angiogenesis in stochastic terms. Descriptive and

mechanistic models of diverse levels of complexity exist also for long-term health risks, namely for radiation-induced cancer and cardiovascular diseases.
Another class of models [2-4] represent the fact that cells respond to any stressor, including ionizing radiation, not as independent entities but in a highly coordinated manner within tissues. The bystander phenomenon clearly illustrates this: Cells directly hit by ionizing radiation emit signals to which neighbor cells react and exhibit similar responses as the hit cells, including DNA damage or cell kill. Ionizing radiation modulates existing signaling processes and their outcomes, e.g. the anticarcinogenic process removing transformed cells upon signaling with normal cells.
An overview of the above-mentioned models will be given, focusing on their mechanistic background and practical applications.

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Contribution ID: 1763

Mechanistic modelling of subcellular and cellular radiation effects with PARTRAC

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PARTRAC [1] is a biophysical simulation tool for modelling radiation effects on subcellular and cellular scales. Starting from cross section databases, it simulates the stochastic nature of individual energy deposition and transport events for photons, electrons, protons and light ions over a wide energy range occurring naturally or in medical and technical applications. Subsequently, the formation of reactive species, their diffusion and mutual reactions are modelled. Induction of damage to cellular DNA is simulated taking into account both direct energy deposits and attacks of reactive species. To this end, multi-scale models of DNA and chromatin structures are implemented, ranging from the double-helix wrapped around histones, over formation of chromatin fibres, loops and domains, to chromosomes in territories of the spherical or ellipsoidal nucleus. In the next module, DNA damage response through non-homologous end-joining of double-strand breaks is followed, explicitly considering both temporal and spatial aspects by modelling enzymatic processing and mobility of DNA termini. Correct rejoining, misrejoining and the formation of chromosome aberrations are distinguished including specific structural abnormalities like dicentrics. Work in progress aims at extending PARTRAC to the endpoint of cell killing. The processes represented, methods used, and benchmarking against data will be discussed. Recent results will be presented on ion-induced DNA damage [2] and induction of dicentrics after ion microbeam irradiation [3]. Future development of PARTRAC will be discussed, too.
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Contribution ID: 1767

Digital Radiography Detectors: Overview and Acceptance Testing / Quality Control Update

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Major digital radiography detector technologies available in 2018 include computed radiography (CR), flat-panel thin-film-transistor (TFT), and complementary metal-oxide (CMOS) large-area array sensors. Each detector technology has unique attributes for latent image capture of the transmitted x-ray beam, signal conversion, and temporal acquisition capabilities. Similar attributes include wide exposure dynamic range, and pre- and post-processing steps necessary to optimize the resultant images for human viewing and diagnosis. Technological advances continue, with introduction of wireless, flat panel arrays with large and small form factors, systems with variable acquisition gain, discrete photon counting devices, and energy discriminating capabilities. A brief overview of current and future x-ray detectors is discussed in the presentation.
The American Association of Physicists in Medicine is developing harmonized and holistic digital radiography acceptance test and periodic quality control procedures to encompass acquisition detectors in addition to the other components in the system, including the x-ray generator, x-ray tube, anti-scatter grid, automatic exposure control subsystem, informatics interfaces, HL7 - DICOM attributes, image processing/calibration issues, and image display characteristics, as examples. The efforts of the task group, now nearing completion, are described.

Contribution ID: 1768

Implementation of the IEC 62494-1 Exposure Index Standard for Digital Radiography

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Digital radiography wide dynamic range attributes and acquisition post-processing capabilities create visibly consistent appearance despite large differences in incident x-ray intensity to the detector. While underexposures can be identified due to visible quantum mottle, overexposures can be difficult to discern. The generic “Exposure Index” is a manufacturer-proprietary method to provide feedback to the radiographer as an indirect indication of digital image quality and noise. Unfortunately, there are as many proprietary Exposure Index methods as there are manufacturers, and complications arise in a multi-vendor environment with a need to share data across institutions, or to a dose registry database. A unified Exposure Index standard for Digital X-ray Imaging Systems, IEC 62494-1, was developed a decade ago, but only recently has there been substantial implementation in the United States.
The standardized Exposure Index (EI) does not indicate patient dose, but is a linearly proportional estimate of the incident radiation exposure to the detector based upon an analysis of the histogram distribution of relevant digital values calibrated to a known incident air kerma. For a given exam, a “Target Exposure Index” (EIT) value is identified in the imaging system protocol database, based upon the type of exam, the type of detector, and the clinical requirements in terms of image quality (noise). Calculation of a “Deviation Index” (DI) indicates under- or overexposure of the incident radiation to the detector: DI = 10 log (EI/EIT). A value of DI=0 indicates the detector radiation dose is appropriate; negative and positive DI values and their magnitude represent levels of

underexposure and overexposure, respectively. Results suggest improved image acquisition reproducibility and radiographic techniques. Radiographers and radiologists benefit from standardized terminology, and clinics can compare exposure index values and deviation index performance with others through a national dose index registry database. Details and experience with the standard are presented.

Contribution ID: 1856

Lower limb prosthetic socket biomechanics, soft tissue mechanics and state-of-the-art technologies and research for assessing socket fit

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Lower limb amputee's residual limb / socket interface pressures have been considered as one of the most viable parameters to quantitatively evaluate prosthetic socket fit. This is supported by the number pressure measurement and finite element modelling investigations over the years, attempting to measure and predict residual limb / socket interface pressures respectively. However, a good prosthetic socket fit today is still highly dependent on the skill and experience of the prosthetist. The question we are raising is – what else besides residual limb / socket interface pressures? In this course, we will present fundamental knowledge of socket biomechanics and residual limb / socket interface pressure measurement. With this background, we will discuss the advances in socket design (e.g. pressure casting) motivated by socket biomechanics. Finally, we will present our future perspectives in socket design, highlighting state-of-the-art research such advanced motion analysis (e.g. using the Computer Aided Rehabilitation Environment (CAREN)), patient-specific residual limb / socket interface and neuromusculoskeletal modelling. The overarching aim of this course is to provide fundamental knowledge in socket biomechanics, highlight current and future technologies that could improve socket fitting, and finally encourage research and development in this area to improve the well-being of patients.

Contribution ID: 1857

Evolution and Innovation in X-ray Tomographic Imaging Driven by Applications

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X-ray-based tomographic imaging such as computed tomography plays an increasingly dominant role in modern medicine and many other disciplines such as security scans and material sciences. In the past 20 years, X-ray tomographic imaging has been enjoying a significant period of innovation, as a result of the rapid advances in research and engineering not only enabled by technological development of hardware and algorithms, but also, more importantly, driven by application needs. This trend is likely to remain at least in the foreseeable future. In the presentation, using examples, I will highlight the past and current, and also speculate the future, evolution and innovation in X-ray tomographic imaging driven by practical applications.
Objectives of the presentation are to discuss
1. Basic principle, and leading medical applications, of diagnostic computed tomography (CT)
2. Algorithm-enabled dose reduction in diagnostic CT
3. Emerging X-ray tomographic technologies enabled by advanced hardware and algorithm
4. C-arm cone-beam CT (CBCT) for radiation therapy, surgery, intervention applications
5. Digital tomosynthesis for screening applications to breast cancer and possibly lung cancer

6. Advances in multi-spectral (or photon-counting) CT

Contribution ID: 1864

Biomechanics of the cell - experiments and mathematical modelling

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The development of modern cell testing technology made possible a whole series of new and unexpected applications of the cell mechanics expanding its scope to limits that couldn't be dreamed of a couple of decades ago. However, the interpretation of cell mechanics could be confusing due to different principles adopted used when measuring cell mechanics and different and mutually incompatible cell mechanics models. The aim of the lecture is to facilitate the understanding of the field to non-experts. We overview a suite of different cell mechanics experiments with the focus on their principles, practices, and results. Along with the experiments, different cell mechanics models are summarized. The application experts will present experimental tools, discuss loading protocols, and evaluation of mechanical measurement results. Examples of interpretation of typical cell mechanical measurements are provided and new prospects of cell mechanics research are outlined.

Contribution ID: 1865

Biophysical modelling of radiation-induced cell death and chromosome damage, with applications for hadrontherapy

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When dealing with the action of ionizing radiation in biological targets, biophysical modelling can be of great help to elucidate the mechanisms that lead from the initial radiation insult to an observable biological endpoint. Furthermore, models can provide predictions in those scenarios where the experimental data are scanty or absent.
Far from being exhaustive, this lecture will present and discuss examples of modelling approaches related to the induction of chromosome aberrations and cell death, which are strictly inter-related because some aberration types, such as dicentric chromosomes, have a high probability of leading to clonogenic cell death. Both endpoints are relevant for cancer therapy: although the death of tumour cells is the main objective, chromosome aberrations in normal cells can be regarded as indicators of normal tissue damage.
In discussing the various approaches, the attention will be focused on the different model assumptions and parameters, the comparisons with experimental data, and the possible implications in terms of biophysical mechanisms and/or applications for cancer therapy. In this framework, a two-parameter model developed in Pavia (called BIANCA, BIophysical ANalysis of Cell death and chromosome Aberrations [1,2]) will be presented, as well as its recent application to produce a radiobiological database that, following interface to a radiation transport code (e.g. FLUKA) or a TPS, can predict cell death and chromosome damage by hadrontherapy beams.
[1] Carante MP and Ballarini F. Calculating Variations in Biological Effectiveness for a 62 MeV Proton Beam.. Front. Oncol. 2016;6:76.
[2] Ballarini F and Carante MP. Chromosome aberrations and cell death by ionizing radiation: evolution of a biophysical model. Radiat. Phys. Chem. 2016;128C:18-25.
Acknowledgements: this work was partially supported by INFN (projects "ETHICS" and "MC-INFN")

Contribution ID: 1873

The use of Fourier metrics for quality control of x-ray imaging systems: MTF and the assessment of sharpness

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Routine assessment of imaging system sharpness has always been an important aspect of quality control (QC) protocols. This is especially relevant to mammography: the imaging of microcalcifications places strong constraints on system and detector sharpness. Prior to the transition to readily available DICOM image data, sharpness was assessed using line pair test objects. Now that digital image data are universally available, the presampling modulation transfer function (MTF) has quickly gained widespread acceptance as an objective measure of component or system sharpness, provided the appropriate image types are available. A similar situation exists in fluoroscopic imaging: the visualization of small (moving) vessels places constraints on parameters that influence system sharpness. X-ray image intensifiers (XRII) have been largely superseded by flat panel (FP) detectors these days. Line pair resolution testing of dynamic (fluoroscopy) systems should be replaced by Fourier methods, as image sharpness remains a crucial component of dynamic imaging system performance. Access to the necessary image data will be greatly facilitated with the implementation of the XR-27 NEMA standard.
In this talk we will define the presampling MTF and discuss techniques for the measurement of this parameter via edge and wire based methods. A distinction is made between the sharpness of the total system and that of the underlying subcomponents such as the x-ray detector or x-ray source size. MTF measurements are then used to explore the interplay of component sharpness within the imaging chains used for full field digital mammography (FFDM), digital breast tomosynthesis (DBT) and cardiac angiography imaging.

Contribution ID: 1874

Advances in functional Magnetic Resonance Imaging (fMRI)

Mário Forjaz Secca
Hospital Central de Maputo, Maputo, Mozambique

With the advances of MRI and its applications to functional imaging, a new field of research and clinical applications has arisen, designated fMRI (functional Magnetic Resonance Imaging). Because it harmless, mechanically non-invasive and it does not imply the injection of any contrasts into the body, fMRI has largely replaced PET studies for regular brain studies, being the imaging modality of choice in neurosciences. Also it has the advantage of MRI being a very complete and versatile imaging tool that can produce very high quality anatomical images as well as white matter fibre tracts with the technique known as Diffusion Tensor Tractography. All these combined produce a wealth of information on the brain which can be used both for neuroscience research and for clinical applications. More recently a new area has emerged with the production of EEG electrodes compatible with MRI, leading to the technique of simultaneous acquisition of EEG and fMRI, with great applications to Epilepsy in particular. fMRI is one of those areas where Medical Physics and Biomedical Engineering mix constantly to produce an exciting field of research with a lot of potential.

Contribution ID: 1875

Medical Device Safety

Alan Murray

Engineering and Medical Faculty, Newcastle University, Engineering and Medical Faculty, United Kingdom

Medical devices have made a huge contribution to medicine and surgery. They enable diagnostic and therapeutic procedures that were not possible or even envisaged a few decades ago to be undertaken safely. Patients can generally hope to live to an active old age.
However, with sadness we need to acknowledge that medical devices can and do cause harm. Thankfully, the percentage of procedures that result in patient harm or death is very small. Nevertheless there is much that can be done to improve this situation. Medical staff and bioengineers have collaborated successfully to innovate these new procedures and devices. It is important that they contribute to improving safety.
Medical devices can fail for many reasons. They include the following: devices can be too complicated to use, user are poorly trained, devices can unexpectedly transfer to an unwanted mode, they can fail long before their expected life is over, maintenance can be poor, wrong consumables can be used, and the inventing bioengineer may not have fully understood the clinical problem. There is much that can be done to improve this situation.

Contribution ID: 1876

Center for Advanced Preclinical Imaging - Invitation to Hands-On Workshop

Luděk Šefc, Pavla Francová, Věra Kolářová, Karla Palma
Center for Advanced Preclinical Imaging (CAPI), 1st Medical Faculty, Charles University, Prague, Czech Republic

Center for Advanced Preclinical Imaging (CAPI), First Faculty of Medicine, Charles University (Prague) – member of Czech-BioImaging (a national research infrastructure for biological and medical imaging), invites you to a Hands-On Workshop on preclinical in-vivo imaging of small laboratory animals.
CAPI is equipped with following preclinical imaging modalities:
Magnetic Particle Imaging (MPI) – MPI scanner (Bruker)
Optical Imaging (OI) – Xtreme In Vivo (Bruker)
Magnetic Resonance (MRI) – ICON (Bruker)
CT-PET/SPECT imaging – Albira (Bruker)
Ultrasound – Photoacoustic imaging (US – PA) – Vevo LAZR X (VisialSonics)
High resolution spectral X-ray scanner (Advacam)
The workshop will be focused on the following topics:
a) Animal-handling, anesthesia, contrast agent application, animal monitoring system
b) multimodal imaging
c) comparing X-radiography using different detection systems (CCD, flat panel and WidePix detectors)
The workshop will be held within CAPI in Prague, i.e. Salmovská 3, 120 00 Praha 2, Czech Republic, http://www.capi.lf1.cuni.cz on Monday 4. 6. 2018 from 14.00 to 18.00.

Contribution ID: 1877

NTCP models

Arjen van der Schaaf
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Radiotherapy plays a pivotal role in the treatment of cancer but it is also associated with a large spectrum of toxicities. Normal tissue complication probability (NTCP) models attempt to describe the dose-response relationship of these toxicities. Prospective data registration programs are increasingly used to collect large standardized data sets of good quality. Modelling techniques become more advanced by adopting methods from the field of (bio)statistics and machine learning, enabling data driven exploration of complicated dose response relationships and a large variety of other predictive factors, including emerging factors like genetics and image features. Also, biological experiments are narrowing down on the potential mechanisms, aiming to find anatomical targets. Still, NTCP models are dominantly phenomenological in nature and depend mostly on data rather than on confirmed theories. They should not be regarded as general abstractions of an absolute truth but as conjectures that originate from accumulated experience. They need to be developed with proper restrictions to guard against overfitting. Generalizability and causality of these models need to be tested in independent cohorts. Even then, many different plausible phenomenological models may exist that are all consistent with the available data. This educational course will include characteristic examples from recent developments in the Netherlands and in our department, illustrating processes from data collection to toxicity reduction.

Contribution ID: 1878

Implementing traceability in molecular radiotherapy

Ludovic Ferrer
Medical Physics, ICO René Gauducheau, SAINT HERBLAIN, France

Nuclear medicine has always had numerous weapons to treat cancerous disease thanks to radiopharmaceuticals that bind β particles to molecules of interest. Recently, this arsenal has been enriched by new radiopharmaceuticals such as radium-223 chloride or lutetium-177 labelled with peptides. In these procedures, treatment dosage are rarely administrated according to tumours or organ at risks absorbed doses as opposed to external radiotherapy procedures. Indeed, posology is more often dictated by a single activity administrated to all patients. In some cases, administrated activities are normalized to patient surface area or patient body weight which is not as optimal as a personalized injected activity derived from absorbed doses estimations.
This situation was justified by the difficulty to put exhibit correlation between absorbed doses and patient outcomes. However, this situation is evolving and recent literature show that correlations exist as long as dosimetry is implemented the proper way. One could argue hybrid SPECT/CT cameras availability helped a lot. Indeed, quantitative bias corrections are easier to implement in 3D imaging than in planar whole-body imaging.
Moreover, scientific community is pushing strongly towards standardization of acquisition/reconstruction procedures as well as data management in order to achieve dosimetry results reproducibility.
This is especially true in the context of multi-center trials needed for the development and validation of new radio-therapeutic approaches.
In addition, the calculation workflow related to absorbed doses calculations up to result reporting needs to be standardized.
This is especially true as dosimetric calculations result from several chained intensive computing operations and involve several meta-data related to patient radiopharmaceutical injection to name a few.
This talk aims at presenting various issues associated with the implementation of a traceability in the context of dosimetry procedures in molecular radiotherapy, with emphasis on some solutions implemented in various clinical trials for which the author performed dosimetric calculations.

Contribution ID: 1879

Track structure simulations with Geant4-DNA

Sebastien Incerti

IN2P3, CNRS, GRADIGNAN, France

The Geant4-DNA (http://geant4-dna.org) extension to the Geant4 (http://geant4.org) general purpose Monte Carlo toolkit aims to provide an open access platform capable of simulating ionising radiation induced early biological damage at the sub-cellular scale. This extension is entirely included in Geant4 and can be used to simulate step-by-step physical interactions of particles (electrons, protons, alpha particles including their charge states, and a few ions) down to very low energies in liquid water and select biological materials, thanks to a variety of physics models. In this lecture, we will present the functionalities of Geant4-DNA for the simulation of track structures. Example applications will be shown using our freely accessible Geant4 Virtual Machine.

Contribution ID: 1880

The use of Monte Carlo simulations to optimise new detector designs

Susanna Guatelli, David Bolst, James Vohradsky, Linh Tran, Jeremy Davis, Anatoly Rozenfeld
Centre For Medical Radiation Physics, University of Wollongong, Wollongong, Australia

Monte Carlo simulations, modelling particle interactions with matter, are a very useful tool to design and improve novel radiation detectors. Geant4 (www.geant4.org) is a free, open-source Monte Carlo Toolkit, with applications spanning from High Energy Physics to medical physics and space science. It is used at the Centre For Medical Radiation Physics (CMRP), University of Wollongong, to improve the design of new silicon detectors for radiotherapy Quality Assurance and radiation protection. Geant4 is also used to characterise the response of the novel detectors in radiation fields of interest, supporting the experimental characterisation of the devices.
The talk will be dedicated to the description of a Geant4-based study aimed to improve the design of Silicon-On-Insulator (SOI) microdosimeters for Quality Assurance in proton, carbon ion and Boron Neutron Capture therapies. Since the 90's, the CMRP is developing SOI microdosimeters as alternative to conventional tissue equivalent proportional counters (TEPCs), which have several limitations such as high voltage operation, large size of assembly which reduces spatial resolution and an inability to measure an array of cells.
In particular, Geant4 has been used to develop a methodology to convert microdosimetry measurements in silicon to tissue and to optimize the dimensions of the silicon sensitive volumes of the device. It has also been used to predict the detector response when irradiated in proton (e.g. MGH, Boston, US and IThemba Labs, Cape Town, South Africa) and carbon ion therapy (e.g. HIMAC, NIRS, Chiba, Japan) facilities. The use of Geant4 in microdosimetry has been validated with respect to experimental measurements.

Contribution ID: 1881

Dual energy CT – advantages and limitations

Mahadevappa Mahesh
Radiology, Johns Hopkins University School of Medicine, Baltimore, United States

Dual energy CT has been possible for some time now and has demonstrated considerable advantages in clinical diagnosis. DECT is achieved by ways that are unique to different CT platforms. DECT is considered as a first step towards achieving true "Spectral CT". DECT has the potential to improve lesion detection and characterization, reduce artifacts and possible quantification of CT images. Advanced applications such as kidney stone classifications, gout detection, automatic bone removal, virtual non-contrast enhanced images and many others are routinely used clinically. In spite of these advantages, DECT is still aiming to gain wider acceptance in clinics.

This presentation will discuss the various ways dual energy CT is possible among the various CT platforms, along with the uniqueness of each method. Will also discuss the advantages and limitations of DECT and explore reasons that are holding DECT from being widely used.

Contribution ID: 1884

Seven years from nuclear accidents at Fukushima ― low dose radiation effects and biomedical engineering

Nakahiro Yasuda
Research Institute of Nuclear Engineering, University of Fukui, Tsuruga, Japan

Short review of seven years countermeasures on the TEPCO-Fukushima Dai-ichi Nuclear Accident will be given based on experiences from viewpoints of a researcher in radiation field, a scientific secretary in the Japanese Cabinet and an emergency medical team member in disaster countermeasure headquarters at Fukushima.
Radiation monitoring was one of key issue to make decisions on sheltering and evacuation for public, on restrictions to enter the affected area, on food restrictions for public, decontamination of residential area, and to promote health care program for public. In this session, explanations on these countermeasures will be presented with problems from acute phase to recovery phase. It has not been succeed that explanations of knowledge on radiation effects on human body by scientists and explanations of radiation restrictions in various measures based on radiation measurements by the administration. In addition, the fear based on the lack of understanding of radiation and the memory of the atomic bombs has caused demands and countermeasures that seem excessive to the government.
Based on these matters, seven years have passed since the accident. Further tasks of returning residents, revitalizing communities and problems related to reactor decommissioning will be describe with possible roles for researchers. Thus, in this session, we look back on nuclear and radiation accidents in history and extract lessons for the next disaster. We will clarify issues to be solved in the future for researchers engaged in radiation biology and bio-engineering.

Contribution ID: 1892

Artificial intelligence and big data in future medical imaging – what could be expected?

Carlo Cavedon[1], Maria Grazia Giri[1], Alessio Pierelli[1], Stefania Montemezzi[2]
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[2]*Radiology Unit, University Hospital of Verona, Verona, Italy*

Artificial intelligence is seeing a renewed interest in medical imaging thanks to advanced algorithms and increased computational power. Applications include automated detection of abnormalities as well as highly specialized tasks, e.g. early prediction of treatment outcome or searching for apparently hidden correlations between the radiological phenotype of a tumor and its molecular subtype or genotypic classification. Machine learning methods used in the pioneering era of artificial intelligence are increasingly being replaced by more advanced approaches, especially deep learning algorithms.
On the other hand, the full potential of artificial intelligence can only be expressed when a vast amount of data are used. This is necessary either to train a machine-learning algorithm with a large training set of annotated data or to look for hidden correlations in data banks, typically obtained in a large multi-institution cooperation. Management of big data poses the challenging problem of data quality, an aspect that deserves major efforts in order to exploit the full capability of deep learning algorithms. Issues such as prospective standardization and data homogeneity are of

special importance in medical imaging. Depending on the imaging modality, these aspects may assume a complexity that can be regarded as the major limiting factor in medical imaging data mining. For example, modern magnetic resonance imaging offers an enormous portfolio of different morphological, functional and quantitative investigations, whose acquisition parameters may vary significantly from site to site. Data heterogeneity is among the major threats to the potential of data mining based on artificial intelligence methods, and requires huge organizational efforts to the researchers involved in the development of machine-learning methods in medical imaging.
In this talk, basic concepts of artificial intelligence and data mining as well as examples of diverse applications in medical imaging will be introduced.

Contribution ID: 1897

Breast dosimetry: Where are we and where are we going?

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The introduction of digital tomosynthesis for breast imaging has brought about many questions, regarding its optimal clinical application, dosimetry, artifacts, image quality, and quality control, among others. Given that breast tomosynthesis seems ideally suited for screening, its optimization for population-based screening implementation is an especially important topic of interest. The appropriate number of views to acquire, number of readings to perform, its use along real mammograms or synthetic mammograms, are all open questions that need to be addressed. However, the optimal combination of these parameters are most probably dependent on the manufacturer of the system in question. Furthermore, these issues will have a direct impact on the dose involved in screening tomosynthesis. We will review the current options for how tomosynthesis could be implemented for population-based screening, how this would impact clinical performance, reading time, and breast dosimetry.

Contribution ID: 1906

Measurement and calculation of x-ray and neutron doses outside the treatment volume

Stephen Kry
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Advances in radiotherapy have greatly improved our ability to deliver conformal tumor doses while minimizing the dose to adjacent organs at risk. However, there remains concern over stray radiation to normal tissues away from the treatment field as this radiation may induce second cancers, cardiac disease, and other late effects. This risk is becoming more relevant as patients live longer after treatment, providing an increased opportunity for late effects to manifest. In order to assess the potential risk to the patient, it is first necessary to know what radiation exposure the patient is subjected to. While the treatment planning system reports the dose in and near the treatment field, it does not provide reliable (if any) dosimetric information away from the field edge, and it does not provide any information on neutron doses. A serious challenge exists in that the assessment of stray x-ray and neutron doses can involve unique considerations. For example, when measuring the dose outside the treatment field, it is often important to consider the radiation energy spectrum, dose rate, and general shape of the dose distribution (particularly the percent depth dose), which are very different outside than inside the treatment field. Neutron dosimetry is also particularly challenging, and common errors in methodology can easily manifest as errors of

several orders of magnitude. Calculation of the non-target dose (whether by Monte Carlo or analytical solutions) similarly requires unique consideration.
This presentation will highlight the recommendations from the recently published AAPM Task Group 158 report on non-target doses to provide guidance and strategies for physicists to measure and calculate x-ray and neutron doses away from the treatment field. This presentation will do this in the context of risks to the patient and clinical considerations.

Contribution ID: 1913

Additive manufacturing in medicine

Radovan Hudak, Jozef Zivcak
Department of Biomedical Engineering and Measurement, Technical University of Kosice, Košice, Slovakia

Nowadays, additive manufacturing (AM) otherwise known as three-dimensional (3D) printing is fully implemented into the medical production. According to Research and Markets from September 2017, 3D Printing combining with medical imaging technology and software has potential to create $1.5B personalized surgery market by 2027.
Department of Biomedical Engineering and Measurement together with CEIT Biomedical Engineering company designed and produced more then 45 implants made of titanium alloy using additive technologies, which were subsequently implanted by Slovak and foreign surgeons. Presentation will cover description of medical additive manufacturing, including CAD/CAM design and production technologies, case studies of selected implants, verification and validation processes in medical AM, recent market regulations and future forecasts.

Contribution ID: 1917

Small field dosimetry in radiotherapy

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[2]*MedAustron, Wiener Neustadt, Austria*

Increased use of small photon fields in radiotherapy has raised the need for standardizing their dosimetry using procedures consistent with those for conventional radiotherapy. A Code of Practice for the dosimetry of small static photon fields was prepared by international working group, established by the IAEA with the AAPM and published by the IAEA as TRS-483. It consists of six chapters and two appendices. The first chapter provides an introduction and the second one a brief discussion of the physics of small photon fields with emphasis on those aspects that are relevant to understanding the concepts of the Code of Practice. These include the definition of field size, the field size dependent response of detectors, volume averaging, fluence perturbation corrections, reference conditions and beam quality in non-conventional reference fields. The third chapter introduces all details of the formalism used while the fourth chapter provides a comprehensive overview of suitable dosimeters for reference dosimetry in conventional and machine-specific reference fields and for the determination of field output factors in small fields. The fifth chapter gives practical recommendations for implementing reference dosimetry in both conventional and machine-specific reference fields and the sixth chapter provides the practical recommendations for the determination of field output factors in small photon fields. Detailed discussions on how the data for chapters five and six have been derived from the literature and how their uncertainties have been estimated are given in the Appendices one and two, respectively. For beams with flattening filter (WFF beams) these data are consistent with the ones given in IAEA TRS-398 and the update to AAPM TG-51. For FFF beams additional corrections are taken into account for the difference in water to air stopping power ratios between FFF and WFF beams and for volume averaging due to the non-uniform lateral beam profiles.

Contribution ID: 1921

Effects, risks and detriment of low radiation doses and their implications in medical diagnostics and treatment

Marie Davídková
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The shape of the dose-response relationship for radiation-induced health effects at low doses and low dose rates is a critical knowledge for establishing radiation protection system and risk assessment. The uncertainty in low-dose region comes from the lack of sufficiently large cohorts combined with the lack of understanding the underlying mechanisms. In present, five basic model options on low dose response tend to be considered following exposure of the whole body or of individual tissues: i) linear-no-threshold, ii) upwardly curving with no threshold, iii) linear or upwardly curving above a given threshold dose, iv) supra-linear (hypersensitivity), or (v) complex bi-modal relationship taking into account potential hormesis at low doses (Sources and Effects of Ionizing Radiation. Vol. II Effects. UNSCEAR 2000 Report to the General Assembly with Scientific Annexes, United Nations, New York; ICRP Publication 103. The 2007 Recommendations of the International Commission on Radiological Protection. Annals of the ICRP 37 (2-4), Elsevier Science Ltd, Oxford; Tubiana Int. J. Radiation Oncology Biol. Phys. 63(2), 317–319, 2005).
The lecture will overview recent findings about processes in cells, cell tissues and living organisms following low dose exposure to ionizing radiation. Current understanding of bystander effects, adaptive response, genomic instability and the role of immune system will be summarized. The implications of the current knowledge for medical diagnostics and treatment will be discussed.

Contribution ID: 1923

Introduction to equation-based modeling and simulation with Modelica and OpenModelica with focus on physiology modeling using Physiolibrary - Part 2

Jiří Kofránek[1], Filip Ježek[2], Jan Šilar[1]
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[2]*Department of Cybernetics, Czech Technical University, Faculty of Electrical Engineering, Prague, Czech Republic*

The development of models of human physiology was facilitated by a new generation of simulation environments using Modelica language. Fundamental innovation of Modelica language is the possibility to describe individual parts of the model as a system of equations directly describing the behavior of that part and not the algorithm of solving of these equations (see http://physiome.cz/modelica.pdf).
This tutorial gives an introduction to the Modelica language, the OpenModelica environment, and an overview of modeling and simulation in a number of application areas.
The tutorial will show acausal approach of modeling physiological system using Physiolibrary, an open-source library for biomedical modeling, which allows presenting complex models composed from different domains in comprehensible and maintainable form. Together with participants, models will be constructed of cardiovascular system, chemical reactions, body thermal transfer, osmotic phenomenon and integrative approach. Attendees should bring their own computers to participate in the hands-on sections of the tutorial.

Based on participants previous knowledge, tutorial may be extended to introduction of model-based dynamic optimization with OpenModelica including goal functions, constraints, convergence and other advanced features of OpenModelica. Bring your laptop for exercises.
First part of tutorial will introduce acausal and object oriented Modelica language using an open-source tool OpenModelica (www.openmodelica.org) and a commercial tool Dymola. Attendees can install the open-source OpenModelica tool in advance before the tutorial.
The second part of the tutorial will consist of hands-on sections that will demonstrate building selected models of 1) cardiovascular system dynamics – using hydraulic domain. 2) common biochemical reactions – using chemical domain. 3) body thermal transfers with blood flow using thermal domain 4) liquid volume of the penetrating solution in intracellular space, extracellular space, interstitial space, blood plasma or cerebrospinal fluid using osmotic domain 5) integrative approach which connects these domains together.

Contribution ID: 1938

Machine learning on routine medical imaging data

Johannes Hofmanninger, Georg Langs
Department of Biomedical Imaging and Image-guided Therapy, Medical University of Vienna, Vienna, Austria

Imaging data contributes a wealth of information to clinical treatment decisions in individual patients. In the daily routine, specific visual patterns for certain diseases, treatments and organs are detected and interpreted by highly skilled radiologists to determine the state of health of a patient. Modern machine learning techniques not only hold the potential to reduce subjectivity, increase efficiency and improve quality of this process through computer aided detection but also serve as means to discover novel markers, predict disease course or treatment response and discover hidden unknown phenotypes. Classical machine learning algorithms rely on large sets of well annotated and curated training data. In medical imaging such datasets are not only difficult to create but are limited, since annotation is only feasible on a relatively small number of cases and selection or study specific data acquisition can introduce bias and limits the range of observation represented in the data. In contrast, machine learning from routine data could enable the discovery of relationships and markers beyond those that can be feasibly annotated, incorporating the full real world variability by sampling a wide variety of cases. However, large heterogeneity in the data, noise and the absence of ground truth pose huge challenges when it comes to use real world data for machine learning.
In this educational session, basic concepts of machine learning with a focus on medical imaging, a variety of exemplary applications and different methods ranging from fully-supervised, weakly-supervised and unsupervised machine learning will be introduced. Examples of data mining in daily-routine images, the challenges and potential future applications will be discussed.

Contribution ID: 855
1. Diagnostic Imaging
01.22. Keynote lecture

KEYNOTE LECTURE: MRI in patients with implantable electronic devices: a teamwork approach

E Russell Ritenour
Radiology and Radiological Sciences, Medical University of South Carolina, Charleston, South Carolina, United States

In the US alone, there are approximately 650,000 new pacemaker (PM) and Implanted Cardio Defibrillator (ICD) procedures per year, with a projected growth rate of 15% per year. There is roughly a 50% chance of an indication for MRI in a PM/ICD patient over their lifetime.
MR Safe pacemakers came onto the market in 2011, but the patient population will continue to have MR “Unsafe” PMs and ICDs for many years. Remnants of the devices, such as abandoned pacemaker leads, will continue for some patients’ lifetimes and the number of patients needing MRIs will increase as the population ages. Despite the growing patient population, many hospitals still view the presence of PMs/ICDs as a contraindication for MR imaging, particularly of the thorax. Until recently, even some academic centers in the US have opted not to scan such patients or to limit their scanning to modalities other than MRI.
In this presentation, current literature and general recommendations of scientific and professional societies as well as regulatory bodies in the US and Europe will be reviewed. The Medical University of South Carolina (MUSC), an Academic Center for the Southeast of the United States has been scanning such patients for several years. This undertaking is an example of the use of a teamwork approach to hospital policy, an approach in which members of different disciplines and different departments work in concert to meet the medical and safety challenges of relatively new medical issues. Specific procedures, guidelines for pulse sequences, Specific Absorption Rate, electronic lead configuration, review of vendor information, and the steps for medical approval followed at MUSC will be presented.

Contribution ID: 861
1. Diagnostic Imaging
01.22. Keynote lecture

KEYNOTE LECTURE: Fast Field-Cycling MRI: a new diagnostic modality?

David Lurie, Lionel Broche, Gareth Davies, James Ross
School of Medicine, Medical Sciences & Nutrition, University of Aberdeen, Aberdeen, United Kingdom

Most contrast in conventional MRI arises from differences in T1 relaxation time. Studies on small tissue samples have shown that extra information could be obtained from T1-dispersion (plots of T1 versus magnetic field strength), but this information is invisible in conventional MRI since scanners operate at fixed magnetic field (e.g. 1.5 T). We are developing Fast Field-Cycling Magnetic Resonance Imaging (FFC-MRI) to exploit T1-dispersion as a new biomarker, with the aim of increasing diagnostic potential.
FFC measures T1-dispersion by switching the magnetic field rapidly between levels during the pulse sequence, with relaxation occurring at the “evolution” field (usually a low value) and always returning to the same “detection” magnetic field (a higher value) for NMR signal measurement. FFC-MRI obtains spatially-resolved T1-dispersion data, by collecting images at a range of evolution magnetic fields.
We have built two whole-body human sized scanners, operating at detection fields of 0.06 T [3] and 0.2 T. The 0.06 T device uses a double magnet, with field-cycling being accomplished by switching on and off a resistive magnet inside the bore of a permanent magnet; this has the benefit of inherently high field stability during the detection period. The 0.2 T FFC-MRI system uses a single resistive magnet which has the advantage of increased flexibility in pulse sequence programming, at the expense of lower field stability during the detection period, necessitating more complex instrumentation.
We are investigating a range of applications of FFC relaxometry and FFC-MRI. Our work has demonstrated that FFC relaxometry can detect the formation of cross-linked fibrin protein from fibrinogen in vitro, through the measurement of 14N-1H cross-relaxation phenomena, known as “quadrupolar dips”. We have also shown that FFC-MRI can detect changes in human cartilage

induced by osteoarthritis. Recent work has focused on speeding up FFC-MRI by incorporating rapid MRI scanning methods.

Contribution ID: 25
1. Diagnostic Imaging
01.01. Computed tomography

Topogram-Based Tube Current Modulation of Head Computed Tomography for Optimizing Image Quality while Protecting the Eye Lens with Shielding

Yuan-Hao Lee
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Objective. This study investigates the effects of CT (computed tomography) eye shielding and topogram-based tube current modulation (TCM) on radiation dose to the eye lens and the maintenance of the image quality of head CT examinations.
Materials and Methods. Patients who underwent health examinations were recruited in compliance with the protocol approved by the Ethics Committee of the Joint Institutional Review Board at Taipei Medical University. Participants' brains were scanned with a water-based marker simultaneously by a multislice CT scanner (SOMATON Definition Flash) under a fixed tube current-time setting or topogram-based TCM. The lens dose was measured with Gafchromic films, whose dose response curve was previously fitted using thermoluminescent dosimeters, in the presence or absence of barium sulfate or bismuth-antimony shield laid above. For the assessment of image quality, two radiologic technologists independently reviewed CT images and applied four sets of three-point Likert scales to evaluate image artifacts as well as the visibility of the optical nerves, eye lenses, eyeball margins and eye-surrounding tissues.
Results. The application of barium sulfate and bismuth-antimony shields decreased 24% and 44% of the lens dose on average at the fixed tube current-time setting, respectively. Nevertheless, both the shields degraded image quality at the fixed tube current-time setting. Under topogram-based TCM, the dose saving potentials of barium sulfate and bismuth-antimony shields were maintained. The discriminative capability of eyeball margins was significantly improved by the application of topogram-based TCM upon the use of barium sulfate shield. In addition, topogram-based TCM significantly optimized the image quality of eye-surrounding tissues when bismuth-antimony shield was applied.
Discussion. Eye shielding affected the ability of CT to image soft tissues that are close to the shield. The results of this study indicate that the balance between eye exposure and CT image quality can be optimized by implementing topogram-based TCM.

Contribution ID: 220
1. Diagnostic Imaging
01.01. Computed tomography

An accurate multi-material decomposition method in dual-energy CT

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Objective: Dual-energy CT (DECT) has the material differentiation capability by utilizing the material characteristic that the material liner attenuation coefficient (LAC) varies with respect to different x-ray energy spectra. In DECT clinical application, multi-material decomposition (MMD) plays an important role to distinguish the complicated components within human body.

Nevertheless, the decomposed image quality of MMD using DECT suffers from low accuracy and magnified noise due to the complication and variation of the material composition in the CT image. We propose an accurate MMD method in image domain to combat for the issues.
Methods: We collect sets of pixels, i.e., pixel blocks, in the CT image according to the intensity similarity within each block. According to the piecewise constant property and energy-dependent property of CT image, we assume that the blocks with high intensity similarity belong to the same or similar material. The block-matching technique is applied to group the blocks. The main material component and composition of each block are pre-selected by comparing the distance between the basis materials and the center of mass (COM) of the coordinates of the grouped pixels in the energy map. MMD is processed by looping over the pre-selected material composition with the mass and volume conservation and the assumption that each pixel contains at most three materials. The MMD result with maximum volume fraction of the main component material is selected as the optimal solution. The method is evaluated on the customized water phantom and head patient.
Results: The decomposition accuracy of water phantom and head patient are increased by 65.2% and 20.8% as compared with the direct inversion method, respectively. The decomposed image noise is decreased by 80.6% and 43.1%, respectively.
Conclusion: The proposed method achieves accurate multi-material decomposition and noise suppression. The high-quality material images substantially facilitate DECT-based clinical applications.

Contribution ID: 290
1. Diagnostic Imaging
01.01. Computed tomography

Optimization of energy in determination of urinary stone composition using micro CT

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Urinary stones are crystals of dissolved minerals found in the urinary system. The treatment applied to remove urinary stone depends on the composition, size and the location of the stone. The purpose of this study was to assess the optimum energy in a determination of urinary composition using micro CT. Five urinary stones from patients who had undergone surgical procedures had been scanned in vitro method using micro CT Skyscan 1173. The stones were placed in a transparent box and were scanned at the parameters of 45 until 115 kV with interval 10 kV, step rotation of 0.20, the aluminum filter of 1 millimeter, and resolution of 13.89 micrometers. The projections as many as 1200 projections were reconstructed using NReconServer V1.7.0.4 software. The Parameters of reconstruction were 8 % of beam hardening, ring artifact correction of 15, and 1 in smoothing. After reconstruction, each 8-bit .bmp image was quantified in CT Analyser 1.16.4.1. Two Regions of interest (ROI) that were two circles with a diameter 78 pixels were drawn on the image. The grey value of five stones that have minimum standard deviation was compared. As the results, the source of voltage was 115 kV that made the minimum standard deviation of urinary stones. The grey values of five urinary stones were 76, 32, 72, 82, and 32 respectively. However, the high energy (115 kV) could not differentiate the stone number 1 and 4. They were could be differentiated using low energy (65 kV). The grey values of five urinary stones were 126, 37, 116, 132, and 35 respectively at low energy. The conclusion of this study was that there are two optimum energies for scanning. The two optimum energies to determine of urinary stones using micro CT were 65 and 115 kV.
Keywords: optimum energy, urinary stone, micro CT

Contribution ID: 311
1. Diagnostic Imaging
01.01. Computed tomography

Discrete-time image-reconstruction system with total variation regularization for computed tomography

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Computed tomography (CT) scanners are widely utilized for screening the human body. A filtered back-projection (FBP) procedure and iterative reconstruction (IR) techniques are methods to reconstruct CT images from projection data on X-ray sensors. The FBP method is generally used in clinical CT scanners because its reconstruction speed is quicker than that of IR methods. In contrast, IR methods, which are described by difference equations and are often referred to as discrete-time image reconstruction (DIR) systems, can produce high-quality images with fewer artifacts even for a small number of projection data.
When objects with high X-ray absorption-coefficients like metal are in the imaging area, both the FBP and IR methods produce low-quality images with a lots of radial artifacts around image regions corresponding to the objects. Such images are unacceptable in clinical diagnosis. Ozeki et al. have proposed a method that can suppress radial artifacts generated from a metallic object by complementing projection data corresponding to the object. However, it needs to identify the correct position of the object in a tomographic image and its identification requires long time.
The total variation of an image with such radial artifacts takes a higher value than the image that such artifacts are removed. To reconstruct acceptable-quality images without complementing projection data, I proposed a new DIR system in order to optimize an objective function with a regularization term on the discrete total variation of an image. The proposed system is based on gradients of the objective function and can quick compute gradients of the total variation using two convolutional operators for vertical and horizontal pixels. My numerical experiments demonstrated that the proposed system could reconstruct acceptable-quality images without complementing projection data generated from a phantom image including a blob with high X-ray absorption-coefficients.
This work was supported by JSPS KAKENHI #JP17H01816.

Contribution ID: 425
1. Diagnostic Imaging
01.01. Computed tomography

Local affine transformation method for tomosynthesis

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In this report, a new method for image reconstruction for tomosynthesis is proposed. This technique consists in using local affine transformations and preliminary geometric calibration. The suggested approach makes it possible not to consider the geometry of the instrument and possible inaccuracies in determining the parameters of the investigation. As a result, this method allows to achieve a higher tomographic resolution. A comparison was made with the methods that are currently used in tomosynthesis. Experiments based on the results of real mammography researches were conducted.

Contribution ID: 648
1. Diagnostic Imaging
01.01. Computed tomography

Estimated organ dose variability due to QA protocol

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The advancement of imaging technology and the increased use of computed tomography (CT), has increased the potential risks associated with the ionizing radiation. The most practical way to prospectively determine the radiation potential dose absorbed by the organs and tissues of the body utilizes QA phantom or mathematical methods.
In order to evaluate the dose of a patient we perform QA dose measurement using ionization chambersor small size devices such as TLDs. Another way to assess organ doses is a mathematical methods of dose production software eg (Org Dose, CT-EXPO, imPACT)
Organ and tissue radiation dose prior to a CT scan is currently estimated in Irelands health service using the imPACT software and relies on CTDI measurements. These estimates are based on CT system specific Monte Carlo simulations and organ equivalent dose calculation. The Monte Carlo database is providing by NRPB (1). We have taken the AAPM (2) dose equilibrium (Deq) method and CTDI method and compared the estimated organ dose values, which we verify using TLD Randoman measurements (table in bottom).
The results of both methods including direct and indirect measurements for each CT scanning protocol (head, chest and pelvic) were found to have significant variability in estimated organ dose.

Organ- dose estimation by using CTDI (mGy) - dose estimation by using new method (Deq)(mGy)
Bone marrow- 2.8- 3.7
Lung- 11 - 14
Stomach - 1- 1.3
Breast- 11- 14
Liver- 1.7- 2.2
Oesophagus (Thymus)- 12- 15
Thyroid- 3.1- 4
Skin - 3- 3.9
Bone Surface- 6.5- 8.4
Brain- 0.092- 0.12
Salivary Glands (Brain)- 0.092- 0.12
Kidney- 0.37- 0.48
Pancreas- 1.4- 1.7
Spleen- 1.2- 1.5
Thymus - 12- 15
Muscle- 2.3- 3
Gall Bladder- 0.48- 0.62
Heart- 9.2- 12
ET region (Thyroid)- 3.1- 4
Lymph nodes (Muscle)- 2.3- 3

Contribution ID: 662
1. Diagnostic Imaging
01.01. Computed tomography

How Automatic Exposure Control systems may misinterpret CT localiser information leading to increased CTDIvol

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The Automatic Exposure Control (AEC) system of a CT scanner aims to optimise patient radiation dose and image quality. This is achieved by determining patient size and attenuation, and modulating tube current. The scanner output is therefore specific to the patient and/or body region being scanned, allowing for appropriate image quality to be achieved. In order to estimate patient size and attenuation, a 2-d x-ray localiser is firstly acquired. The size of the patient, automatically determined from the localiser, is dependent on the position of the patient during the scan. Incorrect positioning, either too close to or far from the x-ray tube, can lead to the patient becoming magnified (or diminished), which in turn leads to an incorrect mA being used. This miscentring of the patient ultimately leads to a CTDIvol that is not optimal. An approximately linear relationship between CTDIvol and the offset between the patient centre and the isocentre would be expected.
The change in CTDIvol with table height was investigated as part of the testing of a newly commissioned PET/CT Siemens Biograph 16 Horizon. By changing the table height and obtaining PosteroAnterior (PA), AnteroPosterior (AP) and lateral localisers, along with corresponding CT scans for anthropomorphic and uniform phantoms, it was possible to simulate patient miscentring under various conditions.
A linear relationship was found for AP localisers; however, this was not the case for the PA topogram. Upon investigation, it appeared for a subset of bed heights, that the table itself was misinterpreted as the patient, leading to an increased width and attenuation, and therefore an increased CTDIvol in some cases. This work thus highlights the importance of fully testing CT AEC systems to fully understand their operation and limitations.

Contribution ID: 675
1. Diagnostic Imaging
01.01. Computed tomography

On the CT dose index: are we meeting the challenge?

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The standardized dose descriptor introduced at the beginning of the 80s, the computed tomography dose index (CTDI), has long been recognized as a metric to quantify the radiation output from a CT examination that is easily and reproducibly measured, and that captures the majority of the scatter tails for even wide x-ray beam widths. International standards now require manufacturers to display the pitch-normalized metric (CTDIvol) prior to scan initiation and the radiology community has become very familiar to typical values of this metric. However, it has been suggested that modern developments in CT technology permit patient dose to be determined in a more adequate way that allows representing the risks to patients, and that is now time to forgo the use of the CTDI (or variants) for CT dose optimisation. In this work, we explore the main problems concerning the use of the CTDIvol as a relevant dose index trough a retrospective study of 25 of the most common CT examinations at a South American imaging centre including adult and paediatric patients using a total of three CT scanners. Applicable results were compared with diagnostic reference levels (DRLs) from European and North American countries. We also analyse CTDIvol measurements for CT quality assurance with a standard 100mm-long ionisation chamber

with a CTDI phantom made of polymethylmethacrylate. Our research shows that although CT technology is changing at a quick pace, CTDIvol keeps being a practical and valuable method for the task of dose optimisation because is well established and uniformly adopted.

Contribution ID: 784
1. Diagnostic Imaging
01.01. Computed tomography

Enhancing μCT 3D imagery by independent component analysis of projection images

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In this work, we investigate the usage of independent component analysis (ICA) in processing μCT projection images to improve the quality of the final reconstructed 3D images. For this, each projection image is imaged from two to six times with different x-ray energies and exposure times. This is to produce projection images with different contrasts. ICA is then performed on each projection image set, resulting in a set of independent component images (ICIs) for each projection direction. It is then identified, which ICIs carry object information, and the 3D image is reconstructed using only those ICIs from all projections. Thus, the noise and artifacts contained in the other ICIs are eliminated from the reconstructed 3D image. Our rationale is that noise and artifacts should be removed as early as possible in an image processing chain, and that by ICA, it is theoretically possible to completely remove the noise and artifacts that are independent of the object imaging data, given that the original projection image data fulfilled the basic assumptions of ICA. In addition to noise and artifact removal, we investigate the possibilities of using ICA of projection image sets in image segmentation. We demonstrate the method with different ICI-based 3D reconstructions of a phantom and a biomedical sample imaged by an Xradia MicroXCT-400 device.
The work of J. M. A. Tanskanen has been supported by Jane and Aatos Erkko Foundation, Finland, under the project Biological Neuronal Communications and Computing with ICT.

Contribution ID: 888
1. Diagnostic Imaging
01.01. Computed tomography

Assessment of cancer incidence and mortality risks associated with effective dose of computed tomography examinations

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Advances in diagnostic medical imaging in the past few decades using procedures such as computed tomography (CT), have significantly enhanced health care delivery. The effective doses and associated cancer incidence and mortality risks were estimated for adult patients undergoing the five most common types of CT examinations, namely, head, neck, chest, abdomen and pelvis, at Sweden Ghana Medical Centre (SGMC) in Accra, Ghana. The two methods employed in the study were patients' data collection and phantom measurements to verify the patien-ts' data. The effective doses were estimated using the dose length product (DLP) from the control console of the CT machine and the anatomic region specific conversion factors. The lifetime attributable risks of cancer inciden-ce and cancer mortality for each patient for a particular examination were both

determined from the effective dose, age and sex of each patient using the standard Biological Effects of Ionizing Radiation (BEIR) VII criteria. The effective doses were all within the range of 1 - 10 mSv recommended for CT examinations. The average risk for all the examinations was observed to be very low, i.e. 1 in 10001 to 1 in 10 000. The average lifetime attributable risk (LAR) of cancer incidence was 0.049 % (1 in 2041), while for risk of cancer mortality, the average was 0.030 % (1 in 3333)

Contribution ID: 1015

1. Diagnostic Imaging

01.01. Computed tomography

Effects of different imaging parameters on the ct number of coronary plaques in coronary computed tomography angiography: a phantom study

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Purpose: Coronary computed tomography angiography (CCTA) has been increasing used for the characterization of the coronary plaque. This study aimed to investigate the effects of different scanning parameters and reconstruction algorithms on the CT number for both calcified and non-calcified plaques in CCTA.

Materials and Methods: Nine phantoms with different material densities mimicking the calcified and non-calcified plaques were constructed. The phantoms were imaged using a dual-energy multislice CT scanner (Somatom Definition AS, Siemens, Germany) with different scanning modes (single-energy CT (SECT) versus dual-energy CT (DECT)), tube voltages and reconstruction methods. The CT numbers of the phantoms were measured and compared statistically using ANOVA and paired-sample t-test.

Results: Statistically significant differences ($p<0.05$) were found on the CT numbers between SECT and DECT for both calcified and non-calcified plaques, and between 80 and 140 kVp for calcified plaques. For non-calcified plaques, no significant difference ($p>0.05$) was found between different reconstruction kernels, except when compared to the sharp kernel (B 46f). For calcified plaques, significant differences ($p<0.05$) were found in CT numbers between very soft (B10f) and sharp (B46f) kernels, as well as between soft (B20f) and sharp (B46f) kernels. Lastly, ¬¬no statistically significant difference ($p>0.05$) was found between the CT numbers of difference reconstructed slice thicknesses/increments for both calcified and non-calcified plaques.

Conclusion: The CT numbers of both calcified and non-calcified plaques differed significantly when scanned using DECT and SECT techniques. The CT numbers of calcified plaques differed significantly when scanned using 80 and 140 kVp. For reconstruction kernels, significantly higher CT number was observed in data sets reconstructed using softer kernel. Hence, these parameters should be taken into account when CT numbers are considered in the diagnosis of coronary calcification.

Contribution ID: 1103

1. Diagnostic Imaging

01.01. Computed tomography

Radiation dose and lifetime attributable risk (LAR) of cancer incidence in prospectively ECG-triggered coronary computed tomography angiography (CCTA)

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Purpose: This study aimed to measure the absorbed doses in organs for prospectively ECG-triggered coronary computed tomography angiography (CCTA) using five different state-of-the-art CT scanners in a female adult anthropomorphic phantom and to estimate the effective dose (HE) and the lifetime attributable risk (LAR) of breast and lung cancer incidence.
Materials and Methods: Prospectively ECG-triggered CCTA was performed using five commercially available CT scanners: 64-detector-row single source CT (SSCT) (GE and Philips systems), 2 × 32-detector-row dual source CT (DSCT), 2 × 64-detector-row DSCT and 320-detector-row SSCT scanners. Absorbed doses were measured in 34 organs using optically stimulated luminescence dosimeters (OSLDs) loaded in a standard female adult anthropomorphic phantom. HE was computed using phantom measurement data. LAR for cancers of breast, lung and others were estimated and compared.
Results: Both breasts and lungs had the highest radiosensitivity and received the highest radiation dose during CCTA examination. The highest HE was received from 2 × 32-detector-row DSCT scanner (6.06 ± 0.72 mSv), followed by 64-detector-row SSCT (5.60 ± 0.68 and 5.02 ± 0.73 mSv), 2 × 64-detector-row DSCT (1.88 ± 0.25 mSv) and 320-detector-row SSCT (1.34 ± 0.48 mSv) scanners. The LAR for breast cancer is higher than lung cancer (2 to 66 cases per 100000 persons vs. 8 to 47 cases per 100000 persons) in young women who are less than 30-year-old while LAR for lung cancer is higher than breast cancer after 30-year-old.
Conclusion: The radiation doses and LAR for cancer incidence from a prospectively ECG-triggered CCTA are relatively small and depend on the scanner models and imaging protocols. LAR for breast cancer increases exponentially for younger women hence the judicious use of CCTA examination needs to be considered for this population.

Contribution ID: 1177
1. Diagnostic Imaging
01.01. Computed tomography

Computed tomography organ dose determination using ImPACT simulation software: our findings in south-west Nigeria.

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Background: The use of multi-slice Computed Tomography (CT) machine has increased in South-West Nigeria due to high request by physician to properly manage their patients. The need to determine organ CT dose has become necessary.
Aim and Objective: The aim is to calculate dose for each organ using the ImPACT dose simulation software, and to determine if dose vary significantly with each organ among the 7 CT units and to compare our findings with international studies with similar software and other methods.
Materials and Methods: Seven CT units denoted as A-G was used for this study. The CT vendors were General Electric (GE), and Toshiba. An ImPACT Patient Dosimetry Calculator Software was used to determine organ dose to the head, chest, abdomen and pelvic region. Data analysis was done using SPSS 16.0 (SPSS Inc, Chicago, IL, USA).

Results: The mean dose for organs to the head (brain and eye lens) was 27.87±9.58 and 55.27±22.34mGy; chest (lungs, breast, thyroid and heart) was 30.63±8.21, 26.41±6.76, 10.21±7.00 and 29.93±9.65mGy; Abdomen (stomach and liver) was 34±12.8 and 33.05±9.93mGy and Pelvis (bladder and uterus) was 32.44±13.8 and 28.97±7.14mGy respectively. There was significant difference in organ dose for brain (P = 0.000), eye lens (P = 0.001), lungs (P = 0.000), breast (P = 0.000), thyroid (P = 0.008), heart (P = 0.000), stomach (P = 0.000), liver (P = 0.001), bladder (P = 0.000) and uterus (P = 0.002) among the 7 CT units. There was no significant difference in organ dose for this study and those of Tanzania, Turkey and United Kingdom but significant difference was seen in that of Thailand.

Contribution ID: 1186

1. Diagnostic Imaging

01.01. Computed tomography

X-ray computed tomography spectral imaging of iron concentrations approaching physiological levels in human tissue

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Alzheimer’s disease (AD) has been long-associated with evidence for regional brain iron accumulation, and there is an ongoing debate over its role in disease pathogenesis. Altered cortical brain iron deposition has been proposed as a candidate marker to assist with clinical diagnosis of AD; robust techniques for early and differential diagnosis of AD are lacking. X-ray Computed Tomography (CT) is one of the fastest and most affordable modalities to image the human brain, and there is increasing interest in the use of Dual Energy CT (DECT) to quantify the concentration of different chemical elements from the spectral data acquired.
In this study, a series of experiments were performed to test whether DECT has the sensitivity to discriminate physiological concentrations of brain iron. Samples of various concentrations of iron were scanned on a GE Discovery 750HD scanner (GEMS, Milwaukee, USA). Energy-specific attenuation data were plotted and analysed, from which the concentration of iron can be deduced.
Iron concentrations were verified using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Clinical field strength 3 Tesla (3T) MRI, and 9.4T MR Microscopy using a Bruker micro-imaging MicWB40 probe, were also performed so that the field-dependent influence of iron on transverse relaxation (R2) could be tested, and to enable corroboration of DECT results in the clinical setting through use of a 3T MRI scanner.
This initial study confirms scope to use DECT to measure iron concentrations at pathophysiological levels and approaching physiological levels. The approach has scope for application in detection and monitoring of certain neurodegenerative disorders. By extending the study to evaluate human brain tissue, this will determine if DECT has clinical utility to identify and quantify elevated regional iron levels in the human brain more quickly and affordably than with equivalent MRI techniques.

Contribution ID: 1302

1. Diagnostic Imaging

01.01. Computed tomography

Radiation dose measurements in Coronary CT Angiography: Literature Review

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CT coronary angiography (CTA) is increasingly utilized for the noninvasive assessment of coronary artery disease (CAD) due its ability to exclude or diagnose CAD with high accuracy and fast acquisition time diagnosis in symptomatic and asymptomatic patients. CT delivers high radiation doses to organs that are in the direct path of radiation beam. Thus, there is a potential risk of inducing cellular damage or radiation-induced cancer due to exponentially increased use of this technique in medicine. Exposure of the heart to high doses of ionizing radiation is associated with cardiac lesions, but there are no conclusive studies regarding ionization radiation at low doses and the risks involved for CTA. The purpose of this study is to review the literature describing the effect of radiation dose on the circulatory system, with emphasis on the heart during the CTA procedures. The results demonstrated the effective dose in recent bibliographies range between 4.3 and 11.6 mSv, and the patients were exposed to considerable radiation doses (radiosensitive organs, such as lens of the eye, breast, thyroid or heart). Estimation of patient radiation risk helps to improve staff knowledge/consciousness of radiation exposure. Radiosensitive organs receive a significant radiation dose during CTA procedures, therefore rigorous reassessment of justification criteria and optimization measures of the procedure are needed. The main factor observed was the different methodologies of dose estimates found in literature. A national survey is highly recommended to establish a diagnostic reference level for CTA. A CTA procedure is operator-dependent. Therefore, continuous training in CTA use and safety is crucial.

Contribution ID: 1331
1. Diagnostic Imaging
01.01. Computed tomography

Dynamic myocardial perfusion measurement using low-dose computed tomography

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Introduction: Coronary artery disease is the leading cause of death and morbidity worldwide. There are currently no non-invasive test available that can determine the complex interactions of focal stenosis, diffuse epicardial atherosclerotic coronary narrowing, and microvascular dysfunction. Despite the proven clinical value of quantifying myocardial blood flow (in mL/min/g) for distinguishing different presentations of coronary artery diseases, there are no widespread clinical methods to measure myocardial blood flow. A low-dose computed tomography (CT) technique using a first-pass analysis (FPA) was developed that can be used to accurately measure blood flow.
Methods: A retrospective FPA technique using only two volume scans for accurate dynamic myocardial perfusion measurement has previously been validated in a swine animal model. In the current study, a prospective FPA technique was evaluated. Different severity stenoses were generated in the left anterior descending (LAD) coronary artery of anesthetized, closed-chest swine using angioplasty balloon catheters to produce partial occlusion. Contrast-enhanced volume scans were acquired using a 320-slice CT scanner at 100 kVp. After segmentation of the myocardium and extraction of the coronary arterial trees, perfusion measurements were made with the FPA technique using only two volume scans. The blood flow measurements from prospective FPA technique were compared with the validated retrospective measurements.

Results: The results of the prospective perfusion (PPro) measurements in mL/min/g was in good agreement with the retrospective (PRet) results (PPro = 0.90 PRet + 0.22, R2 = 0.91). The radiation dose for the dynamic perfusion measurement was reduced to be as low as 0.5 mSv.
Conclusions: The results indicate that accurate myocardial blood flow measurement can be made using a first-pass analysis technique in conjunction with a whole organ CT scanner. This low-dose technique can be used for physiological assessment of coronary artery disease.

Contribution ID: 1353
1. Diagnostic Imaging
01.01. Computed tomography

Reducing radiation dose in adult plain head CT using a low-dose protocol implemented on a dual slice computed tomography scanner

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Background: The widespread use of Computed tomography (CT) accounts for more than half of all radiation exposure in diagnostic radiology and contributes largely to the increasing cumulative dose to the population. In our institution, adult head CT examination accounts for at least fifty percent of all CT examinations, thus CT dose reduction strategies are important in optimizing patient exposure.
Methods: In this study we compared the weighted volume CT Dose index (CTDIvol) and Dose Length Product (DLP) for 108 adult patients (age> 18) who underwent routine non-contrast adult head CT examination. Only images who were deemed diagnostically acceptable and where diagnostic information can be derived were included in this study.
Results: The mean CTDIvol for the standard and low dose protocol is 21.94 mGy and 14.05 mGy respectively. This translates to about 36% dose reduction in the CTDIvol values. For the dose length product, the mean DLP for the standard protocol is 327.28 mGy-cm and 215.44 mGy-cm for the low-dose protocol. This is equivalent to a 34% dose reduction in the DLP values. All differences were all statistically significant (p<0.0001).
Conclusion: Implementation of a simple dose reduction strategy using a low-dose protocol achieved significant dose reductions in routine adult plain head CT examination in a dual slice computed tomography scanner.
Keywords: Diagnostic Imaging, Computed Tomography, Dose optimization, Low-Dose Protocol

Contribution ID: 1460
1. Diagnostic Imaging
01.01. Computed tomography

High vs low concentration of K2HPO4 liquid phantom in ultralow-dose QCT for the assessment of bone mineral density

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Introduction:Nowadays, more than DXA as a gold standard for bone densitometry, Quantitative Computed Tomography (QCT) measures bone mineral density (BMD) using a Computed Tomography (CT) scanner with a calibration standard phantom. Some metabolic disease affect cortical part of the skeleton and consequently, increase the fracture risk. Therefore, the purpose of this study was to: 1) demonstrate, the accuracy of using different ranges of K2HPO4 concentrations for cortical volumetric BMD (vBMD) via ash gravimetry and 2) the precision of these liquid phantoms in hybrid iterative reconstruction-based computed tomography.
Materials and methods:Hydrogen dipotassium phosphate (K2HPO4), in three concentration ranges of K2HPO4 with two exposure settings in iDose (level 7); limited mAs to 36 mAs and auto mAs ,up to 227 mAs. Twelve similarly sized cubes of bovine cortical bone were used. The correlation between measured equivalent QCT density and HU and also with ash as a gold standard were evaluated using linear regression analysis.
Results:The equivalent density of bovine cortical specimens decalcified based on three different concentration ranges with two exposure settings are highly correlated with samples ash densities as a gold standard (R2 ≥ 0.89). Moreover, relative changes of concentration for 6 months period is 20% for 50 mg/cm3 and about 0.5% for high concentration.
Discussion: The cortical range calibration density are applicable for cortical bone density quantification in ultra-low dose computed tomography. Since iterative-reconstruction base computed tomography remove noise across all frequencies.
Conclusion: These assessments, coupled with evaluation of different K2HPO4 concentration make the cortical bone quantification accurate with regards of ALARA (as low as reasonably achievable) principle.
Keywords: Ultra- Low Dose, Quantitative Computed Tomography, Cortical Bone, Tibia, Hybrid Iterative Reconstruction

Contribution ID: 1648

1. Diagnostic Imaging
01.01. Computed tomography

Performance of the Toshiba Aquilion 16 MSCT Scanner: Results from a 4 year period

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Our purpose is to present the results of a 4 years period quality control routine test performed on a Toshiba Aquilion MSCT scanner, to assure compliance of the monitored parameters with baseline values and detect system performance malfunctioning. The weekly test, is a 15 minute check acquisition of the CATPHAN 600 phantom sections. Baseline values were established using the average of 10 images in sequential mode 120 kV, 200 mAs, collimation 1x6mm, FOV=240mm, CTDIw=45.9mGy, kernel FC70 and surface dose SD=25mGy. Performance indicators: Noise (the standard deviation of the HU measured in a central ROI of 28cm2 (40% - phantom useful radius); Homogeneity (maximum difference on the average HU measured in 4 periphery ROI's relative to a central ROI each with 10cm2; Spatial Resolution (zoomed visualization of the last visible group of a pattern of lp/mm using constant WW, WL); Low Contrast Resolution (diameter * %contrast (mm*%) for each target - 3 groups of different sized low contrast targets 10HU, 5HU, 3HU - 2 images averaged) and HU linearity (linear regression coefficient r2>0.98 of straight line plot of HU versus linear attenuation coefficient). Results: Noise: σ=5.36±2%; maximum deviation: 8.6%; outliers (>10%): two (12.3;16.0%). Homogeneity: HU=9.53±4%(T); maximum difference deviation: 14.7%;

outliers (>15%): six (16.7;15.7%). Spatial Resolution: 9 lp/cm. Low contrast: < 2.1mm*%. HU linearity: r2>0.995 All parameters within European Guidelines tolerances despite the 4 x-ray tube changes. The customized test proved to be a simplified but incomplete method for system performance consistency evaluation since it was inefficient in the detection of ring artifacts caused by faults in detector system calibration for the head protocol. The addition of a spiral acquisition in the uniform section, lead to direct visualization and awareness of this type of artifacts but still do not prevent the detection of artifacts in larger FOVs or in special collimation sets.

Contribution ID: 1667
1. Diagnostic Imaging
01.01. Computed tomography

Patient size and tissue location dependent corrections on Hounsfield numbers in clinical X-ray CT imaging

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Background: X-ray CT numbers are in Hounsfield Units (HU) and represent body tissues' attenuations. Hounsfield numbers are calculated using water's attenuation coefficient as their reference. Accurate calculations of CT numbers are critical for clinical diagnosis as a small difference in HU may differentiate cancer from normal tissues. In practice, various artefacts such as beam hardening need to be corrected and CT systems calibrated before CT numbers are presented. Despite all these efforts, the CT numbers still vary depending on locations within the body and patient body sizes. These variations of CT numbers need to be corrected in order to achieve a true quantitative CT.
Purposes: The purposes of this work are to establish a scheme and system for correcting location and body size effects on CT numbers and present correction results for various CT systems.
Methods: The attenuation coefficient of water was found to be dependent on the depth from body's entrance surface. Energy dependent geometric and body size correction factors for water attenuation coefficient have been established for correcting the HU numbers. CT number variations from various CT systems were used to test the newly established scheme for the HU corrections.
Results: For a GE 4 slice vintage CT scanner, a perfect match has been achieved for positon shifts as well as a combination of size increase and position shifts. For a Philips Allura Xper-FD20 C-arm CT system, the position shift contributed about 5% error in additional to measurement error. For a GE Discovery HD 750 CT system, the size effect on the CT numbers are in excellent agreement with correction factors.
Conclusions: The newly established geometric and body size correction factors should be implemented in clinical X-ray CT imaging systems to improve CT accuracy.
Keywords: X-ray CT imaging; Hounsfield Unit correction, water attenuation coefficient, size effect, location dependent.

Contribution ID: 1738
1. Diagnostic Imaging
01.01. Computed tomography

Volume scan computed tomography imaging in child craniosynostosis treated patient by expansion cranioplasty

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Objective
320-detector-row multidetector computed tomography (MDCT) volume scan enables the scanning of up to 160 mm in length in a single rotation with a shortest exposure time of 0.35s. Because it does not require over-beaming and overlap scanning, volume scan involves lower radiation exposure than helical scan. However, when using volume scan for imaging the skull, the wide cone beam effect brings the possibility of problems in the measurement of the bone extension because there is a difference in the visualization of the skull.
The objective of this study was to compare volume scan and helical scan for visualizing the skulls of children with craniosynostosis.
Materials & Methods
A pediatric head phantom was scanned using a 320-row MDCT. The scanning parameter with 120 kV tube voltage, CT-AEC tube current, 0.6-s rotation time, 0.5-mm reconstruction interval, and volume scanning with 320 × 0.5 mm collimation a single rotation, and helical scanning with 64 × 0.5 mm collimation and beam pitch 0.688. The gantry angle was changed from −15° to 15° in 5°increments. Exposure dose was measured by a dosimeter inserted into phantom, measuring the center dose of body axis direction four points. Volume-rendered 3D images were created on a workstation, and volume and bone extension were measured and compared between the volume and helical scans.
Result
The volumes measured from the volume-rendered 3D image matched between the volume and helical scans to between 96% and 99%, and the length of the bone extension to matched 20.7 mm. For the same image quality, the exposure dose was 40% less for the volume scan.
Conclusions
For the CT scan for child craniosynostosis treated patient by expansion cranioplasty, compared to a helical scan, a volume scan allows an equivalent image in a shorter time with lower radiation dose, which can be useful.

Contribution ID: 1751
1. Diagnostic Imaging
01.01. Computed tomography

A Bayesian observer for task-based image quality assessment in computed tomography

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In computed tomography, a compromise needs to be made between the radiation dose received by the patient and the quality of the reconstructed image. In order to evaluate this trade-off, it is important to have reliable methods for quantifying the quality of the tomographic image reconstructions. Task-based image quality assessment is a family of methods that have been developed for this purpose. In this family of methods, model observers are often used to solve a classification task on a large number of reconstructed images. The performance of this classification is used to calculate a figure of merit which quantifies the quality of the reconstructions. We have developed a new model-observer that can be used in task-based image quality assessment. The observer is based on Bayesian methods and provides a natural way to quantify the uncertainties involved. Making certain prior assumptions about the distribution of our model parameters, we can analytically derive an expression for the posterior distribution of the figure of merit. The structure of our analytical solution enables us to use a simple Monte Carlo algorithm to sample this posterior. We have applied our observer to experimental and simulated images, and have shown that its performance is close to the performance of the Channelized Hotelling Observer, which is considered the gold-standard in the literature. We have estimated credible intervals for the figure of merit, and have shown that their coverage probabilities are reasonably close to the coverage probabilities of corresponding confidence intervals.

Contribution ID: 492
1. Diagnostic Imaging
01.02. Cone–beam CT

Image quality optimization and soft tissue visualization in Cone-Beam CT imaging

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Background: Cone Beam CT imaging, while providing better spatial resolution and exposing the patient to lower radiation doses than conventional CT-scanning, is also subject to spatially dependent bias due to the beam energy spectrum, resulting in a very limited capacity for quantitative imaging. Routine reconstruction softwares use algorithms based on filtered backprojection, relying on rudimentary corrections with respect to the physics of the problem. These properties have a direct impact on contrast resolution and soft tissue visualization.
Objective: The goal of this project is to improve image contrast resolution and to reduce the presence of artifacts. This will contribute to a better soft tissue imaging and thus to reinforcement of diagnosis efficiency and accuracy.
Method: An iterative polyenergetic approach to CBCT reconstruction is proposed to improve image quality and avert the artifacts caused by the beam hardening phenomenon and monoenergetic approximations at reconstruction. It takes into account the X-ray spectrum emitted by the source, the energy-dependent attenuation coefficients of selected tissues and prosthesis materials, and the geometry of a cone-beam system. The method is based on an adapted version of IMPACT (Iterative Maximum-Likelihood Algorithm for CT), which defines the attenuation coefficient as a linear combination of photoelectric effect and Compton effect. The proposed algorithm is then tested on synthetic and experimental phantom datasets.
Results: Our preliminary results demonstrate an important reduction of cupping and successful quantitative reconstruction of simple phantoms, such as water cylinders. These preliminary results point towards very interesting perspectives for soft tissue imaging. After improving the method for complex objects, we aim to tackle other artifacts such as metallic artifacts and work towards quantitative imaging of several types of tissues.

Contribution ID: 1209
1. Diagnostic Imaging
01.02. Cone–beam CT

Assessing Etot for a C-arm CBCT system using the ICRU/AAPM phantom

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Assessment of the radiation output of a C-arm Cone Beam CT (CBCT) is of particular concern to the medical imaging community as the use of such acquisitions increases. Of particular interest is an approach to allow an apples to apples comparison of absorbed dose in a phantom for C-arm CBCT and conventional CT. AAPM report 111 provides a framework for dosimetry on any CBCT system. The phantom developed by the ICRU and AAPM offers a platform to assess the total energy deposited in a phantom from CBCT acquisitions.
In this work we describe the use of a long phantom to capture the entirety of the scatter tails from a C-arm CBCT acquisition and describe how measurements can be made to assess Etot (the metric described in AAPM report 111 as the total energy deposited) in C-arm CBCT systems to facilitate comparison to conventional CT systems. The use of a long phantom (such as the ICRU/AAPM phantom) and a small ion chamber or solid state sensor are required to calculate Etot, though short phantoms may be used in lieu of an extended phantom once the rise to equilibrium dose function of the acquisition protocol is known.
For a single C-arm CBCT acquisition, Etot can be calculated by the following steps. First, determine the H(a) function (planar average rise to equilibrium function for an acquisition of extent a). This can be calculated by measuring the dose profile along the extent of a long phantom using a small dosimeter and performed at different radii and ordinate positions in the phantom. Second, determine the planar average dose at the central location of a phantom for the acquisition protocol. Etot may then be calculated as the product of a constant, the scan extent and the planar average dose divided by H(a).

Contribution ID: 1365
1. Diagnostic Imaging
01.02. Cone–beam CT

Quantitative performance evaluation of mobile cone-beam CT for head and neck imaging

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Cone-beam computed tomography (CBCT) has become increasingly popular in dental and maxillofacial imaging due to its accurate 3D information, minimal radiation dose, and low machine cost. In this paper, we propose the newly developed mobile CBCT scanner which combines the benefits of CBCT and mobility to extend its applications to head and neck imaging and allow faster access to a patient at various clinical sites without transporting the patient to the radiology department. With the large area detector, only a single rotation is needed to reconstruct the field-of-view of almost the entire head. Our filtered back-projection reconstruction and artifact reduction algorithms were based on GPUs to speed up the calculations. The quantitative performance was evaluated in the aspect of radiation doses and image quality. The radiation doses were measured using both CT dose index and dose area product (DAP) and compared with other CBCT and multi-slice CT (MSCT) machines. Then, we analyzed image quality using the standard cone-beam phantom through the automated analysis program. The effective doses radiated from the proposed mobile CBCT machine were within the range of 0.113 - 0.197 millisieverts, while the normalized DAP measurements were within the range of 38 - 104 mGy-cm2, which are significantly below the expected achievable dose of 250 mGy-cm2. The overall image quality of the proposed scanner

was mostly comparable to other MSCT and CBCT scanners. The high contrast resolution was as high as 12 line pairs/cm and the cupping artifacts were less than 1.5%. Noise was considerably high as expected in typical CBCT. Geometric accuracy of the reconstructed images provided the errors less than 0.16 mm or 0.12%. Due to low radiation dose, high accuracy and adequate image quality as compared to others, the proposed mobile CBCT has high potential for diagnosis and treatment planning in cranio-maxillofacial and otolaryngology applications.

Contribution ID: 1780
1. Diagnostic Imaging
01.03. Radiography

Image density of computed radiography's film to extend time of processing imaging plate

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Computed radiography is a digital image method to image acquisition in diagnostic radiography. It needs a imaging plate to save the image data of X rays that had attenuated. Imaging plate contain phospor material and had limited time in storage image less than 24 hours after exposure. The purpose of this study was to assess image density of computed radiography's film to extend time of processing imaging plate using densitometre. The stepwedge was placed on patient table and were exposed for 4 cassettes. Each cassette was processed with extended time for 12 hours, 24 hours, 36 hours, and 48 hours. As the result, the density of 4 computed radiography's film were 0.78, 0.73, 0.69 and 0.67 respectively. The conclusion of this study was the image density was influenced by the extended time of processing imaging plate. When the extended time were 12 hours, the density were 0.78. If the extended time were increased (48 hours) the density were decrease (0.67)

Contribution ID: 102
1. Diagnostic Imaging
01.04. Breast imaging

Development of fibroglandular-variable breast phantom and its application to quantitative assessment of undetectable lesion rate in digital mammography

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Purpose
In individualized screening mammography, the risk of undetectable lesions in dense breast is a serious problem. Quantitative assessment of the undetectable lesion rate remains to be established since the interval cancer used for assessment is age-indeterminate; additionally, the lesions vary in size and shape. In addition, no breast phantoms exist with variable fibroglandular density and distribution. We developed an original breast phantom with identical composition and distribution to that of actual breasts. To practice advanced individualized screening mammography, we clarified the quantitative relationship between fibroglandular density and its distribution with undetectable lesion rate in dense breast.

Methods
An original breast phantom consisting of adipose- (C: 72.0%, O: 16.4%, H: 9.2%, N: 2.4%) and fibroglandular-equivalent materials (C: 69.5%, O: 17.3%, H: 8.9%, N: 2.3%, Ca: 1.4%, P: 0.6%) was developed to perform a receiver-operating characteristic (ROC) study. Fibroglandular density was adjusted to 25%, 50%, and 75% by arbitrarily mixing the two materials, where fibroglandular density refers to the fraction by weight of fibroglandular tissue to the total tissue. Simulated microcalcification, mass, and spicula lesions were inserted into the phantom by changing the fibroglandular distribution. Fifty positive and fifty negative images obtained for the above fibroglandular densities were used as case samples for the ROC study. Six certified radiological technologists in breast cancer screening participated.
Results
The area under the curve (AUC) was larger for more experienced observers with all lesions. AUC rates for 50% and 75% fibroglandular densities were 20.5% and 32.0%, respectively, for microcalcification, lower than those for 25%. Similar tendencies occurred with other lesion types. Microcalcification, mass, and spicula lesion types were influenced by fibroglandular density in descending order. We demonstrated undetectable lesion risk in dense breast quantitatively using an originally developed breast phantom, which is imperative to practice advanced individualized screening mammography.

Contribution ID: 104
1. Diagnostic Imaging
01.04. Breast imaging

Prediction of fibroglandular density and breast dose based on physical characteristics and lifestyle habits

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Purpose
Many countries are attempting individualized breast cancer screening to address the problems associated with mammography in dense breast, namely, the risk of missing lesions and necessity of high X-ray exposure for early cancer detection. It is controversial whether women with dense breast should undergo screening mammography. To resolve this issue using medicophysical technology, we developed prediction models for fibroglandular density and mean glandular dose (MGD) based on simple, easily determined physical characteristics and lifestyle habits as predictor variables. By using these models, women can choose appropriate screening modalities before undergoing mammography.
Methods
One thousand mammograms from Japanese women aged 25–85 years with normal breasts were used in this study. First, accurate three-dimensional fibroglandular density and MGD were calculated using our previously published original method (LNCS 9699, pp.377-384, 2016). To develop prediction models for fibroglandular density and MGD, multiple logistic regression (to select effective independent variables) and stepwise multiple regression (to determine the prediction model) analyses were applied to all mammograms. The independent variables were age, compressed breast thickness, height, and body mass index (BMI) as physical characteristics; and age at menarche, pre- and post-menopause, birth experience, breastfeeding, dietary habits, alcohol consumption, smoking, and physical activity as lifestyle habits.
Results

The most effective factor for predicting fibroglandular density was age, with 1.4 and 2.5 times greater impact than compressed breast thickness and BMI, respectively. Physical characteristics and lifestyle habits predicted 54.5% of the total fibroglandular density variance. The most effective factor for predicting the MGD was compressed breast thickness, with 1.5, 3.2, and 7.4 times greater impact than fibroglandular density, age, and height, respectively. These independent variables explained 65.5% of the total MGD variance. The prediction models are a valid deciding criterion for national and individual benefits of screening mammography.

Contribution ID: 155
1. Diagnostic Imaging
01.04. Breast imaging

2D/3D effective ultrasound breast examination

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For breast cancer examination several studies have shown statistical significance of ultrasound and its inclusion next to mammography in the whole breast screening. Ultrasound is more appropriate for the dense-breast population, without ionizing radiation involved and with affordable technology . The disadvantage of the most widespread form - handheld probe examination - is the lack of full 3D representation. We propose to improve the common ultrasound examination by introducing computer aided tools that provide data analysis support and work with position tracking devices often already present in modern ultrasound devices. The novel framework for breast examination is based on handheld probe complemented by a 3D position tracker. The proposed tool has new functionality next to the common ultrasound image/video acquisition which lessens the intricacy of the 3D object/2D frame-wise data relationship. The framework evaluates the level of breast coverage by highlighting parts which were not sufficiently examined, both space- and time-wise. The expert is asked to follow a standard screening procedure and his/her movements are recorded and evaluated. We conducted a blind validation test by tracking several radiologists that were asked to perform whole breast screening on 75 patients . In average 3.8% of the breast surface was missed, which is equivalent to around 10 cm2 . We also calculated other characteristics of the examinations, such as average time, influence of expert’s experience, discrepancies between right and left breast examinations, etc. The second improvement enables to locally generate 3D view of the present structures. Developed novel tool improves the breast examination with handheld ultrasound probe by minimizing the 3D-2D discrepancy. It monitors the level of breast coverage during the examination and provides local 3D views of objects of interest.

Contribution ID: 511
1. Diagnostic Imaging
01.04. Breast imaging

Size and shape of spherical objects on full-field digital mammography and digital breast tomosynthesis images

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Preoperative tumor size measurement for staging of invasive breast cancer is often performed using mammography. However, accuracy of object representation on the images is not evaluated. This study assessed the accuracy of size and shape representation of spherical objects on full-field digital mammography (FFDM) and digital breast tomosynthesis (DBT) images. On the breast support table, 6 polymethylmethacrylate slabs, 5 mm thick, were positioned, with 9 aluminum spherical objects of 30 (±0.1) mm diameters, between the first and second slabs. X-ray imaging was performed using FFDM and DBT (angular range 15° and 40°, with correction of magnification), and repeated with the objects placed between the third and fourth slabs, and subsequently between the fifth and sixth slabs. The longer diameter of the spherical objects and aspect ratio were measured to evaluate the size and shape, respectively. Steel-Dwass test was performed for comparative analysis. A P value <.05 was considered significant. The longer diameter of the spherical objects on the FFDM were increasingly magnified (median, range) with increasing distance, 20 mm (32.5 mm, 31.8–33.5 mm) and 40 mm (33.6 mm, 32.9–34.7 mm), between the breast support table and object center, whereas in case of DBT, it was approximately the same as the actual object (overall, 30.4 mm, 30.0–31.7 mm). At each height, the longer diameter was significantly different between the FFDM and DBT15° and the FFDM and DBT40° images (all P = .001), with no significant difference in that between the DBT15° and DBT40° images, and also no significant differences in the aspect ratio for all combinations (overall, 1.02 mm, 1.00–1.06 mm). The size evaluated on the FFDM was magnified as compared to the actual objects, and was approximately the same on the DBT images. Thus, preoperative tumor size determination on FFDM images should be avoided.

Contribution ID: 739
1. Diagnostic Imaging
01.04. Breast imaging

Response of CR detector plates for use in mammography equipment

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Breast cancer is the second cause of cancer deaths among women, overcome only by meloma cancer. The detectors commonly used in CR mammography are photostimulable phosphor plates, whose response to radiation varies in relation to the parameters applied to the X-ray tube for the acquisition of mammographic images. The high incidence of this disease makes important the analysis and monitoring of the entire mammographic system in order to ensure the optimal performance, seeking that its diagnosis is made early increasing the chances of patient cure. The objective of this study is evaluate the response of a CR plate for variation of the applied voltage and time. For this purpose, two X-ray beams of 30 and 35 kV were selected and a successive exposition of the CR plate was made, varying the exposure time from 0.06 to 3.5 s. Then, with a solid-state detector, the air kerma was measured with the same parameters previously used, and subsequently, with the acquired images, correlating the intensity value recorded by the CR plate

with the measured air kerma value, obtaining the response curve in relation to the exposure time and the air kerma for each voltage. The determination of these response curves will help to know the performance of the CR plate, which will allow selecting the most appropriate parameters within the sensitivity range of the CR plate for the acquisition of mammographic images.

Contribution ID: 1089
1. Diagnostic Imaging
01.04. Breast imaging

Evaluation of a microwave tomographic system and a realistic breast phantom

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A microwave tomographic imaging system for breast-cancer detection is being developed at Chalmers University of Technology. 16 monopoles antennas are uniformly placed in a circle of diameter 15.2 cm, surrounding the sample under test. A modern vector-network analyzer (VNA) is used to measure the S-matrix for frequencies between 1 and 2 GHz. The coherent amplitudes and phases are then used in a Gauss-Newton based algorithm to reconstruct images of the sample at given frequencies. The sample is immersed in a lossy coupling bath made out of glycerin and water. This is done partly to match the environment to the sample properties and partly to suppress surface waves. In order to evaluate the system, measurements have been performed on the realistic 3D-printed phantom developed by at the Supelec institute in France. This is an intricate part that highly resembles the geometry of a real human breast. The system has successfully been able to reconstruct images of the Supelec phantom, as has been reported in earlier studies, but the high plastic percentage of its total volume has been proven to complicate the reconstruction of the interior of the phantom. The low dielectric properties of the plastics compared to the coupling and tissue mimicking liquids highly scatters the propagating waves due to the high contrast. Hence, the interior of the phantom is complicated to image. In this study, we first performed MR images of the phantom and applied analysis tools from the NIH software package ImageJ to assess the proportion of space occupied by the printing plastic to gauge the possible impact. In addition, we performed imaging experiments where the liquids in the adipose and fibroglandular region were identical to that of the surrounding background. These experiments provide important insight into distortions that can be expected when utilizing this phantom.

Contribution ID: 1623
1. Diagnostic Imaging
01.04. Breast imaging

Application of clusterization algorithm in the diagnosis of breast cancer in magnetic resonance image: an approach through k-means method

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The present work consists in the segmentation of magnetic resonance imaging of the mammary tissue using the computational method called k-means. This type of segmentation is based on the k-means classification method, so the idea of the algorithm is to provide a classification of information according to the image data itself, based on analyzes and comparisons between its numerical values. To verify the efficacy of the k-means method, the images segmented by this algorithm were compared with the same images segmented by means of another algorithm, called

Otsu. The objective of this work was to perform segmentation via k-means method on magnetic resonance imaging of the mammary tissue, in order to aid the detection of mammary tumors. The k-means algorithm is used to segment images, according to their attributes, into k classes (clusters). He assumes that the attributes of the points in the image form a vector space. Mathematically we can say that k-means minimizes the quadratic error function. The k-means classification partitions a set of data into a number of homogeneous clusters with an appropriate measure of similarity, to better analyze the properties of the image. This process consists of dividing the magnetic resonance images into classes, which make up groups in which each is separated by level of similarity. The k-means technique was tested on magnetic resonance imaging and a greater efficacy was observed in the aid of the detection of mammary tumors when compared with the results obtained by the Otsu algorithm. The Otsu algorithm also presents a segmented image, but with a less clear image. The k-means segmentation method, which is based on the theory of automatic classification optimization to extract the region of interest, shows satisfactory results in the detection of breast tumors in relation to the results obtained with the Otsu method.

Contribution ID: 1888
1. Diagnostic Imaging
01.04. Breast imaging

Image quality evaluation of phase contrast mammographic techniques

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Purpose: Despite the technical improvements in breast imaging, early diagnosis and lower rate of missed lesions remain a primary goal against breast cancer. The aim of this paper is to investigate further the potential contribution of phase contrast imaging, combined with breast tomosynthesis (BT) in improving breast imaging outcomes and diagnosis. Methods: A phantom composed of paraffin wax with three different embedded mammographic structures, spheres, fibers and $CaCO_3$ powder, was constructed. Mammographic and BT images at two acquisition arcs were acquired, in phase contrast mode of two object to detector distances (ODD). The experiments were performed using synchrotron radiation at 20 keV within the conventional mean glandular dose (MGD) range. Evaluation metrics were introduced in order to assess quantitatively the detection of breast abnormalities and the image quality from different modalities.
Results: Visual and quantitative assessments of the images acquired showed that the increase of ODD resulted in superior contrast and stronger edge enhancement for all the features. BT images eliminated the overlapping effect and made possible the in depth localization of structures. In addition BT images demonstrated higher values of all the evaluation metrics compared with mammographic images especially for the narrow arc of 15°.
Conclusions: The results of this study showed that BT phase contrast imaging is a promising technique that can be proved important for the detection of small details in breast screening and diagnosing.

Contribution ID: 278
1. Diagnostic Imaging
01.06. New imaging techniques (X-ray phase contrast, spectral imaging, monochromatic imaging…)

Automatic diagnosis of melanoma using machine learning

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Skin color is comprised of blood color and melanin. Melanin is produced by melanocytes, which can grow into skin cancer, melanoma. Melanoma progresses quickly and the population of patients has increased, especially in Europe and America. Melanoma has been diagnosed by a subjective judgment of a dermatologist with an accuracy of 75-85%. Melanoma is a highly malignant type of cancer. The 5-year survival rate decreases 20% for every 1 mm of tumor growth. Accordingly, melanoma should be treated in an early stage.
Melanoma creates various colors, differing from benign nevi. In this study, we develop an automatic diagnostic support system using such colors. In general, a camera takes a picture using three colors, red, green and blue. We use a Hyperspectral Imager (HSI) which measures many wavelengths. Therefore, the HSI can be observed fine-granted color. The specifications were the following: Wavelength can be measured from 397.9nm to 756.6nm, and the wavelength resolution is 1.45nm. We used single wavelengths images for analysis from 500nm to 750nm, and the resolution is 10nm, so intervals are 26. Measurement range is 500(width) by 658(height) pixels, 18.3nm by 21.5nm. Special resolution is 32.7 μm.
We used Hyperspectral Date (HSD) of malignant melanoma and benign nevi received from one medical institution. The number of HSD of melanoma is 116 and benign nevi is 183, so the sum is 299 images. We converted the HSD into single wavelength images. In each image, we calculate feature values (the sum is wavelengths by feature value), examining tumor whole area, tumor area and peripheral tumor area. We distinguished the images between melanoma and benign nevi with Support Vector Machine (SVM) using these feature values. The accuracy using RGB image is 72.13%, and the accuracy using HSD is 78.69%. This study shows that HSD achieved better accuracy than conventional images.

Contribution ID: 518
1. Diagnostic Imaging
01.06. New imaging techniques (X-ray phase contrast, spectral imaging, monochromatic imaging…)

Spectrum analysis for quantitative skin evaluation

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In recent years, skin aging caused by ultraviolet light exposure (i.e., photoaging) has garnered attention in the fields of beauty and health care, as ultraviolet light exposure can promote wrinkles and photosensitivity. However, few practical techniques exist for quantitatively evaluating such aging. Photoacoustic (PA) imaging, a novel modality, can portray differences in tissue characteristics. To verify quantitative skin evaluations with PA imaging, we undertook spectrum and frequency analyses.
We investigated the effects of skin aging progression on PA signals. At a 460–600-nm wavelength, we measured PA signals of 50-μm-thick porcine skin sections with acoustic resolution photoacoustic microscopy (AR-PAM).We used an oxidizing reagent (i.e., acrolein) that produces results similar to photoaging. To simulate various degrees of skin aging, we changed the acrolein concentration and number of processing days; at all wavelengths, PA signal intensity from the epidermis was higher than that from the dermis. We investigated that in terms of the relationship between the PA signal and photoaging, PA signals from both the epidermis and dermis increase as photoaging progresses.
To enhance the image contrast at the dermis, we conducted frequency analysis. Generally, PA signals from microstructures such as capillaries and fibrous tissue are high in frequency and low in

intensity; therefore, those signals are buried in high-intensity signals with low-frequency contents. We separated the frequency range and building up the compositional image. The image contrast at the dermis was improved.
These analytical results demonstrate the feasibility of quantitative skin evaluations through PA imaging. Studies featuring a transducer with a broad frequency band, appropriate wavelength regions, in vivo measurements, and more practical systems must be developed and used in the future.

Contribution ID: 529
1. Diagnostic Imaging
01.06. New imaging techniques (X-ray phase contrast, spectral imaging, monochromatic imaging…)

Material Identification and Visualization using Multi Energy X-Ray Imaging: Initial Results

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In the present paper a novel x-ray imaging technique based on multi energy CT imaging is presented, that allows identification and recognition of the different tissues in the imaged cross section. A series of X-ray tomographs are produced at different energies, afterwards by combining values of every pixel at every different energy, X-ray attenuation curves of imaged materials on pixel level are calculated. Filtering or curve fitting is applied, either before or after attenuation's curve calculation. Curves of each pixel are compared to those of known materials from a material attenuation curve database. The identified materials are then depicted by replacing pixel values of the imaged cross section with a numerically color-coded system, where each colour represents the presence of determined tissues within the image. Results of a simulation study are presented. Software phantoms and x-ray simulated images were produced using the in house developed XRayImagingSimulator. A disc phantom has been created with built in cylinders of different tissue mimicking materials (i.e. water, fat tissue, soft tissue, muscle tissue). Cone Beam CT (CBCT) was simulated, and 90 different sets of ideal x-ray images were created using monochromatic energies from 10 to 100 keV using a step of 1 keV. Each set consisted of 360 projection images and reconstructed images were created using Filtered Back Projection. Different Gaussian noise levels were added to the reconstructed images in order to simulate real medical imaging doses. The resulted images were analysed using the proposed method. In this study a series of approaches have been tested, including filtering, curve fitting of the calculated attenuation curves, along with different curve comparison techniques, such as Haussdorf Distance and Procrustes analysis. Even in presence of high noise levels, all different tissues within the image were identified and depicted in the imaged cross section.

Contribution ID: 601
1. Diagnostic Imaging
01.06. New imaging techniques (X-ray phase contrast, spectral imaging, monochromatic imaging…)

Effect of source energy and target/filter combinations on the performance of coded-aperture X-ray phase contrast mammography

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X-ray phase contrast imaging (XPCI) can provide an enhanced method in mammography due to its demonstrated high potential in subtle detection and differentiation between soft tissues. The purpose of this study was to evaluate the effect of beam characteristics on a laboratory phase-sensitive mammography prototype, which employs the edge illumination concept.
To do so, we developed a Monte Carlo simulation framework in Gate code, in which a geometrical optics-based description has been implemented. A general coded-aperture (CA) XPCI system was simulated in this framework, and validated by an experimental setup. The code was used to simulate a CA-based XPCI mammography prototype system, and a breast phantom featuring a PEEK cylinder as the contrast detail. For a given photon flux, the Contrast-to-Noise Ratio (CNR), absorbed dose, and Figure of Merit (FOM) were calculated from absorption and refraction images retrieved from the breast phantom for various target/filter combinations at different tube voltages typically used in mammography.
Simulation results showed a good agreement with the experimental data. According to the results, for a Mo target (0.03-mm Mo filter) at 25 to 40 kVp range, FOM values were obtained as 3.5-0.9 and 51.9-63.4, respectively, for the absorption and refraction images. The calculations for a Tungsten target with 0.05-mm Rhodium filter at 25 to 40 kVp resulted in FOM values in the range of 1.9-1.0 and 58.5-69.0 for absorption and refraction images, respectively.
In summary, as the energy increases, absorption FOMs decreased but refraction FOMs increased except at 40 kVp for W/Rh spectrum. FOMs of refraction images were 17-70 times higher than absorption FOMs for a Mo/Mo target at this energy range. This increase factor for W/Rh varied between 30-64. Overall, a Mo/Mo combination resulted in higher absorption-contrast FOMs but lower phase-contrast FOMs than a W/Rh one, the latter especially at mid energies.

Contribution ID: 678
1. Diagnostic Imaging
01.06. New imaging techniques (X-ray phase contrast, spectral imaging, monochromatic imaging…)

Towards in vivo K-edge X-ray micro-CT with the Pixirad-I/Pixie-III detector

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X-ray spectral computed microtomography (μ-CT) has gained considerable interest in recent years thanks to the development of photon counting X-ray imaging detectors. Through the energy-based discrimination of the photons, obtained by setting up the discriminator threshold at different levels, they allow measuring photon energies with an accuracy appropriate for several practical applications. The major potentials of this approach are multiple contrast images (sometimes referred to as “color” or “spectral” images), obtained by using a single polychromatic source. In contrast to multiple acquisitions with different tube spectra, photon-counting spectral CT eliminates the risk of misregistration due to motion between consecutive scans and it allows for the elimination of dark noise in the image by rejecting all the events below the signal threshold. Of particular importance is the application of spectral CT in preclinical models where small animals are scanned and an effective discrimination among e.g. soft-tissue, bone and K-edge contrast agents can be in principle performed in a single shot. This abstract presents a project involving

INFN Trieste, INFN Pisa and Elettra – Sincrotrone Trieste S.C.p.A. where an effective spectral micro-CT setup based on the Pixirad-I/Pixie-III detector with the ultimate aim of in vivo small animal imaging is under study. A description of the current status of the hardware configuration as well as the considered image processing and reconstruction software solutions are here presented. Preliminary results based on test objects are also included.

Contribution ID: 801
1. Diagnostic Imaging
01.06. New imaging techniques (X-ray phase contrast, spectral imaging, monochromatic imaging…)

Label-free endogenous chemiluminescence imaging of oxidative processes in human skin

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Oxidative processes present across all types of organisms, including humans, cause chemical formation of electron excited species with subsequent endogenous ultra-weak photon emission. Thus, imaging of this endogenous chemiluminescence using ultra-sensitive devices potentially enables label-free monitoring of oxidative stress in optically accessible areas of human body, such as human skin. However, no quantified imaging of oxidative processes in human skin has been performed until now using endogenous chemiluminescence under controlled extent of oxidative stress conditions. Furthermore, the mechanisms and dynamics of endogenous chemiluminescence is not fully explored. Here we demonstrate that different degrees of oxidative processes on skin can be spatially resolved through non-invasive label-free endogenous chemiluminescence imaging in a quantitative manner. Additionally, to obtain insight into the underlying mechanisms, we developed and employed a minimal chemical model of skin based on a mixture of lipid (linoleic acid) / melanin / water to show that it reproduces essential features of the response of a real skin to oxidative stress. Our results contribute to novel non-invasive label-free methods for quantitative monitoring of oxidative processes and oxidative stress.
The only human subject involved was the first author of this work. Authors acknowledge the support from the Czech Science Foundation, grant no. GA13-29294S. Authors participate in COST Actions BM1309 and CA15211 project between Czech and Slovak Academy of Sciences, no.SAV-15-22.

Contribution ID: 942
1. Diagnostic Imaging
01.06. New imaging techniques (X-ray phase contrast, spectral imaging, monochromatic imaging…)

Dynamic contactless thermography as a supportive imaging method in surgery of colorectal carcinoma

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The quality of intestinal blood supply is extremely important for an adequate intestinal anastomosis healing. During the surgery the blood supply of the intestine may appear macroscopically sufficient even though the microperfusion is not fully adequate. The degree of blood supply of remaining intestinal segment and the determination of the resection margins position is estimated subjectively by the surgeon's experience or objectively by means of invasive indocyanine green fluorescent imaging. The subject of our study is to evaluate the possibility of using infrared thermal imaging as an alternative objective non-invasive imaging method in assessing intestinal blood supply.
The principle of determination of the optimal resection margin be means of the dynamic contact-less thermal imaging is the comparison of surface temperatures and heating dynamics in resected intestinal segments and the remaining vital parts of the intestine used to construct the anastomosis. A pilot study on thermal imaging measurements was done in a porcine model as well as in colorectal carcinoma patients. An infrared thermocamera Workswell WIC 640 was used in our study. The thermal imaging was correlated with the indocyanine green imaging method.
Based on the data evaluated, present experience of the surgical team and the post-operative conditions of the patients, it is evident that the dynamic thermal imaging is a useful supportive tool for determination of the optimal intestinal resection margins plane and thus contribute to lowering anastomotic complications rate in colorectal surgery.

Contribution ID: 1096
1. Diagnostic Imaging
01.06. New imaging techniques (X-ray phase contrast, spectral imaging, monochromatic imaging…)

Evaluating the usefulness of a handheld photoacoustic imaging system for quantifying fat rate in liver

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Quantification of fat rate in liver is useful for the early detection of liver disease. Fat accumulation can lead to development of chronic hepatitis such as non-alcoholic fatty liver disease (NAFLD). Some cases of NAFLD progress to non-alcoholic steatohepatitis (NASH), which can lead to more serious diseases such as cirrhosis or liver cancer. Although ultrasonography is widely used for assessing fatty liver, its quantitative performance and objectivity are not high. Photoacoustic (PA) imaging, a novel modality, is expected for applying to evaluate fatty liver. To evaluate fat rates, we developed a handheld PA system with a tunable wavelength laser. This study verified the usefulness of the system to estimate fat rates by analyzing PA spectra.
As a biological sample, mixtures of chicken liver and olive oil (mixing rates of lipids in the liver are 0–0.3 with an interval of 0.1) were used. We acquired PA spectra of the sample using the developed handheld system. Nanosecond pulses of laser light (800–1300 nm wavelength, 30 Hz repetition rate) were guided to the sample surface by an optical fiber bundle close to the linear ultrasound probe (SL15-4; center frequency is 8 MHz).
All liver samples have peak PA intensity of around 900 nm and around 1210 nm for wavelengths where the light absorbance of hepatic parenchyma and lipid is high. To estimate the fat rate using photoacoustic methods, the photoacoustic signal intensity ratio between the two wavelength regions was calculated as described above. Signal intensity ratios agreed well with the composition ratio between liver and lipid masses.

These analyses underscore the advantages of using PA spectra for fat rate evaluation, demonstrating our system's feasibility for early fatty liver detection. Increasing the light penetration depth must be achieved in future studies, along with in vivo measurement capabilities.

Contribution ID: 1108
1. Diagnostic Imaging
01.06. New imaging techniques (X-ray phase contrast, spectral imaging, monochromatic imaging…)

Usefulness evaluation of handheld photoacoustic imaging system for visualizing hypodermal tissue

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Visualization of hypodermal tissue is useful to examine clinical conditions of some diseases such as internal bleeding by trauma, subcutaneous hematoma, and venous thrombosis. Spatial recognition of abnormal findings is also important for surgical treatment. Ultrasonography is mainly used to evaluate them. However, some difficulties persist in handling ultrasound (US) imaging systems because it cannot provide high-contrast images. Photoacoustic (PA) imaging, a novel modality, is anticipated for application to visualizing hypodermal tissues. To realize easy-to-use biological PA imaging, we developed a handheld PA imaging system. This study verified the system's usefulness for portraying internal bleeding.
Chicken breast meat was used as a biological sample. To simulate internal bleeding, preserved ovine blood was injected into the meat at a depth of approximately 15 mm from the surface (3 points, 0.1 ml each). We acquired PA images of the sample using the developed handheld system. Nanosecond pulses of laser light (800 nm wavelength, 30 Hz repetition rate) were guided to the sample surface by an optical fiber bundle close to the linear ultrasound probe (SL15-4; 8 MHz center frequency, 4–15 MHz frequency band). US images were also acquired simultaneously using the same probe. These images were acquired through 40 mm at 0.5 mm intervals.
As a result, US images had low image contrast. Moreover, the spatial distribution of simulated bleedings was portrayed with little clarity. On the other hand, the PA images displayed those distributions with high contrast.
These analyses revealed important advantages of PA imaging for the visualization of internal bleeding, demonstrating the feasibility of our system for internal bleeding surgery treatment. Further studies must be conducted to reduce the influence of viewing-angle limitations, to reduce noise from unexpected signal resources, and to provide in vivo measurements.

Contribution ID: 1163
1. Diagnostic Imaging
01.06. New imaging techniques (X-ray phase contrast, spectral imaging, monochromatic imaging…)

Thermographic evaluation in patients with hypothyroidism and fibromyalgia by analyzing the hands temperatures

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The objective of this work was to perform a thermographic evaluation in patients with hypothyroidism (HP) and fibromyalgia (FM), analyzing the temperatures of the palms of the hands. It was selected a database containing 136 electronic records of thermographic images of patients, which were chosen according to the following inclusion criteria: records containing thermographic images at anteroposterior (AP) orthostasis top and AP in cervical extension; male and female individuals above 18 years old; individuals with HP, FM and without the diseases; containing laboratory reports and diagnostics; descriptive anamnesis of the patient profile and questionnaire of criteria for FM. The records were classified into three groups: Group 1 (G1) – with HP and FM (50 patients); Group 2 (G2) – with FM without HP (56 patients), Group 3 (G3) – without the diseases (30 individuals). The selected images were evaluated using the computational program Flir Report, where the thyroid extension distance in the AP image and three points on the topographic region of the thyroid gland were marked, obtaining an average temperature of the region. A point on each hand’s palm was marked in the orthostasis superior AP image, bilaterally, in order to obtain the temperature of this point. The temperatures data were statistically analyzed in the program Microcal Origin 6.0. The average temperatures for the HP and FM groups G1, G2 and G3 were, respectively, 30.4±0.3°C, 29.8±0.3°C and 30.1±0.3°C. These temperatures were statistically different between themselves and the Pearson´s linear correlation coefficient (ρ) was equal to 1, meaning that the variables are correlated among themselves. Thus, it was possible to conclude that, for the studied groups, the greater or lower the metabolic activity of the thyroid gland in patients with FM, greater or lower will be the activity in the region of the palms of the hands.

Contribution ID: 1621
1. Diagnostic Imaging
01.06. New imaging techniques (X-ray phase contrast, spectral imaging, monochromatic imaging…)

A study on magneto-acoustic signals under continuous sinusoidal excitation

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Methods based on the magnetic-acoustic (MA) effect are of great significance in studying the electrical imaging properties of biological tissues and bio-currents. The measuring accuracy and signal-to-noise ratio (SNR) of the commonly used pulse exciting method is low. This study proposes a continuous wave MA imaging method, a kHz-range continuous signal with an amplitude ranging several Volts is used to excite the MA signal to improve the SNR. The amplitude and phase of the MA signal are measured to locate the acoustic source via lock-in technology. Simulations and experiments in pork samples were performed to validate the method. The results show that, the measured MA signal magnitude accuracy increased up to 1e−7 Pascal using the lock-in amplifier under 10mA current excitation. The sonic source locating accuracy reached several millimeters. The SNR of the detected MA signal was improved by more than 25 dB. This study sets a foundation for using continuous sinusoidal wave excitation with high accuracy and SNR to locate the sonic source and image the distribution of tissue’s electrical parameters. This method also aids in monitoring and locating the biological current, and in reconstructing neural activity.

Contribution ID: 1792
1. Diagnostic Imaging
01.06. New imaging techniques (X-ray phase contrast, spectral imaging, monochromatic imaging…)

Iterative sensitivity matrix based Magnetic Resonance Conductivity Tensor Imaging (MRCTI)

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Recently proposed magnetic resonance conductivity tensor imaging (MRCTI) technique reconstructs high resolution anisotropic conductivity images which are proved to have a critical importance in radio-oncological imaging as well as source localization fields. In MRCTI technique, at least two linearly independent current injections are applied to the region to be imaged and resulting magnetic flux densities are measured using magnetic resonance imaging techniques. But amount of currents that should be applied for reconstruction constitutes the main drawback of the technique. In this study, an iterative reconstruction algorithm based on sensitivity matrix approach is proposed and tested using both simulated and experimental data. Simulation and experimental results show that the proposed technique enables us to decrease the injection current level while maintaining the high resolution imaging capability of MRCTI and increasing the contrast resolution together with noise immunity of the technique.

Contribution ID: 105
1. Diagnostic Imaging
01.07. Magnetic resonance imaging and spectroscopy

Comparative assessment of optimised T2 and T2* sequences for quantification of iron in paediatric patients with sickle cell anaemia

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Measurement of liver iron concentration is a key parameter for the management of transfused dependent patients with Sickle Cell Anaemia (SCA). Magnetic resonance imaging (MRI) has already demonstrated high accuracy to quantify liver iron content in blood Transfused Dependent patients . There is however little data on the literature that compared T2 and T2* MRI sequences in sickle cell anaemia (SCA) .
The aims of this work were thus to investigate two optimised T2 and T2* MRI sequences, determine their viability for the quantification of iron concentrations in transfused dependent SCA and compare them to the standard serum ferritin method.
The two optimised sequences were subsequently investigated on quantifications of liver iron of 10 volunteers and 25 paediatric patients with SCA. Experimental work was done using a 1.5 Tesla Philips MRI scanner at a Hospital in Khartoum, Sudan.
Linear correlation was found between T2* and serum ferritin ($R2 = 0.989$, $p < 0.001$), T2 and serum ($R2 = 0.856$, $p < 0.001$) and T2 and T2* measurements ($R2 = 0.845$, $p = 0.67$). The results demonstrate that both of the optimised T2 and T2* sequences could provide reliable measurements in the quantification of range of iron concentrations on transfused dependent paediatric SCA patients.
Keywords: MRI, iron concentrations, sickle cell anaemia (SCA), paediatric patients.
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Contribution ID: 354
1. Diagnostic Imaging
01.07. Magnetic resonance imaging and spectroscopy

Basic study of the imaging conditions on tumor volume measurement using 3D-MR imaging of the liver while patient holds breath

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To evaluate treatment effectiveness according to Response Evaluation Criteria In the Solid Tumor (RECIST) group guidelines, it is important to understand the change over time of tumor volume more accurately. Tumor volumetric measurement using liver 3D-MR imaging tends to cause measurement errors because the liver moves with the diaphragm during imaging while the patient is holding the breath. The breath holding method of the patient when 3D-MR imaging for measurement of tumor volume was performed was discussed using a movable simulated tumor phantom. Furthermore, optimal imaging conditions (breath holding method, slice section, voxel setting, phase encoding direction) with the least influence by body motion were studied. Based on three breath holding methods, the simulated phantom was moved in the direction of the foot-head along the line of the MRI receiver coil. The image sequence was a 3D-T1 weighted fast field echo method. The imaging time was fixed at 20 seconds. As a result, the breath holding method with the smallest measured volume error is functional residual capacity (FRC) breath hold (0.1mm/s). The optimum imaging condition is when the imaging section is set in the axial direction and the phase encoding direction is perpendicular to the moving direction with an iso voxel as small as possible. In the case where it is necessary to set the phase encoding in the direction parallel to the proceeding direction, imaging with the setting of rectangular voxel can suppress the measurement error of the volume. In order to measure accurate volume using liver 3D-MR imaging, it is necessary to know the direction of movement of the tumor during respiration and to set appropriate breath holding method, section, phase encoding direction and voxel size.

Contribution ID: 702
1. Diagnostic Imaging
01.07. Magnetic resonance imaging and spectroscopy

Wide tuned volume coil for small Animal MRI on 4,7T

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Wide tuned radiofrequency volume coil for Small Animal MRI allows receiving of MR signals on wide-band different frequencies. For this reason, it is possible to work with 19F and 1H resonance

without changing a special individually coil. The images for different nucleus do not require movement with the animal.
Therefore, 1H and 19F images can be easily compared. The birdcage construction of this coil allows volume imaging of small rodents, for example mice. Speciality of this coil is advantageous use of distributed parameters of transmission lines. This solution improves homogeneity of fields, improve resonance quality factor, and allows homogeneous tuning on many points at the same time. The advantage is also the price reduction for elimination of many nonmagnetic lumped capacitors.
On 4,7T resonance it works from 185 to 203MHz. Classic Birdcage constructions works only with 3% frequency tuning. A coil produces signal levels comparable with classical one frequency coils. Quality factor unloaded coil is Q200 = 328 a Q188= 331. A Coil was tested on 4,7T Bruker Biospin located at IKEM, Prague.

Contribution ID: 914
1. Diagnostic Imaging
01.07. Magnetic resonance imaging and spectroscopy

Diffusion-weighted imaging in trigeminal nerves after stereotactic radiosurgery

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Trigeminal neuralgia may be treated using Leksell Gamma Knife Surgery
(LGKS) with applied dose 80 Gy into the root of the nerve. Changes in the trigeminalnerves after irradiation were previously studied using histological methods,however in-vivo diffusion-based approaches included small numbers of patients and used low resolution, vulnerable to partial volume effects.To the best of our knowledge,early changes in diffusionwere not previously studied.
Eleven patients (6F,5M,62-79,average 70) with unilateral neuralgia (7left-sided,4 right-sided) underwent MRI prior LGKS, early after (n=9,1:23-5 hours after end of irradiation, mean 2:46±1 SD) and five months later (150.4 days±72 SD). High-resolution structural and diffusion data were acquired on 3T Siemens Skyra scanner (diffusion-weightedsequence;voxel 1.6 mm isotropic;5 b=0;30 directions;b=0/1000/2000;antero-posterior and postero-anterior acqisition). For patients with right-sided symptoms, brains were right-left flipped. DTI analysis was performed using FSL.
Tract-based spatial statistics (TBSS,FA>0.3) early after LGKS revealed focal decrease of highest principal eigenvalue (L1) in the irradiated area of nerve and decrease of both,L2 and L3 in the rest of the nerve in the prepontine cistern. Widespread fractional anisotropy (FA) increase and radial diffusivity (RD) decrease with mean diffusivity (MD) decrease in the proximal part of the nerve were detected.
Five months after LGKS MD and RD remained decreased, no FA changes were detected. In small area L2 and L3 changes were present, L1 changes were widespread.
The early FA increase and RD/MD decrease may be attributed to L2 and L3 decrease due to early post-irradiation changes.On follow-up, these changes were not significant. L1 decrease may cause late MD decrease, the absence of decrease of FA and presence of RD changes suggest minor changes of L2 and L3 being present as well.
We present the first systematic review of DTI changes in the trigeminal nerves after LGKS and especially the first study showing early effects.
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Contribution ID: 1299
1. Diagnostic Imaging
01.07. Magnetic resonance imaging and spectroscopy

Diffusion and perfusion MR parameters in locally advanced rectal cancer management: an explorative study

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Background: Diffusion Weighted (DW) and Dynamic Con- trast Enhanced (DCE) MRI have been used in therapy assessment of sev- eral tumors. Purpose: The aim of this paper is to explore the possibility to apply DW- and DCE-MRI in Locally Advanced Rectal Cancer (LARC) to predict complete pathological response (CPR) to short-course radio- therapy (SCRT). Methods: 34 patients with LARC underwent DCE and DW-MRI before and after SCRT. Afterwards, patients were surgically treated. Pathological responses were registered. Tumor Regression Grade (TRG) on a scale from 1 to 5 on the surgical sample was used to classify the response. Two groups (CPR=1 complete pathological response and CPR=0 partial response) were identified. The discriminative power of several features from DW and DCE MRI has been investigated. Specif- ically, diffusion features from the intra-voxel incoherent motion (IVIM) model have been computed by means of Siemens MR Body Diffusion ToolBox; in addition, diffusion kurtosis parameters have been estimated. As regards DCE features, we used the Standard Index of Shape (SIS) which our group has proposed in previous works. DW features and SIS have been evaluated on a statistical basis (Wilcoxon-Mann-Withney test for two independent samples, Area Under Curve of Receiver Operating Characteristics). Results: All diffusion features showed a significant vari- ation after therapy; however, this difference was not significant to predict complete response. SIS was the only feature to show statistical signifi- cant difference between the two groups. ROC and tree-based analysis revealed an optimal cut-off of 78.26 with specificity and sensitivity of 0.93 and 0.86 respectively.

Contribution ID: 1319
1. Diagnostic Imaging
01.07. Magnetic resonance imaging and spectroscopy

MRI acoustic noise risk assessment and management

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Introduction
This paper presents a problem about the acoustic noise risk assessment and management in the magnetic resonance practice. The aim is the protection of people health defined according to the WHO which is a state of complete physical, mental and social well-being of any person.
Material and Methods
The auditory safety of patients and workers, their non-auditory safety effects and the interference during operator /operator and operator/patient interaction are considered.
In order to take account of this:
• we studied the acoustic noise in the MRI process, and in the environment, when the noise is annoying and/or unbearable for occupational or not occupational neighbour activities;

• we consider different limits and reference level according to Italian law, European rules, literature evidence and our experiences.
In order to assess the risk, and to select prevention and protection measures and PPE, we thought it would be very useful to have SPLA, SPLpeak and SPLC and SPLz data, and the acoustic noise spectrum. These data have to be referred to specific experimental sets with detailed reference points (isocenter bore, NEMA position…), phantoms, sequences, SW version and microphones.
Results
A lack of data and an inadequate assessment have been put in evidence: if the noise is annoying it will be necessary to have a measure of it to select passive and active ear protections, shields or low noise emitting sequences.
In some cases, surrounding activities have been moved. Our results have been shown in a 1,5 T site
and as local authorities
Conclusions
Acoustic noise has to be considered and assessed in the first step of MR planning site and activity. It can be reduced to appropriate level. Acoustic noise would be evaluated compulsory also by competent authorities for the control of compliance of the RM implants for a formal green lig

Contribution ID: 1373
1. Diagnostic Imaging
01.07. Magnetic resonance imaging and spectroscopy

Assessment of brain water content in peripheral inflammation by an optimized single-voxel MR spectroscopy quantitation technique

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Increased brain water content (BWC) of up to 12% has been reported in brain inflammatory disease. However, no study has assessed variation of BWC in peripheral inflammatory disease, such as psoriasis. Meanwhile, there are reports of significant variations in brain metabolites in peripheral inflammatory disease. Even the commonly used metabolites as reference standards in quantitative magnetic resonance spectroscopy (MRS) studies have been implicated in these variations. BWC, as one of the reference standards, has not been considered by previous studies mostly due to the challenge of acquiring the water signal within tolerable times in patients, for accurate estimation of BWC. In this study, we developed a technique of BWC quantification by optimizing the standard MRS acquisition of metabolites from which unsuppressed water spectra were extracted using a validated post-processing procedure. The extracted in vivo unsuppressed water signal was adjusted for all necessary correction factors, and calibrated against a reference signal deduced from voxel position-dependent polynomial equations derived from head coil sensitivity maps obtained from phantom experiments. Experiments were conducted on psoriasis patients (mean age ± SD = 46 ± 10 years) and controls (mean age ± SD = 39 ± 12 years), comprising 16 (8 males, 8 females) participants in each group. CHESS water-suppressed spectra were recorded from the anterior cingulate cortex and bilateral hippocampi of participants using the standard PRESS sequence. BWC did not vary significantly ($p > 0.05$) between patients and controls, across all the brain regions of both patients and controls, and in patients at baseline and post anti-inflammatory medication. BWC in this study compared with published estimates, indicating that the technique is accurate. The results further indicate that BWC is unaltered in

peripheral inflammation, and thus support the use of BWC as an internal reference standard for absolute quantitative MRS studies of peripheral inflammation.

Contribution ID: 1374
1. Diagnostic Imaging
01.07. Magnetic resonance imaging and spectroscopy

Prevalence of subclinical lesions in the brain magnetic resonance imaging findings among Migraine patients

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Introduction: Previous studies showed the frequency of magnetic resonance imaging (MRI) abnormalities in patients with migraine at 12% to 46%.
Methods: This cross-sectional study was performed on the 300 migraine patients who were admitted to Amir-almomenin and Baghiyatolah Hospital, Tehran, Iran. All the patients were examined by an expert neurologist regarding the International Headache Society criteria, migraine and its type were diagnosed. Afterward, patients underwent MRI and its findings were recorded. Data were analyzed by SPSS 11.5 using Chi square test and the significant level was considered P≤0.05.
Results: Of total, 28.7% patients were in 21-30 years' group, and 12.3% patients were male. The duration on disease in the most of patients (45.3%) was more than 5 years. Also, 56.7% have more than 1 headache attack during a month. HTN, diabetes, hyperlipidemia and cardiovascular disease were reported in 7.3%, 2.7%, 1.7% and 3.3%, respectively. The most type was common migraine and classic at 88.7% and11.5%, respectively. Also, abnormal findings in MRI was seen in 11.3% that through it 5.7% have lacunar infarct and 6.75 have white matter lesions (WML). There were a significant association between MRI findings and age, number of headache attack in months, HTN, type of migraine and subclinical lesions (P≤0.05) However, there were no any association between MRI findings and sex, diabetes and hyperlipidemia.
Conclusion: Although there are no specific magnetic resonance imaging findings peculiar to migraine, detection of WML should be taken into consideration in patients with migraine (especially migraine with aura). Frequency of attacks is an important indicator of existence of WML.
Keywords: Magnetic resonance imaging; White matter lesions; Migraine

Contribution ID: 1622
1. Diagnostic Imaging
01.07. Magnetic resonance imaging and spectroscopy

Fuzzy logic based system in the support of diagnosis of brain tumors

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This work consists in applying the automatic classification method called fuzzy c-means in magnetic resonance imaging (MRI) of the human brain to aid in the detection of tumors. This type of segmentation is based on the region growth method that differs it from conventional classification methods by using the fuzzy set concept, which is appropriate to deal with inaccuracies and/or uncertainties in certain regions of a given image. In order to verify the efficacy of the fuzzy c-means method, the segmented images were compared with the same images, but segmented by means of another algorithm, called Otsu. The objective was to perform a segmentation via the fuzzy c-means method on magnetic resonance imaging of the human brain to aid in the detection of tumors. The fuzzy classification divides a set of data into a number of homogeneous clusters from an appropriate measure of similarity, to better analyze the properties of the image. The most used method of fuzzy clustering is the fuzzy c-means algorithm, proposed by Dunn and generalized by Bezdez. This process consists of dividing the magnetic resonance images into classes, which make up groups in which each is separated by level of similarity. The fuzzy c-means technique was tested in different MRI images and a greater efficiency was observed in the aid of the detection of brain tumors when compared with the results obtained by the Otsu algorithm. The Otsu algorithm also presents a segmented image, but with a less refined edge. Through the fuzzy c-means segmentation method, which is based on the fuzzy number theory to extract the region of interest, satisfactory results are obtained in the detection of brain tumors. This occurs due to the influence of fuzzy numbers, for which a pixel may belong to more than one region, but with different degrees of pertinence.

Contribution ID: 1719
1. Diagnostic Imaging
01.07. Magnetic resonance imaging and spectroscopy

Fast in-vivo high-resolution diffusion MRI of the human cervical spinal cord microstructure

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Diffusion Magnetic Resonance Imaging (dMRI) is a widely utilized method for assessment of microstructural processes in the central nervous system i.e., the brain and the spinal cord (SC). In SC, almost all previous human studies utilized diffusion tensor imaging (DTI) that poorly reflects the actual situation in white matter (WM) as it does not account for areas of fibers crossings. While High Angular Diffusion Resolution Imaging (HARDI) promise to overcome DTI drawbacks, long acquisition times critically limit its applicability in clinical human studies. Also, previous human HARDI dMRI studies suffered from limited spatial resolutions with couple slices of 1×1×5mm3 being acquired in tens of minutes. Thus, we have optimized a novel fast HARDI protocol that allows collecting dMRI data at high angular and spatial resolutions in clinically-feasible timeframe. Our 3T Siemens Prisma data were indeed acquired in less than 9 minutes containing a total of 75 scans with different dMRI weightings and exceptional spatial resolution of 0.67×0.67×3mm3 (after interpolation in Fourier space) covering cervical C4-C6 segments. So far, our preliminary outcomes demonstrate applicability of our technique in healthy individuals when showing good correspondence between low fractional anisotropy (FA) gray matter areas on the dMRI scans and the same regions delineated on T2-weighted MR images with spatial resolution of 0.35×0.35×2.5mm3, while allowing to detect crossing fibers that were previously shown in vivo only in animal models.

Contribution ID: 1744
1. Diagnostic Imaging
01.07. Magnetic resonance imaging and spectroscopy

Preliminary study of tractography and MR spectroscopy brain examinations in Parkinson’s disease

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Parkinson's disease (PD) is characterized by the progressive neurodegeneration of dopaminergic substantia nigra pars compacta (SNpc) neurons projecting to striatum. The loss of nigral DA-neurons induces of a reduction in extracellular dopamine concentration in the striatum, which correlates with motor impairments (deficits). In brain there are several motor areas: putamen (parts of striatum), substantia nigra and supplementary motor area. The aim of this study is to investigate in vivo patients with PD and control group - healthy volunteers for evaluation of nerve fibers structure using MR tractography and amino acid concentration using proton MR spectroscopy studies (MRS). We investigate correlation between neurotransmitter concentrations and nerve fiber tracts of selected movement brain area. The work presents the results of pilot study for tractography examination procedures and their results of control group. All studies were performed on 3T MRI scanner (Discovery MR750w 3.0T, GE, USA) being the equipment of CNSLab. Prepared protocols for proton MRS used single-channel coil, 512 repetitions and TE=26 ms for one area corresponding to the occurrence of motion area (putamen), with a linewidth of water signal at half-high of approximately 7Hz. Parameters selected for MRS studies is selected for observing of signaling neurotransmitters: glutamine and glutamate (quantitative study of glutamine and glutamate in the putamen against creatine). For tractography studies we used 25 directions. Analysis of diffusion tensor and its scalar parameters: ADC (Apparent Diffusion Coefficient), MD (Mean Diffusivity), FA (Fractional Anisotropy), AD (Axial Diffusivity), RD (Radial Diffusivity) in selected areas take place after completion of the study, in "postprocessing" using 3D Slicer software. Results of tractography scalar parameters of putamen are in agreement with average literature data for this region. This will allow the evaluation of single-hemispheric and inter-hemispheric nerve fibers and their connections. Results of the pilot studies allow preparing optimal procedures for further patient examinations.

Contribution ID: 711
1. Diagnostic Imaging
01.08. Optical imaging

Assessment of changes in cytochrome-c-oxidase concentration in the brain cortex using near infrared spectroscopy: wavelength optimization study

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Near-infrared spectroscopy (NIRS) measurements carried out on the subject's head contain contributions from extracerebral and intracerebral tissues. The aim of the study is optimization and validation of a time-resolved multi-wavelength NIRS measurement method in estimation of changes in concentrations of the chromophores contained in the blood circulating in the brain: oxy-, deoxy-haemoglobin and cytochrome-c-oxidase (CCO) separately in intracerebral and extracerebral tissue compartments. CCO enzyme is involved in more than 95% of oxygen consumption and plays a major role in the energy balance of the cell and can be estimated using NIRS technique [Tachtsidis et al. 2006]. Changes in concentrations of chromophores resulting from physiological changes can be recovered from the corresponding changes in recorded distribution of times of flight of photons [Liebert et al. 2004]. In the present study the selection of wavelengths necessary to estimate CCO concentration in the brain tissue was optimized considering uncertainty in estimation of changes in absorption coefficient at multiple wavelengths. The propagation of

uncertainty in estimation of changes in absorption coefficient [Liebert et al. 2012] was extended to take into account the choice of wavelengths and estimation of CCO. Monte Carlo simulations were performed to determine the optimal 16 consecutive wavelengths for estimation of changes in concentration of CCO and to determine the dependence of the calculated uncertainty in CCO estimation on: the number of wavelengths employed, the responsivity of a detector, the source-detector distance, the thickness of the top layer, and the background optical properties of the medium.
Results demonstrate that increasing the number of wavelengths beyond 16 does not significantly reduce the uncertainty in measurements. The optimal 16 consecutive wavelengths are in the lower range and start from 650 nm. The obtained results allow for optimization of the multi-wavelength time-resolved setup for measurement of changes in concentration of CCO at the bedside.

Contribution ID: 726
1. Diagnostic Imaging
01.08. Optical imaging

Compact time-resolved diffuse correlation spectroscopy system – preliminary studies

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Diffuse correlation spectroscopy (DCS) and time-resolved near infrared spectroscopy (TR-NIRS) are noninvasive methods to measure optical properties and blood flow of a biological tissue. We have developed an instrument based on combination of DCS and TR-NIRS which can be potentially used for simultaneous assessment of brain tissue oxygenation and blood flow assessment in adult humans.
We employed a compact picosecond pulsed diode laser (PicoQuant, Germany) to emit coherence light pulses at 760nm which were delivered to the investigated medium using a multimode fiber. A single mode fiber was located 1cm apart from the source fiber on the surface of the medium to deliver photons diffusely reflected from the tissue to a photomultiplier tube detector. Time correlated single photon counting module (Becker&Hickl, Germany) was used to measure time of flight of each photon. Combined TR-NIRS-DCS technique allowed to acquire distributions of times of flight of photons (DTOF), to estimate optical properties based on DTOF and estimate depth selective blood flow based on time-gated autocorrelation function [Sutin et al. 2016, Pagliazzi et al. 2017].
During a series of experiments on a liquid phantom, the particles velocity in the medium was increased by changing the phantom temperature. The results show that, by increasing temperature, the normalized electric field autocorrelation curve (g1) is shifted towards shorter lag times. Furthermore, in order to study sensitivity of the technique to particle movements appearing at different depths, autocorrelation function was calculated for various time-gates of the DTOFs acquired on a two-layer solid-liquid phantom including a solid slab of 5mm thickness as the top layer. The results indicate that the shape of the autocorrelation curve depends on length of photons path in the medium and the curve becomes flat for the photons which propagate through the top layer only.
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Contribution ID: 743
1. Diagnostic Imaging
01.08. Optical imaging

Assessment of sensitivity of NIRS measurement in reflectance geometry – experimental studies and its comparison with Monte Carlo simulations

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The near infrared spectroscopy (NIRS) is a tool allowing for assessment of changes in brain oxygenation using difference in spectral properties of oxy- and deoxyhemoglobin. The measurements are typically carried out on the surface of the head in reflectance geometry. The advanced form of NIRS technique is based on acquisition of distributions of times of flight of photons (DTOF) and allows to estimate depth-resolved changes in absorption of the tissue.
Sensitivity factors describing sensitivities of changes in statistical moments of DTOFs to changes in absorption are usually calculated by Monte Carlo simulation [Liebert et al. 2004]. In this paper an experimental method for sensitivity factors i.e. Mean Partial Pathlength, Mean Time of Flight Sensitivity Factor and Variance Sensitivity Factor estimation is presented.
Studies were carried out on a homogenous liquid phantom. The measurement setup [Sawosz P. et al. 2012] was based on the time-gated intensified CCD camera which was positioned in such a way that the upper surface of the phantom was imaged. The near infrared laser beam, was delivered to the aquarium's side wall. The time gated camera, combined with a delay unit, allowed to collect photons within narrow acquisition time window, at defined delays in relation to the laser pulse. It led to obtaining a DTOF for each pixel of the image. Signal processing enabled to estimate statistical moments of the recorded DTOFs and in consequence also SF.
The proposed technique of imaging SF in the medium was validated by comparison of the experimental results with the simulated distributions of sensitivity factors, calculated with the use of the Monte Carlo code [Wojtkiewicz et al., under review].
It will be shown, that the sensitivity factors matrices obtained from both, experimental and theoretical method, depend on optical properties of the medium. Moreover. the influence of source-detector separation will be analyzed.

Contribution ID: 781
1. Diagnostic Imaging
01.08. Optical imaging

Assessment of the reaction to reduced cerebral perfusion in air force pilots using lower body negative pressure test: NIRS-based study

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A methodology for assessment of the reaction to reduced cerebral perfusion and orthostatic stress leading to ischemic hypoxia and reduced muscular tension which are frequently experienced by pilots of highly maneuverable aircrafts is proposed. The measurement setup consists of a chamber which generates a low pressure around the lower part of the body - LBNP (Lower body negative pressure) placed on the tilt table.
Studies were carried out using the in-home developed NIRS system to assess changes in oxygenation of the cerebral cortex, based on measurements of diffusely reflected light at 735 and 850 nm. The measurements were carried out on a group of 12 cadets of the Polish Air Force

Academy and 12 healthy volunteers in order to evaluate the dynamic changes in cerebral oxygenation. Measurement protocol consisted of:
1. Rapid tilting of the bed to +70º (60 seconds).
2. Rapid reduction of the LBNP down to -100 mmHg (60 seconds).
3. Rapid tilting of the bed to +70º with rapid reduction of the LBNP down to -60 mmHg (30 seconds), afterwards rapid change of the bed position to 30 º with return of the LBNP to its baseline (30 seconds).
The repetitive pattern of changes in the concentration of total hemoglobin (ΔCHbt) in response to the rapid decrease of the pressure around the lower part of the body and change of the bed tilting angle was observed for both groups of investigated subjects. However, the CHbt changes observed in healthy volunteer group reveal larger dispersion than in the group of pilots. A number of parameters derived from NIRS signals were proposed based on amplitudes of ΔCHbt and dynamics of hemodynamic response. The proposed parameters may allow for evaluation of cortical blood flow response to sudden ischemia and, potentially, for assessing predisposition of a subject to be a pilot.

Contribution ID: 796
1. Diagnostic Imaging
01.08. Optical imaging

Human iris diagnostics using double-snapshot method and spectral line imaging

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Here we present a fast method and a device for human iris diagnostics. We use reflectance properties to recognize different eye pathologies. A specially made device with automatically switchable five different wavelength laser diodes (405 nm, 450 nm, 525 nm, 656 nm and 849 nm) is used for illumination and image capturing. Laser diodes, four of each kind, are arranged in a circle to ensure uniform illumination of the camera field of view. Mini-computer Raspberry Pi 3 with OmniVision OV5647 sensor and 3.5’ touch screen is used for image taking. Laser speckle artefacts are reduced with a special patented technology [1]. Double-snapshot approach for obtaining five monochromatic images is used in the device [2] – first image is taken when 525 nm, 656 nm and 849 nm wavelength laser diodes are switched on, and second image is taken when 405 nm and 450 nm wavelength laser diodes are switched on. Then, RGB crosstalk correction algorithm [3] is used to extract five monochromatic images – one for each of the five lasers. Also spectral reflectance’s coefficient is calculated for each of the used wavelengths in every pixel of the image by using reference images. This new device will be tested on human iris. Results will be presented in the conference.
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Contribution ID: 940
1. Diagnostic Imaging
01.08. Optical imaging

Hyper-spectral imaging of the human brain reveals slow sinusoidal, hemodynamic oscillations at distinct frequencies

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1. Introduction
Slow sinusoidal, hemodynamic oscillations (SSHOs) around 0.1 Hz are frequently seen in mammalian and human brains. Four patients undergoing functional surgery for epilepsy offered a unique opportunity to determine which SSHOs are present on the human brain.
2. Methods
Hyper-spectral recordings of 4 to 7 wavelengths were made with a two systems: 1) consisting of liquid crystal tunable filter and a monochrome camera mounted to the surgical microscope, 2) consisting of a flat panel light source with 600 LEDs with 17 peak-wavelengths with a monochrome camera mounted in the middle. Concentrations of oxy- and deoxy-hemoglobin were calculated for each set of wavelengths and image pixel. A Fourier transform was applied along the time axis to determine the oscillating amplitude at each frequency. Oscillating regions were determined by manually delineating bright areas.
3. Results
For all 4 patients multiple SSHOs were constantly visible during the entire 4 to 10 minute acquisition time. The observed SSHOs were localized to specific cortical regions with a very distinct frequencies and showed a fixed but sometimes large phase difference within that region. SSHOs of deoxygenated hemoglobin appeared to have an opposite phase with respect to the oxygenated hemoglobin SSHOs. Deoxyhemoglobin SSHOs’ amplitude was 90% of the oxygenated hemoglobin SSHOs’ amplitude.
4. Discussion & Conclusion
Despite the fact that SSHOs have been known for many decades, their function is still unknown. This study shows that SSHOs have very specific characteristics like frequency, phase and location. More research is needed to study their dependence on pathology, anesthetics and electrical or visual stimuli. Hyper-spectral imaging of the human brain offers a new way to study the origin and function of SSHOs on the human brain.

Contribution ID: 1053
1. Diagnostic Imaging
01.08. Optical imaging

Diffuse optical imaging for breast screening using a dual-direction measuring module of parallel-plate architecture

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We demonstrate a working prototype of an optical breast imaging system involving parallel-plate architecture and a dual-direction scanning scheme designed in combination with a mammography machine, therefore, this device can be operated while compressing a breast using two plates. This system was validated in a pilot study to demonstrate its application in imaging healthy and malignant breasts in a clinical environment. In this study, the components of the self-developed imaging system are demonstrated and explained, including its measuring architecture, scanning mechanism, and system calibration as well as the reconstruction algorithm is presented. With the help of the structural information of mammograms, scanning sections were selected for the collection of optical data that are used to reconstruct diffuse optical images of tissue. Compared with the data of single-direction projection, more information can be acquired from the dual-direction one realized by one pair of dual linear scanning arrays. Additionally, the evaluation of feature indices for highlighting the existence of malignant tissues is proposed and the feature index curves of intensity and phase can succinctly demonstrate the corresponding forward measurements. Moreover, we present five representative cases: one subject with no disease (a control measure), one positive but benign case, one suspected case, one invasive ductal carcinoma, and one positive case without follow-up treatment. A region-of-interest analysis demonstrated significant differences in absorption between healthy and malignant breasts, revealing the average contrast between the abnormalities and background tissue to exceed 1.4. Except for ringing artifacts, the average scattering property of the structure densities was 0.65–0.85 mm-1.

Contribution ID: 1311
1. Diagnostic Imaging
01.08. Optical imaging

The study of diagnosis support system for endoscopic image of gastric disease by HSV images

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(Introduction) The endoscopic diagnosis and therapy have been applied in various cases, then the data volume has been increasing, and the burdens of doctors increased. So we have been studying about the diagnosis support system.
(Purpose) We want to make the precise detection system for bleeding region, white coating regenerating epithelium, edema and scars for the endscopists to reduce the burden of the diagnosis by HSV color coordinates.
(Principle) The endoscopic images are detected that the reflection light from the tissue after absorption, scattered, transmitted, and reflected in tissue. So each disease regions have specific color according to specific wave length.
(Method) The HSV coordinates consists of H (Hue), S (Saturation) and V (Value)). The Hue depends on a wavelength of exposure light. Then, we thought that it could be applied to automatic recognition of ulcer and bleeding by hue in endoscopic image. In this study, we optimized the hue and value, then it could be detected more precisely than previous our study.
(Results) Especially, the bleeding region was detected by HSV coordinates more precisely than the previous RGB coordinates. We were quantitatively examined by many endoscopic images. If it was the HSV image, we were able to detect the bleeding region precisely in the upper gastrointestinal mucosa by optimized hue and value.
(Conclusion) We reconfirmed that the Hue is correlated wavelength. The optimized HSV coordinates of endoscopic image could be diagnosed that the bleeding red region and white coating regenerating epithelium precisely.

Contribution ID: 1404
1. Diagnostic Imaging
01.08. Optical imaging

Capsaicin effects on human facial and neck temperature

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Capsaicin is an alkylamide that can be found in chilli peppers as its irritant component with some analgesic properties. It has also many other properties, so it may help to control peripheral nerve pain as well as can be helpful during chemotherapy and radiotherapy. Capsaicin, as irritant compound, affects body temperature. Our research is aimed to specify what is its effect to facial and neck temperature.
As we were interested in temperature measurement and its visualization, we used the Workswell WIC 640 infrared camera to obtain temperature distribution images. Facial and neck temperatures were measured before and after ingestion of about teaspoonful of Jalapeño chilli pepper extract (1.17 grams) of 6.000 – 8.000 SHU. Measurement was performed for 2 minutes 30 seconds for 12 people (4 males and 8 females) aged 20-30 years.
The temperature increase of different parts of the face depends on individual physiology of volunteers participating in the study and is observable immediately after ingestion of the Jalapeño chilli pepper extract. Temperature rise was observed between 1 – 2°C in oral region, between 0 – 1,5°C in frontal region, between 0 – 1°C in canthi, and 1 – 0,9°C in the neck region after 2 minutes. It was confirmed there is an obvious relation between the temperature rise and subjective perception of the hot taste. Facial temperature is growing slower and less in the group of people who like hot taste.
To summarise our results, capsaicin alkylamide affects surface body temperature. The temperature rice is probably caused by a psychosomatic reaction – brain gives a signal for vasodilatation in the specific body region. Using the appropriate amount of capsaicin can be helpful in medicine but we must consider individual variability of physiological reactions to this irritant substance which are also represented by the observed skin temperature changes.

Contribution ID: 1548
1. Diagnostic Imaging
01.08. Optical imaging

3D Biopsies with MEMS based Handheld Confocal Microscope

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Currently, performing clinical tissue diagnosis has to be performed through excised tissues by observing them under a microscope for histopathological interpretation. While this process has been the standard of care for over 50 years, there are significant limitations that include processing artifact, sampling error, time consumption, and interpretive variability. Light can achieve spatial resolution that is far superior to that of other imaging modalities, including computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound. Recently, tremendous progress has been made in the development of MEMS based fiber-optical microendoscopes that can be used inside the human body to directly visualize tissue in vivo. These advances have been made possible by significant technological progress in flexible optical fibers, micro-optics, and compact scanning mechanisms such as MEMS scanners. A novel combination of MEMS scanners and advanced optical imaging modalities such as confocal microscopy or two-photon microscopy will provide new directions for advanced endoscopic diagnosis. Currently, these instruments are being used with medical endoscopes to collect high-resolution fluorescence images from the inner lining of hollow organs, such as the mucosa of the digestive and respiratory tract, to guide tissue biopsy. In this work, we will introduce recent development of MEMS based fiber-optical endoscopy.

Contribution ID: 1900

1. Diagnostic Imaging
01.08. Optical imaging

Mueller matrix formalism applied to the study of biological cells

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Polarimetry has shown to be a very useful approach in problems that involve light-matter interaction. This is supported by its many successful applications in a variety of fields, like astronomy, agriculture, weather radar, environmental science, etc. More recently, imaging polarimetry has become a field of increasing activity in medicine and biology because of its non-invasive nature and its potential to identify local properties in propagating media, something particularly important in the context of biomedical diagnosis [1]. When interacting with matter the polarimetric properties of light are affected in a way that is related to the optical properties of the material. These changes can be analyzed with the Mueller matrix M [2], that fully characterizes the optical changes induced by a given sample. Because this matrix is a complex object, some kind of transformation is required to interpret the information and obtain any physical insight.
Regarding the study of biological cells, previous works show that some processes occurring in cells may alter their optical properties and therefore be potentially detectable under polarimetric observation. For instance, it can be a very handy tool for the identification and discrimination of cancerous cells [3]. We suggest that polarimetry could also be useful for the identification of processes that take place inside a cell, like the phase in the cell division cycle (mitosis), or to distinguish some change in its state (apoptosis) or shape. Another interesting possibility is characterizing the degree of cell-surface adhesion, a well-known and essential process in cell communication [4].

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Contribution ID: 101
1. Diagnostic Imaging
01.09. Ultrasound imaging and optical coherence tomography

Low- and high-speed arrivals decomposition in 10-19 kHz transmission sounding of human lungs

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Background: The phenomenon of 10-40 kHz sound transmission through human lungs with speed of about 1000 m/s was revealed by Rueter et al., 2010. Korenbaum et al., 2014, using signal compression technique, found low- and high-speed sound propagation components in the frequency range of 10-19 kHz.
Objective: A more detailed study of the characteristics of sound transmission in human lungs in the frequency range of 10-19 kHz.
Method: The 14-channel receiving apparatus with accelerometer sensors having a linear performance up to 20 kHz was used. Chirp signals 10-19 kHz (6 min) were emitted into human

thorax by small shaker. A convolution of emitted and received signals was used. Sound propagation in human lungs was studied in paths with opposite chest positions of shaker and sensors in 4 volunteers.
Results: The possibility of decomposition of the received signals into high- and low-speed arrivals is verified in independent sample. The existence of low-speed arrivals with propagation velocities of 150-50 m/s, which amplitude and/or velocity is inversely dependent on the air-filling of lungs (inspiration/exhalation) has been revealed. These arrivals may be treated as a result of sound propagation mainly through the lung parenchyma. On the contrary, the amplitudes of high-speed arrivals with velocities of 150-1000 m/s are enhanced with a decrease in air-filling of lungs. Thus they may be connected to the sound propagation mainly through high-density tissues of thorax. The 4 variants of the ratio of the amplitudes of high- and low-speed arrivals have been found. Only one of them is characterized by the predominance of amplitudes of high-speed arrivals, both during inspiration and exhalation, which may be acoustically interpreted as a reduction in air-filling/ventilation of lung parenchyma.
The study was supported by the RFBR grant 16-08-00075-a.

Contribution ID: 127
1. Diagnostic Imaging
01.09. Ultrasound imaging and optical coherence tomography

Interpretation of peak density in high-frequency ultrasound of basal cell carcinoma specimens

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Mohs surgery is a specialized surgery performed on basal cell carcinoma and melanoma skin cancer where slices of skin tissue are removed sequentially and deeper into the tissue after the tumor is excised. Each consecutive slice is examined by standard pathology between excisions. The surgery typically lasts four hours or longer due to the slow process of pathology, but technology for determining tissue malignancy rapidly, accurately, and with high sensitivity would greatly shorten the procedure time. A high-frequency (HF) ultrasound method (10-100 MHz) developed at Utah Valley University has shown promise as a diagnostic tool for breast cancer specimens. The method uses through-transmission measurements of tissue specimens and the parameter peak density. Peak density is the number of peaks in a specified frequency range of the ultrasound spectrum, and correlates to the nuclear diameter of cells in the tissue. Peak density was not only able to differentiate malignant from normal breast tissue specimens, but was also able to identify different types of atypical pathologies and cancers.
The objective of this review is to understand an initial analysis of HF ultrasound data from basal cell carcinoma tested at the Huntsman Cancer Institute. As with breast cancer, the initial skin cancer analysis demonstrated that peak density was able to differentiate between normal and malignant tissue. In data comparisons, however, the observed peak density values in breast cancer specimens were at higher frequencies than in skin cancer specimens, thus suggesting that either larger nuclei or other large scatterers were disrupting the wave being detected in the skin cancer specimens. The purpose of this review is to propose possible explanations for this shift in peak density as a function of frequency, specifically by examining the histopathology differences between skin tissue and glandular breast tissue, both malignant and benign.

Contribution ID: 128
1. Diagnostic Imaging

01.09. Ultrasound imaging and optical coherence tomography

Tortuosity and inflection density analysis for improving breast cancer detection using high-frequency ultrasound

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Background: A high-frequency (HF) ultrasound method, operating in the 20-80 MHz range, was developed at the Biomedical Cancer Research Laboratory at Utah Valley University to analyze tissue samples in real time during breast conservation surgery. Since tissue malignancy changes the cells' characteristics, malignant cells show different responses to HF ultrasound waves compared with benign cells. The UVU method has been tested using cell-level computational models, breast tissue phantoms, and excised breast tissue specimens. Analysis shows high sensitivity for malignant versus benign tumors when compared in the frequency domain using the peak density parameter, the number of peaks and valleys in a specific frequency range.
Objective: Our objective was to expand upon the use of peaks and valleys in HF ultrasonic spectra by analyzing their tortuosity and inflection density. Tortuosity measures the curviness or contortedness of the spectral trace, while inflection density determines the number of points within the spectra where the curvature changes. Combining these two parameters should provide more accurate results than using peak density alone. When accuracy, sensitivity, and specificity for peak density and inflection density are computed for tissue specimens, preliminary results show that there is a strong correlation between these two parameters.
Method and Results: A computational model was developed to study tumor progression in lobular carcinoma in situ using a vector multipole approach to simulate scattering of ultrasound waves in malignant breast tissue containing 1000-2000 nucleated cells. The resultant spectra produced peak density values that correlated to tumor progression and breast cancer type, whereas tortuosity values correlated specifically to malignant cell proliferation. The results of this study indicate that tortuosity and inflection density are complementary to peak density, and together should provide a more powerful analysis technique for the histological typing and microscopic classification of breast tumor margins.

Contribution ID: 129
1. Diagnostic Imaging
01.09. Ultrasound imaging and optical coherence tomography

Phantom results indicate that high-frequency ultrasound directly measures nuclear diameter in breast cancer detection

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Background: Utah Valley University (UVU) has been developing a method for carcinoma detection during surgery using high-frequency (HF) ultrasound operated in through-transmission mode at 10-100 MHz. A 73-patient study conducted at the Huntsman Cancer Institute (Salt Lake City, Utah) in 2014 tested breast cancer specimens with the HF method, and produced a sensitivity and specificity of 82.6% and 72.3%, respectively, for margins, and 87.5% and 82.9%, respectively, for lymph nodes. The HF method uses a new parameter that correlates not only to malignant versus benign tissue, but also to various types of breast cancer and breast pathologies. This parameter measures the number of peaks in the HF ultrasonic spectrum, and is called peak density. The data

indicates that peak density increases successively for atypical, premalignant, and malignant tissue as compared to normal tissue. Recent efforts at UVU have incorporated the HF method into a set of “smart” forceps for the in vivo evaluation of margins and lymph nodes within the surgical cavity.
Objective: This study’s objective was to test the hypothesis that HF ultrasound, specifically the parameter peak density, measures the nuclear diameter of the cells in the tested tissue.
Methods and Results: A computer model of Mie scattering from a single, nucleated cell was used to calculate ultrasonic spectral peaks in the 10-100 MHz band as a function of nuclear diameter. Experiments were also conducted with tissue phantoms containing microspheres. Microsphere diameters varied from 10-102 μm per specimen. The phantoms were tested with both conventional ultrasonic transducers and ultrasound-instrumented forceps. The waveform data were converted into spectra using a Fourier transform. The model and phantom results confirmed the hypothesis that peak density directly correlates to nuclear diameter. This study was vital to the development of the forceps and to the validation of the HF method.

Contribution ID: 201
1. Diagnostic Imaging
01.09. Ultrasound imaging and optical coherence tomography

The sensitivity of high-frequency ultrasound to micro-inclusion size and its implications for breast cancer detection

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A key issue in breast conservation surgery is the high percentage of additional surgeries needed to remove residual cancer not identified during the initial operation. At Utah Valley University, a high-frequency (10-100 MHz) ultrasonic method is being developed as a rapid, intraoperative method for detecting residual breast cancer in surgical margins. This approach uses peak density, a parameter that measures the number of scattered peaks in the ultrasonic spectrum. To better understand the sensitivity of peak density to breast cancer, a phantom study was performed to determine the effects of micro-inclusion (e.g., cell nucleus) size in tissue.
The hypothesis was that the peak densities of mixtures of micro-inclusions of different sizes would be linearly additive, since the peaks would most likely occur at different frequencies and would not coincide with (i.e., mask) each other.
Phantoms were created from distilled water, agarose powder, 10X TBE stock solution, and polyethylene microspheres (0.1% concentration) to simulate micro-inclusions. Phantom models were produced to compare the effects of a single pathology (one microsphere size) with a mixed pathology (two microsphere sizes). Microsphere diameters were 19, 49, and 58 µm. Mixed phantom models consisted of 19+49-µm and 19+58-µm microspheres. Through-transmission measurements were acquired at 50 MHz using a high-frequency ultrasound system.
Peak densities from the mixed microsphere specimens reflected those from the larger microsphere specimens (49-µm and 58-µm), indicating that peak density was not additive. It also showed that the scattering from the larger microspheres dominated in amplitude over the smaller microspheres (19-µm). Since cancer cells have larger nuclei than nonmalignant cells, they should produce greater scattering amplitudes in tissue and dominate over scattering from normal cells. Therefore, high-frequency ultrasound will be particularly sensitive to cancer cells over normal cells in tissue with mixed pathology, and will be effective for detecting residual cancer in margins.

Contribution ID: 259
1. Diagnostic Imaging

01.09. Ultrasound imaging and optical coherence tomography

Use of compressed sensing applied to ultrasound RF raw data in the formation of harmonic imaging

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The study of sparse ultrasound imaging has gained much attention from the scientific community in the last few years. In this work, we present the results of the application of compressed sensing to the raw data of each ultrasound reception channel used in the formation of harmonic ultrasound imaging. Harmonic imaging differs from the classical B-Mode imaging in the sense that it uses signals with twice the center frequency of the ultrasonic transducer, making it necessary to use a higher sampling frequency. For the image formation, we simulated the acoustic response of a numerical phantom in Field II with a linear transducer with center frequency of 3.5 MHz sampled at 35 MHz, obtaining a set of vectors representing the RF raw data of the receiving channels. Later, we used MATLAB to obtain undersampled versions of this raw data by multiplying each vector obtained in the simulation by a random matrix with Gaussian distribution. We used five different matrices with different sizes, leading to five undersampled versions of the raw data. The length of the undersampled vectors were equivalent to the length of the vectors that would be obtained if the data had been sampled at 3.5, 7, 14, 21 and 28 MHz. We used DCT transform as representation basis and l1-MAGIC toolbox to recover the ultrasound signal and then used the recovered vectors to build harmonic images of the phantom. We compared these images with the reference harmonic image (data sampled at 35 MHz), obtaining visually similar images only when using vectors with equivalent sampling frequency of 21 and 28 MHz. The images Structural Similarity Index – SSIMs were calculated and we obtained SSIM ≥ 0.8 for 21 MHz image and SSIM ≥ 0.9 for 28 MHz image.

Contribution ID: 415
1. Diagnostic Imaging
01.09. Ultrasound imaging and optical coherence tomography

High-frequency ultrasound (20-80 MHz) for breast cancer detection in surgical margins: Results from a 73-patient study

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High-frequency (HF) ultrasound has potential to be an effective, inexpensive, and real time method for determining tissue pathology and detecting cancer during surgery. An example of an application that could significantly benefit from HF ultrasound is the detection of residual cancer in surgical margins during breast conservation surgery (BCS). The development of HF ultrasound as an intraoperative tool for BCS promises to greatly reduce the rate of re-excisions due to positive breast tissue margins. HF ultrasound was previously used in a 17-patient BCS pilot study to determine the pathology of 34 surgical margins. Results from this study showed a sensitivity, specificity, and accuracy of 76.9%, 82.8%, and 80.0%, respectively, and demonstrated the potential of HF ultrasound as a breast cancer detection tool. A larger study of this method was subsequently conducted using 349 margin specimens collected from 73 patients during BCS. Specimens ranged from 1-5 cm in length and width, 0.2-1.6 cm in thickness, and required no additional procedures or resection that affected the patient or surgical outcome. Each specimen was tested with HF ultrasound immediately following resection and then forwarded to the pathology

lab. Through-transmission waveforms were collected using two broadband, single-element, 50-MHz transducers; a HF square-wave pulser/receiver; and a 1-GHz digital oscilloscope. Peak density and attenuation were calculated for each margin specimen and then combined in a multivariate analysis. Peak density correlates to the nuclear diameter of the tissue cells, while attenuation correlates more directly to tissue material properties. The multivariate analysis provided a sensitivity, specificity, and accuracy of 82.6%, 72.3%, and 72.7%, respectively. The results of this study show potential for a rapid and inexpensive method for determining the pathology of surgical margins during BCS. Research supported by funds from the Elsa U. Pardee Foundation, the Eppley Foundation for Research, and the State of Utah.

Contribution ID: 463
1. Diagnostic Imaging
01.09. Ultrasound imaging and optical coherence tomography

High-frequency ultrasound for evaluating sentinel lymph nodes during breast conservation surgery

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Standard practice for identifying metastatic breast cancer in the lymphatic system requires analyzing the resected sentinel lymph nodes (SLNs) in the pathology lab. Various specimen assessment techniques have been applied to determine SLN status intraoperatively. However, each method requires the removal of SLNs and a time-consuming in vitro analysis. Additionally, if malignant cells are identified in one or more SLNs, a surgeon may perform a potentially unnecessary axillary lymph node dissection (ALND). A study of breast cancer survivors found that lymphedema occurred in approximately 50% of patients after ALND. Other complications including shoulder dysfunction, wound infection, nerve damage, numbness, and chronic pain. Accurate analysis of SLNs during breast conservation surgery (BCS) would reduce the multiple operations and complications associated with unnecessarily removal of normal SLNs.
A high-frequency (HF) ultrasonic method was developed to evaluate surgical margins and SLNs. This method was tested at the Huntsman Cancer Institute to evaluate 78 lymph nodes from 39 BCS patients to identify metastatic breast cancer. Point measurements were collected from resected lymph nodes and attenuation was calculated using the peak amplitudes of time-domain waveforms. Peak density (the number of peaks and valleys in the 20-80 MHz range) was calculated using the waveforms' power spectra. A multivariate analysis and Fisher's Exact test were utilized to compute the accuracy (87.0%), sensitivity (87.5%), and specificity (86.9%) of the method. The results demonstrate that the HF ultrasonic method is very sensitive in identifying malignant lymph nodes. The method can be used by surgeons both ex vivo on excised specimens and in vivo in the form of ultrasound-instrumented forceps, providing a diagnostic intraoperative instrument for lymph nodes, breast tissue, and other soft tissues. This would reduce the pain, cost, and side effects that many patients currently suffer from, and the unnecessary removal of unaffected tissue.

Contribution ID: 1370
1. Diagnostic Imaging
01.09. Ultrasound imaging and optical coherence tomography

Training towards precise control over muscle activity with the real time biofeedback based on Ultrasound Imaging

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Ultrasound Imaging (USI) enables non-invasively monitoring muscle structures during movement. Computer algorithms, such as feature tracking, can automatically quantify changes in muscle characteristics (thickness, fascicle orientation), detecting even muscle twitches. Typically, these methods are computationally expensive, and can only be used offline. If provided in real-time, detailed information about muscle movement from B-mode ultrasound could help with muscle training.
We propose a new technique based on analysis of changes in pixel intensity between frames of USI video stream that can process a recording within seconds. The aim of this study is to validate this method and verify if it can be used in feedback training of muscle activation.
15 able-bodied volunteers took part in the study over two sessions. They were seated with a foot resting on a force plate of dynamometer. A linear ultrasound probe was positioned over the gastrocnemius muscle. Participants were practising minimum, weak and medium contractions ('attempted', 10% and 25% of the maximum, respectively), in isometric and isotonic conditions. Within a few seconds of each trial, they received visual feedback reflecting the USI analysis, visualising how close their attempt was to the target, allowing them to modify their strategy for the next trial.
Among the participants, a tendency to get closer to the target from trial to trial was recorded for 60.1%, 74.4%, 67.8% of trials for attempted, weak and medium contractions, respectively. Considering the successful trials (those within 10% of the target) 47% of people improved in the second session in the attempted movement task, 73% in weak and 33% in medium contraction (another 33% achieved the same result in both sessions).
We demonstrated that the method provides easily interpreted feedback of muscle contraction in semi-real time (immediately after trial completion), enabling training of muscle activation. Ultrasound feedback improved awareness of fine control of movement.

Contribution ID: 283
1. Diagnostic Imaging
01.10. Optical imaging and microscopy

Development of computer vision techniques to inspect the cytoskeleton rearrangement during stem cell aggregation in time lapse microscopy

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Stem cells can differentiate into diverse specialized cells and this ability can repair and replenish the human body. They bring conventional medicine into a new turning point and therefore become very important in modern medicine. Recently, regenerative medicine focuses on artificially grown stem cells in vitro, then implanting them into human body to help self-recovery. Dynamic behavior of stem cells during in vitro development is diverse and strongly related to the rearrangement of cytoskeleton and a number of intracellular signaling. The cytoskeleton is an intricate network of protein filaments that support the cell architecture and dominate cell motility by performing contractility. The structure of cytoskeleton is continuously reorganized as a cell changes shape, divides, and responds to its environment. Therefore, investigation into its dynamic structural variation gives a clue to understand the biological functional change of the cell. However, current fluorescence microscopic techniques limit to observation on static structure of the cytoskeleton. This study developed a textural-feature extraction technique with the cell segmentation and tracking algorithms to extract the cytoskeleton in the cell images obtained from time-lapse microscopy, and allowed the investigation into the dynamic structure of cytoskeleton during cell

migration. Mesenchymal stem cells (MSCs) cultured in chitosan membranes were investigated in this study. The results show that the texture of single MSCs revealed a transformation from a concentric pattern into a specific directional pattern which corresponded to their moving directions during cell aggregation. In addition, the high correspondence between the textural patterns and the cytoskeleton structures was verified using fluorescence microscopy. Hence, the developed cell image processing techniques may provide a direct and convenient way to inspect the dynamic arrangement of cytoskeleton during cell movement without immuno-fluorescence staining.

Contribution ID: 1793
1. Diagnostic Imaging
01.10. Optical imaging and microscopy

Biaxial ankle movements as an fNIRS example to analyze neural plasticity in chronic post-stroke hemiparetic gait

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The independent gait with the speed is a primary aim on motor rehabilitation for patient with post-stroke hemiparesis. This study investigated functional near infrared spectroscopy (fNIRS) imaging activation pattern for its possibility to regain motor learning in the chronic stage of post-stroke hemiparesis. Ankle movements are important to prevent accidental falls during swing phase of gait cycle due to an unconscious event of sudden foot drop. The ankle passive movement due to gravity during swing phase is independent to the descending signals from primary motor cortex. Thus, an fNIRS activation pattern during involuntary ankle passive movements has sound validity for the series of studies on walking-related ankle movement interventions. A custom robotic device was developed to present isokinetic passive bi-axial ankle movements along ankle and subtalar axes; Inversion, Eversion, Plantar flexion and Dorsiflexion. Total 16 movements of 15 degrees to each direction were randomly presented at 3 degrees per seconds while a subject was comfortably seated with a hemiparetic foot was fastened on the moving foot cradle. 12 age matched healthy elderly subjects consistently disengaged motor related brain area during passive movements primarily because most proprioceptive afferent via posterior spinocerebellar tract reach the ipsilateral cerebellar cortex. 15 subjects with chronic post-stroke hemiparesis mostly engaged contralateral primary sensorimotor cortex and premotor cortex during plantar flexion. Some hemiparetic subjects showed significantly higher spot-like activation in contralateral primary motor cortex during dorsiflexion and eversion. Repetitive passive ankle movements may have permanent effects on post-stroke hemiparetic ankle. We demonstrated that the hemiparetic neural activity during ankle bi-axial passive movements has a practical possibility to assess the brain plasticity indirectly. The ankle-induced neural activity may work for an neuro-physiological attempt of the simple, easy-to-access and effective gait rehabilitation training.

Contribution ID: 570
1. Diagnostic Imaging
01.11. Molecular imaging (SPECT, PET, optical)

Mathematical approach for adding scattered events in image reconstruction by recognizing scattering points in positron emission tomography

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In positron emission tomography (PET) Compton scattering from the object phantom constitutes 40-60%

of total data. Previously, scattered events were rejected from image reconstruction process. But with the advent of detectors with good energy and time resolution, researchers are now interested in adding scattered events in image reconstruction instead of removing it. In this simulation based work, we have used event-by-event (list-mode) data collection scheme to sort out energy and time information for each event. At first, idealistic assumptions for a 2D PET scan setup were made, e.g., exact energy and time information and uniform attenuating phantom medium. Using Compton kinetic equation, locus of scattering points of the single scattered event was calculated and it turned out to be two equal radius circles intersecting each other at two photon detection points. We defined a mathematical distribution function (W) for photons getting scattered in infinitely extended phantom medium with same attenuation coefficient as used in PET scan.
All events of PET scan data were transformed by introducing a virtual medium outside PET detector ring and imagining that there was no PET detector to detect those photons. Hence, each event can be seen as data value for distribution function (W). The transformation process is such that only those data values, which correspond to true scattering points, will obey distribution function (W). We have succeeded in identifying the true scattering point which enables us to add scattered events in image reconstruction. Finally, to evaluate performance characteristics of our data analysis scheme for finite energy resolution case, we have assumed energy resolution ranging from 0.1% to 2% FWHM at 511 keV. So far, we have shown that our mathematical model was still able to recognize original scattering point for low values of energy resolution.

Contribution ID: 1248
1. Diagnostic Imaging
01.11. Molecular imaging (SPECT, PET, optical)

Measurement of the accuracy of event positioning in a gamma ray detector by different algorithms

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Event positioning accuracy in a gamma ray detector was measured. Detector was an array of 24x24 LYSO scintillator crystals, attached to one side of PMMA lightguide brick and opposite side of the lightguide was attached to 8x8 array of silicone photomultipliers. Each scinitllator crystal was 2,4 mm x 2,4 mm x 13 mm in size with front and lateral surfaces covered by mirror scotch tape to optically isolate crystals from each other, while rear surface was optically coupled to PMMA lightguide. Na22 point source and 20mm thick lead block with 1.2 mm pinhole collimator were used to directly irradiate each scintillator crystal individually, so that position of the event was known a

priori. Sum of row readouts and sum of column readouts were used as raw data to establish event positions. Positions of events were estimated by center-of-gravity algorithm, truncated center-of-gravity algorithm, amplitude-weighted and position-weighted iterative algorithms. Energy filtration was applied.
Center-of-gravity algorithm resulted in noisy and geometrically distorted image, with high noise between crystals. Calculation speed was maximum compared to other algorithms used.
Truncated center-of-gravity algorithm resulted in less distorted image with significantly lower noise between crystals. Calculation speed was just a little bit slow compared to the center-of-gravity algorithm.
Position-weighted iterative algorithm showed visually the best positioning quality with most sharp peaks corresponding to single crystals and minimum noise between crystals. Gaussian peak shape was used because raw data was sum of row or column of photomultipliers and sum of individual gaussian distributions with the same center is also gaussian distribution. Calculation speed was slow due to iterative nature of algorithm but modern multicore processors can help to improve computation speed because task has good parallelism ability.

Contribution ID: 417
1. Diagnostic Imaging
01.12. Multimodality imaging

Material analysis for a new kind of hybrid phantoms utilized in multimodal imaging

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The use of new materials in phantoms for medical imaging is of increasing importance, especially concerning hybrid imaging technologies. The purpose of this study was to find new materials suitable for hybrid phantoms which can be used in magnet resonance imaging (MRI), radiology (Rad) and nuclear medicine (Nuc).
Suitable phantom materials have to meet the requirements: tissue-equivalent relaxation and absorption/scattering coefficients, material stability/strength to reproduce tissue structures, chemical and physical stability, no material infestation of bacteria, cost-effective use.
The material samples (m=100g) were based on different amounts of basic components: carrageenan (3%,m/m), agarose (0.8-1.0%,m/m), GdCl3 (30-100µmol/kg), NaNO3 (antiseptic agent, <0.1%,m/m) and H2O. Additional modifiers of different concentrations (1-25%,m/m) were added: Ba(NO3)2, SiO2, CuSO4, MgCl2. These modifiers influence the relaxation times (MRI) and abortion characteristics (Rad/Nuc). The modifiers were chosen according to free electrons, electron-spin-relaxation-time, effective density and atomic number.
For tissue-equivalency, T1/T2-times and Hounsfield Units (HU) of material samples were compared to various human tissues after performing the following experiments: MRI-relaxometry was measured using an inversion recovery and a spin echo sequence at a 1.5T MRI scanner (MAGNETOM Vision, Siemens Healthcare). HU were acquired at 80kV/110kV/130kV using a CT scanner (SOMATOM Emotion, Siemens Healthcare). For nuclear medicine, material samples (10MBq, TC-99m) were examined in a water-phantom utilizing a SPECT-system (PRISM1000, Intermedical).

Tissue structures as soft-tissue, brain (gray/white matter), kidney, and liver can be simulated with high accuracy (<10% deviation in T1/T2-times and HU) using (Ba(NO3)2 as an additional modifier, which meets all requirements and covers T1/T2-times of 700-1400ms/50-80ms and 12-740HU. Functional relationships were investigated by describing the T1/T2-times, depending on the T1/T2-modifier concentrations. Other modifiers did not meet all tissue-equivalent characteristics. Our gel-based approach can also be used in nuclear medicine to generate active tissue structures, e.g. hot nodules with TC-99m. Future research will cover the material eligibility for ultrasound.

Contribution ID: 1359
1. Diagnostic Imaging
01.12. Multimodality imaging

Can DTI isotropic p-map improve detection of tumor extension in patients with postoperative glioblastoma: T2 FLAIR/T2 images versus DTI p-map

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Background and Purpose: Accurate delineation of the clinical target volume (CTV) includes postoperative peritumoral edema plus a 2 cm margin (RTOG) that is challenging issue in radiation treatment of GBM. The aim was to compare the extension of hyperintense pathological regions extracted from diffusion tensor imaging (DTI) isotropic map (p-map) with current radiographically (T2/ T2-FLAIR) method.
Method: 17 patients with GBM were selected who were candidate for radiotherapy. T2/T2-FLAIR images and DTI were acquired before radiotherapy. DTI images were processed using Explore DTI (Version 4.8) software. Motion and eddy current correction, three eigenvalues(λ1, λ2, λ3) and mean diffusivity (MD or D) were computed and used to calculate isotropic component (p=√3D). p map as well as T2, T2-FLAIR images were co-registered using a standard 3D cubic B-spline transformation with normalized mutual information cost function. Hyperintense abnormalities on T2/T2-FLAIR and DTI-p map were segmented by a radiologist with 10 years of experience in neuro-oncology. Pathological region area was calculated for each region. Difference percentage between extracted regions from three modalities were calculated for each patient. Discordance Index (DI) was used to evaluate the degree of similarity in location between pathological regions.
Results: The abnormality area in the p map was smaller than in the T2 and T2 -FLAIR images in all patients with mean difference percentage of 32% ± 0.14 and 37% ± 0.15, respectively. Lack of concordance was observed ranged from: FLAIR/p: 0.21 - 0.772 (average: 0.458 ± 0.18), T2 /p map: 0.258 - 0.781 (average: 0.441 ± 0.13).
Discussion: Radiotherapy planning is based upon hyperintensity region on T2/T2 -FLAIR images despite its known lack of specificity in the detection of subclini¬cal tumor infiltration and white matter disruption. The primarily results of this study highlight the importance of tumor delineation based on either T2 or T2 FLAIR or DTI-derived maps.

Contribution ID: 1505
1. Diagnostic Imaging
01.12. Multimodality imaging

Cardiac magnetic resonance imaging and electroanatomic mapping data semi-automatic merging

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For cardiac physiology examination, two methods are currently widely used. CMR and electrophysiological mapping method using BioSense Webster's CARTO system. If we want to analyze the condition of the patient in terms of possible cardiac arrhythmias, both methods have their place in the diagnosis process. While CMR provides information on mechanical contraction of the heart over time, the electrophysiological mapping method allows for the examination of any deviations from the healthy state based on electrical potentials spreading across the surface of the endocardium. From the cardiologist's point of view, both methods are extremely important. The aim of the project is to provide a functional tool able to map the output of the electrophysiological mapping to the surface of the exported model, constructed in Medviso Segment software, where further analysis and comparison with mechanical strain maps and other electrophysiological outputs can be performed. Output from the CARTO 3 exam provides a rough static heart model with the Local Activation Time (LAT) parameter recorded in the triangle point network on the surface of the model. A similar model can be obtained from CMR data by Medviso Segment software. The major problem with the possible comparison of these structures is the high degree of inaccuracy of the CARTO 3 module. It spatially corresponds to the diameter of the tissue position in one heart cycle and is therefore difficult to assign to any particular anatomical model of the heart. To compare the acquired mechanical and electrophysiological parameters, it is necessary to construct a mathematical transformation that assigns the specific points of one model to the points of the second model. Despite the user dependence and artifacts, method has lower order error than the errors already contained in the model. For this reason, this method is a suitable solution for clinical practice.

Contribution ID: 230
1. Diagnostic Imaging
01.13. Quality assurance/control (QA/QC)

CT spectrometry with a portable Compton spectrometer with stationary and moving tube

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The knowledge of energy spectra of CT X-ray beams is essential for many purposes. Particularly with measured spectra it is possible to get parameters that characterize a specific beam quality and equipment performance. However, CT photon fluxes are too high to be directly measured with most of photon counting detectors. In this sense, this work describes a Compton spectrometer designed in IF-USP LRDMP lab, based on a CdTe detector with proper Al-Pb-Al collimators and shields, to obtain spectra of CT beams. It is based on the measurement of the spectrum of 90o-scattered CT beams. A computer program was developed in MatLab® environment, to correct the

experimental spectra, and reconstruct the primary beam incident on the scatterer from the measured scattered one, including the Waller-Hartree formalism. Tests at LRDMP lab with direct and scattered standard CT beams showed, after processing and normalization, similarity between the reconstructed and the correspondent directly measured beam spectrum. Shielding and scatterer thickness influence on the outcomes was carefully investigated. The system was tested in clinical measurements in a GE690 CT scanner, at a hospital, showing practical positioning on the exam table, using the CT lasers and scout radiographies for alignment. The HVL values obtained with the reconstructed spectra and the stationary tube agree within 3% with those measured in QC tests with ionization chambers. We also double-checked, with good accuracy, the actual scattering angle and the kVp values, through the shift in energy of the K lines and the spectra end point, respectively. Furthermore, measurements with a rotating tube have been made, showing that the accumulated spectrum shape is similar to that obtained with the stationary tube. Although several exposures might be necessary to acquire each beam spectrum with good statistics, the total acquisition time was no longer than two minutes for each spectrum.

Contribution ID: 449
1. Diagnostic Imaging
01.13. Quality assurance/control (QA/QC)

Acquisition Parameters and DTI Measures for 8-Channel and 32-Channel Head Coils: A Fiber Phantom Study

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Diffusion tensor images (DTI) have several applications in many areas of medicine. However, the measured signal is susceptible to noise and artifacts, making it important to check if these factors do not compromise the parameters calculated from the images. Given that there is no standard quality control routine for this kind of images, this work evaluated how the Diffusion Tensor Imaging indices (DTIi) are related to acquisition parameters for an 8-channel and a 32-channel head coil. The study was performed using an in-house developed anisotropic diffusion phantom. DTI acquisitions were performed in a 3T MRI scanner using an 8 and a 32-channel head coil. The phantom had 3 Dyneema fiber bundles, each with a different fiber diameter. For each coil, the following acquisition parameters were changed, one at a time: b-value, echo time (TE), number of averages (NSA), Sensitivity Encoding factor (SENSE), voxel size and the number of directions of diffusion gradients (NDGD). For each acquisition, the DTIi calculated were: mean diffusivity (MD), fractional anisotropy (FA), relative anisotropy (RA), volume ratio (VR), sphericity (CS), linearity (CL) and planarity (CP). Coefficients of Variation (CV) and correlations were evaluated for each DTIi. We found correlation between DTIi and acquisition parameters for both coils tested. The most correlated acquisition parameters (with DTIi) were NDGD, followed by b-value and NSA, for the 8-channel coil and the lowest diameter fiber bundle of the phantom. The DTIi that seemed most susceptible to acquisition parameter changes were FA, CS and CP. The highest CV value was found for CS, CL and CP, when NSA was changed, for the 32-channel coil. The relation between acquisition parameters and DTIi is not yet well-defined. However, it was found that the acquisition parameters that most influence DTIi were the parameters related to diffusion-weighting, for the 8-channel head coil.

Contribution ID: 931

1. Diagnostic Imaging
01.13. Quality assurance/control (QA/QC)

In the case of CT and other X-ray machines, the failure rules and operation quality assurance measures are studied

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Objective: to improve the maintenance efficiency of radio-imaging equipment to ensure its high quality operation. Methods: based on a variety of medical equipment maintenance practice for many years, through the PICKER 6000 CT machine, GE - AMX_ + mobile bedside X-ray machine, Toshiba two row CT machines, Siemens dual-source CT more than two, cardiovascular ZaoYingJi mobile X-ray machine, GE C arm maintenance examples, analysis the failure reason and type. Results: the failure can be divided into five main types and three main reasons, and analyzed the percentage of each fault type and reason, and summarized the failure tendency of 4 medical devices. Finally, six measures to ensure the operation quality and safety of medical devices are put forward. Conclusion: this study can improve the use and maintenance efficiency of instrument and equipment, and can guarantee the operation quality of medical instrument and reduce the medical cost.

Contribution ID: 1201
1. Diagnostic Imaging
01.13. Quality assurance/control (QA/QC)

Quality control in computed tomography

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Images obtained by computed tomography (CT) devices have a high resolution, which allows distinguishing the densities of the tissues. However, this method of imaging provides a higher dose for the patient. To ensure CT image quality, quality control (QA) of equipment's is performed, which includes control tests that are part of a quality assurance program.
There are several guidelines for a QA. In Brazil, the major document that rules the methods of QA in radiodiagnostic it's the Portaria 451/MS. The document doesn't describe the methodology suitable for modern technologies, each of which recommend different time intervals and tests, so each radiodiagnostic services use the manual of manufacturer as a deepened guide.
The objective of this research is to unify a methodology of tests using only one type of phantom instead of the phantoms from each device.
The research is being done in the Hospital de Clinicas de Porto Alegre-Brazil (HCPA). Three types of CT devices were used: GE Brightspeed Edge 8-Slice, Toshiba Aquilion One TSX-301A, and Phillips Brillance CT 16 Power. The phantom used were: the ACR CT Accreditation phantom and phantoms from the CT devices analyzed. Tests like: noise and uniformity, low and high contrast
resolution and CT number were reproduced following the manual of manufacturer with the ACR phantom and manufactures´ phantoms.

The preliminary results showed that the values obtained with ACR phantom are similar, in 90% of the tests, compared with those obtained with manufactures´ phantoms. However, disagreements were found when comparing the CT numbers of different materials for the phantoms.

Contribution ID: 282
1. Diagnostic Imaging
01.15. Image quality measures

Influence of image resolution property on aliasing error of digital Wiener Spectrum

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The noise properties of a radiography system are commonly described by its wiener spectrum (WS). The virtual slit and two-dimensional discrete Fourier transfer (2D-DFT) methods are the two most commonly used and accepted techniques for measuring the digital WS. The 2D-DFT method has been adopted by the International Electro technical Commission (IEC) as noise power spectrum. However, the digital WS contains effect of aliasing error and this error depends on the resolution property of the digital radiography (DR) system. The aim of this work was to show the influence of the aliasing error for the digital WS when the image resolution property was changed.
We examined the influence of the aliasing error using simulated noise images. Two kinds of noise images with different image resolution property were generated by using the Image-J (National Institutes of Health: NIH).These images simulated the image resolutions of an indirect and direct Flat Panel Detector (FPD). The theoretical WS of the simulation noise image can be derived from an analytic numerical formula and added noise. Simulated noise images were analyzed using 2D-DFT method. WS values calculated from those simulation images were compared with the theoretical WS values.
The WS values in the indirect and direct FPD increased, compared with the theoretical WS values. The average relative differences for frequencies up to the Nyquist frequency were 27.9% and 85.2% respectively.
The results showed that the degree of the influence of aliasing error for digital WS depend to a large extent on the resolution property of the DR system. Therefore, we should take account of the impact on aliasing error of digital WS in comparison between DR systems with different resolution property.

Contribution ID: 566
1. Diagnostic Imaging
01.15. Image quality measures

Evaluation of spatial resolution of MRI, optical CT and X-ray CT using MTF for gel dosimeter

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Gel dosimetry is chemical dosimeter used for 3-D dosimetry. Currently, the development of gel dosimeters is underway for the purpose of Q.A. of radiotherapy. The dose evaluation using MRI has been used to read irradiated information from the gel dosimeter in conventional research. Recently, gel dosimetry using dye gels is researched. The dye gel dosimeter cannot be read by MRI. Therefore we actively construct optical CT (OCT) apparatuses. It is necessary to quantitatively compare and evaluate between using MRI and using optical CT.
We made a new gelatin phantom to evaluate the spatial resolution of MRI OCT and X-ray CT(X-CT) using MTF. The phantom is consist of some 0.3 mm diameter air spaces put in spiral patterns to scan MRI OCT and X-CT. From the slice image of the phantom imaged by each device, to obtain the MTF of each device. The past phantom in concept to needle phantom employed by Oldham and Kim (Med.Phys.31 1093-104) cannot scan MRI.
Measurement of this phantom by MRI, X-CT and two in-house optical CT (0-D and 2-D OCT) was employed. As a result, 0.59 (MRI), 0.88 (0-D OCT), 0.89 (2-D OCT), and 1.07 (X-CT) were obtained as a result of Modulation transfer factor at 0.3 Spatial frequency [cycle / mm]. As expected, the spatial resolution of MRI was confirmed to be lower than that of other devices. We made a phantom using a stainless steel pins with the same geometrical arrangement, but we could not analyze it due to magnetic susceptibility artifacts occurred in MRI. From this, we believe that our new phantom is useful for conducting gel dosimetry research.

Contribution ID: 610
1. Diagnostic Imaging
01.15. Image quality measures

Phase-contrast breast-CT : optimization of experimental parameters and reconstruction algorithms

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X-ray breast computed tomography (breast-CT) is a new emerging technique for early breast cancer diagnosis however its application is still limited because of low spatial resolution and high delivered dose. In this framework, synchrotron radiation holds ideal x-ray imaging conditions. Tunable and monochromatic laminar x-ray beam allows to obtain images with high quality, low scatter and dose reduction, due to the selection of the most suitable energy for the given thickness and breast composition. Moreover, the high spatial coherence permits to exploit the phase-contrast effects enabling a better image quality and soft tissue separation.
At the Elettra synchrotron facility a project for in-vivo low-dose, high-contrast and high-resolution breast CT is under development using a high-efficiency photon-counting detector.
Due to the vertical size of the beam (~5 mm) the scan of the entire breast is done in several sub sequential vertical steps. Thus reducing the number of projections is essential to shorten the total acquisition time. Optimized preprocessing algorithms (phase-retrieval) and the state of the art of tomographic reconstruction methods are crucial to improve image quality.

The goal of this work is to compare the performances of standard and iterative reconstruction algorithms at different experimental conditions, evaluating quantitatively the image quality in terms of Contrast-to-Noise ratio and edge sharpness. For this purpose, CT scans of a mastectomy tissue have been acquired at a fixed glandular dose of 5 mGy, with different X-ray energies (32, 35 and 38 keV) and sets of projections (600, 900 and 1200 over 180 degrees). Iterative reconstruction algorithms show very promising results, compared to the gold standard Filtered Back Projection, with a limited number of projections, enabling to obtain images with high contrast and small loss of resolution.

Contribution ID: 612
1. Diagnostic Imaging
01.15. Image quality measures

Clinical validation of a model observer for lesion detection and discrimination tasks in low-dose abdominal CT images

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Assessment of image quality (IQ) in computed tomography (CT) is crucial to ensure correct diagnostic while maintaining radiation dose to the patient at the lowest as possible. Despite the wide use of CT scanner in diagnosis, evaluation of their performances in terms of dose/IQ remains poorly documented. In particular, the medical community is confronted with a lack of robust indicators of IQ. Indeed, commonly used objective physical metrics measurements are nowadays unsuitable for evaluating the IQ in diagnostic radiology especially with the development of iterative reconstruction algorithms. In this context, we propose to objectively evaluate the IQ according to a given clinical task by using a model observer approach, named Non Pre-Whitening Eye filter model (NPWE), well-known for its capacity to reproduce human observer skills. Two types of diagnostic tasks are addressed in this study: detection of small lesions with low contrast, and benign and malignant lesions discrimination. To this end, a torso-shaped water phantom was designed in which plastic water blocks with inserts of different sizes (<7mm), shapes and materials (epoxy resin andTeflon) can be inserted. This phantom was scanned on a GE Discovery 750 HD scanner with routine clinical standard adult abdomen protocols, in single-source mode at different tube voltages (80-140kV) and dual-source mode. The images were reconstructed with the adaptive statistical iterative reconstructed algorithm (ASIR). A wide range of CT dose indices were investigated, from very low dose values to higher ones(~1mGy-20mGy). A clinical study including a group of medical physicists and two senior radiologists as experimental observers was conducted to validate the model observer, by showing correlations between the human and model observers' responses for several cases of lesions and scanning protocols. This suggests the potential ability of our model to optimize the acquisition protocols by reducing the patient dose, while preserving correct diagnosis.

Contribution ID: 615
1. Diagnostic Imaging
01.15. Image quality measures

Studying the impact of tube performance on system image quality for interventional cardiology X-ray systems

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Purpose
This work compares the effect of the X-ray tube and ADRC programming of the newer Siemens Artis Q with the older Artis Zee, using a spatial frequency dependent figure of merit.
Materials and methods
Identical cardiac programs were installed on both systems and measurements were performed with image processing turned off. A phantom composed of 15 composite PMMA/aluminum plates was imaged and entrance air kerma rates (EAKR) were measured versus phantom thickness. Additionally, signal difference to noise ratio (SDNR) was measured using an iron insert centered in the phantom, located at the system isocenter. SDNR was then multiplied by MTF based correction factors for focal spot and motion blurring, giving a spatial frequency dependent parameter: SDNR(u). These MTF correction factors were evaluated at a spatial frequency of 1.4mm-1 and object motion of 25mm/s, which are typical for cardiac imaging. A generalized figure of merit (FOM) ($SDNR(u)^2/EAKR$), describing system efficiency, was then calculated for both systems. Although the same (nominal) x-ray detector model is installed in both units, specific differences in detector performance were accounted for by scaling the SDNR using a noise based correction factor. This minimized the influence of the detector on the comparison and thus reflects x-ray tube performance alone.
Results
The Artis Q gave considerably higher SDNR(u) and FOM results, when considered over all thicknesses (~78mm to ~390mm water equivalent). SDNR(u) increased by 30% and 40% while the FOM increased 51% and 94% for fluoroscopy and acquisition modes respectively.
Conclusion
The X-ray tube and ADRC programming were found to have a large effect on system performance and image quality, something that is often overlooked in favor of detector performance and image processing.

Contribution ID: 1783
1. Diagnostic Imaging
01.15. Image quality measures

Objective measurement of focal spot size and spatial resolution for general radiography using a real-time focus meter slit analysis

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This study used the slit method analysis for objective determination of focal spot size and characterization of spatial resolution using the modulation transfer function (MTF) for a general radiography x-ray tube. The slit device used is an RTI Real-time focus meter consisting of a 10 micrometer slit made of 99.9% Tantalum, an automatic trigger detector, and a digital panel detector eliminating the need for external image receptors. The device is capable of automatic determination of the line spread function for focal spot sizes down to 0.10mm and MTF calculation based on the IEC 60336, DIN 6823, and NEMA XR5 standards.

The MTF was obtained for the smaller focal spot, 0.6mm, of a computed radiography equipment with an E7252X Toshiba Rotanode X-ray tube (1.2mm and 0.6mm focal spot, IEC 60336:2005). The irradiation parameters used are 70kVp at 10mAs (100mA, 100ms) and an enlargement factor: E = 1.94, a slightly small enlargement factor which was limited by the fixed focal spot-to-collimator window and maximum slit to detector distance. The magnification factor (M=1.3) employed in the determination of the MTF is based on IEC 60336: 2005. Nine measurements of the line spread function (LSF) were made for dimensions: perpendicular to anode-cathode axis (width measurements) and parallel to anode-cathode axis (length measurements).
The average width and length measurements at 15% LSF for the 0.6mm focus are 0.622 mm and 0.920 mm respectively with an uncertainty of ±3.007%. The limiting spatial resolution (LSR) was obtained through the measured 10% MTF. For the length measurements, the averaged LSR is 2.462 lp/mm and the obtained average LSR from width measurements is 3.362 lp/mm. Both the measured values for the length and width dimensions of the focal spot image are within the permissible values for a nominal focal spot size of 0.6mm specified by the IEC 60336:2005.

Contribution ID: 332
1. Diagnostic Imaging
01.18. Preclinical imaging

Development of a laboratory based refraction-contrast imaging system using industrial x-ray tube

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X-ray imaging has been widespread diagnostic tool in medicine which is based on x-ray absorption. But little or no image contrast appears at regions with almost the same absorption coefficient of x-ray. Over the past 20 years, alternative imaging techniques based on x-ray refraction have been intensively explored and developed to overcome weak image contrast in soft tissue imaging by existing method based on x-ray absorption. Such alternative imaging techniques include in-line holographic phase-contrast imaging, angle-analyzer-based imaging, and crystal interferometry. All of these techniques can produce fine images of soft tissues when using synchrotron x-ray which provides both monochromatic x-ray with sufficient intensity and high directivity. Necessity of synchrotron facility for these alternative imaging techniques, however, is an obstacle for these techniques to prevail in the field of clinical medicine.
We tried to extract monochromatic x-ray beams with high directivity from an industrial x-ray tube to develop a laboratory based x-ray refraction contrast imaging system. X-ray generator with fixed anode x-ray tube (ISOVOLT Titan E; GE Measurement & Control Solutions) was used, whose target, output, and focus size were Mo, 3 kW, and 1 mm (V) by 5 mm (H), respectively. An asymmetrically cut silicon crystal, (220) diffraction and asymmetric angle of 8.9 degree, was introduced for a monochromator. X-ray photons were concentrated by inverting incidence and emergence direction of Si monochromator differently from ordinary use in refraction contrast imaging. Tube voltage and current were set to 40 kV and 5 mA, respectively. We successfully acquired vertically long line-shaped x-ray beam with 0.5 mm width of K alfa1 (17.5 keV), K alfa2 (17.4 keV), and K beta1 (19.6 keV) of Mo separately because the plane of incidence was horizontal. These monochromatic x-ray beams with high directivity would be utilized for refraction contrast imaging by line scanning method.

Contribution ID: 468
1. Diagnostic Imaging

01.18. Preclinical imaging

Co-registration of the dynamic current density map method applied to epilepsy surgery protocol

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A non-invasive method is developed to identify brain regions compatible with epileptogenic foci. It combines different programming techniques such as free software, electroencephalographic signal processing, MRI and CT image processing.
This method has been included in a protocol of epilepsy, in order to evaluate its performance compared with most commonly used techniques such as ECoG and SEEG.
Also, a method was incorporated to obtain a dynamic three-dimensional visualization of the electrical map during an epileptic seizure and to include it into a multimodal scene of a competent visualizer to assist those who are to make the diagnosis.
This method has been validated with ten patients (six males and four females) against the diagnosis of a medical specialist in the subject. Each of these patients was subjected to epilepsy protocol designed, which was included in the noninvasive method proposed. Within this protocol, there are different types of studies that aim to achieve a complete reading of the situation of each patient and try to establish a diagnosis as accurate as possible. We found that this method is consistent with the results obtained through ECoG and SEEG.

Contribution ID: 1334
1. Diagnostic Imaging
01.18. Preclinical imaging

A screening computer software for vestibular dysfunction

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This project is recommended by a doctor, form SWU, Thailand. According to the Vestibular dysfunction, one of the reasons cause vertigo, is not wildly known even medical society of Thailand. There is a few of doctors that have experience about the disease and diagnosis. In addition, the diagnosis can be wrong due to a fatigue of a doctor's eye muscles. So, using a computer software is beneficial for both doctors for supporting their diagnosis and patients who want to screen themselves before seeing doctor. This project is creating a computer software by using Python language with OpenCV and Dlib library. The software uses OpenCV: Haar cascade classifier to detect face and eyes, and Hough circle to find iris position in eye region and Dlib to detect facial landmarks. The software requires a diagnosis video to detect patient's face and iris while face is turning left and right. The software calculates position of the iris compare to facial landmarks and show graph of left and right iris then analysts duration of iris movement to determine whether a patient has the disorder. The result of the software looks promising, the software can detect face and iris while patient is turning in many angle and calculate the position of the iris and duration of iris movement accurately.

Contribution ID: 1820
1. Diagnostic Imaging

01.18. Preclinical imaging

Evaluation of Timepix3 based CdTe photon counting detector for fully spectroscopic small animal SPECT imaging

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The imaging method of SPECT (Single Photon Emission Computed Tomography) is used in nuclear medicine for diagnostics of various diseases or malfunctions of organs. The distribution of medically injected, inhaled, or ingested radionuclides (radiotracers) in the patient body is imaged using gamma-ray sensitive camera with suitable imaging collimator. Combining many such images taken at different observation angles the 3D image is calculated. Most of SPECT systems use scintillator based cameras. A scintillating screen converts gamma radiation to visible light which is collected and converted to electrical signal by photodetector. This detection principle does not provide good energy resolution and does not allow efficient suppression of unwanted signals such as Compton scattering.
The particle counting Timepix3 based camera with semiconductor sensor has many advantageous properties. It does not suffer from dead time since it uses event based readout, it records energy and detection time for each detected ionizing particle, it provides high detection efficiency and high spatial resolution.
The main goal of this work is evaluation of properties of Timepix3 CdTe detector for SPECT method. The Timepix3 properties such as energy and spatial resolution are exploited for image quality improvement suppressing unwanted signals such as Compton scattering in the sample volume. Thanks to suppression of background is possible to distinguish two neighbourhood objects that are not visible using standard scintillator cameras due to high intensity of background.
Preliminary measurements were performed on specially prepared plastic phantom with cavities filled by radioisotopes and then repeated with mouse in vivo. Plastic phantom was also used as a sample for the follow-up tomographic scan.
Small size and compact read-out electronics with excellent connectivity of USB3.0 allows construction of portable system composed of several Timepix3 units suitable for fully 3D SPECT imaging for preclinical and clinical practise.

Contribution ID: 1832
1. Diagnostic Imaging
01.18. Preclinical imaging

Low frequency acoustic response from biological tissues irradiated by a high frequency acoustic radiation pulse

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Quantitative characterization of the mechanical properties of biological tissue is of great importance to diagnostic pathological processes. For example, breast tumors like Fibroadenoma and carcinoma are generally stiffer than surrounding healthy tissue. Recently elastographic techniques are being explored to evaluate stiffness of soft tissues. In this work, a new technique that uses acoustic radiation force has been developed as an alternative to evaluate small differences in mechanical properties of biological tissues. This technique uses a single high-frequency pulse (MHz) to excite the medium. Non-linear interactions of this acoustic wave in the tissue produces a lower frequency signal (kHz) which is detected by a dedicated hydrophone. This signal carries information of mechanical and morphological properties of the studied region, therefore, it can be processed into images weighted in those characteristics. In this study, we tested the use of this technique to characterize and to generate images of soft and rigid tissue. In this work, a short focused acoustic radiation pulse (f=3.1 MHz, t=15 μs) was used to mechanically excite the sample and the low frequency acoustic response was acquired by a dedicated hydrophone (ITC 6050) with acquisition band going from 1kHz to 70 kHz. A phantom made of paraffin-gel to mimic the soft tissue, containing three inclusions of the same based material with different stiffnesses and the same acoustic impedance was used to generate the acoustic images. The technique was also evaluated using femur bones extracted from mice. The spectral analyses and of the acoustic response has been made. Also, images based on this spectral analysis were generated. Contrast have been seen for different stiffness in the phantom and for different trabecular bone structure.

Contribution ID: 480
1. Diagnostic Imaging
01.19. Imaging bio–impedance and bioelectric sources

Noninvasive imaging of the origin of premature ventricular activity

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Noninvasive localization and imaging of the origin of premature ventricular contractions (PVC) before the electrophysiological study can significantly shorten the time needed for the ablation procedure. In this paper, we present a method allowing localization of the origin by solving the inverse problem of electrocardiography and finding a dipolar source best representing the initial ectopic activity. The method requires measurement of body surface potential maps (BSPMs) and 3D model of the patient torso obtained from a CT scan. The method was tested on 5 patients in Prague (96 ECG leads) and 2 patients in Bratislava (128 ECG leads). BSPMs from the initial interval of individual PVCs were used to solve the inverse problem using inhomogeneous or simplified homogeneous torso model, and all measured ECG leads, as well as only 64, 48 or 32 selected leads. The inversely obtained dipole locations were compared with the catheter position during successful ablation that was determined as the earliest activated point by activation mapping and confirmed by pace mapping. In three patients from Prague and both patients from Bratislava the PVC origin was found in the right ventricular outflow tract (RVOT), in the remaining two patients it was in the left ventricle (LV).
The noninvasive method localized the PVC origins in correct heart areas in all but one patient with localization errors up to 2 cm. In one patient the true origin in RVOT was localized in LV but still within 2 cm from the true position. The use of the more detailed inhomogeneous torso model did not demonstrate significant improvement of the localization but the dispersion of solutions from different PVCs increased. Despite expected robustness of the method, using 48 or less leads resulted in increased number of incorrect locations, with inhomogeneous torso model there were incorrect localizations also from 64 leads.

Contribution ID: 1107
1. Diagnostic Imaging

01.19. Imaging bio–impedance and bioelectric sources

Personalized EEG source analysis with the help of electrical impedance tomography and individually determined head conductivities

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The source imaging problem of electroencephalography (EEG) is an ill-posed inverse problem and sensitive to electric conductivity related errors, particularly errors or inhomogeneities in the skull conductivity. Often it is (unrealistically) assumed that these conductivities are constants within each tissue compartment and even within a group of people. However, in reality these conductivities exhibit individual variations and local variations within the same individual. In this paper, we study with the help of finite element based simulations the use of electrical impedance tomography (EIT) in the determination of personalized head conductivity values. In EIT, electrical boundary measurements and inversion algorithms are used to solve the conductivities. In practice, the greatest benefit of EIT is that the measurements can be carried out by using the same electrodes and electronics as used for EEG measurements. In this study, we show that EIT can be used to determine either bulk conductivity values for different tissues or detect local inhomogeneities in the skull compartment, for example. We demonstrate how the individually determined EIT conductivity maps can improve the EEG source reconstructions. In the future, we envision that multi-modal EIT-EEG can become a common clinical practice to achieve accurate brain source imaging results for individual patients.

Contribution ID: 1229
1. Diagnostic Imaging
01.19. Imaging bio–impedance and bioelectric sources

Effect of elimination of noisy ECG leads on the noninvasive localization of the focus of premature ventricular complexes

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Premature ventricular complexes (PVCs) in patients with underlying chronic structural disease increase the risk of sudden cardiac death and total cardiac death. Accurate localization of the PVC focus is highly important for successful radiofrequency ablation (RFA). PVCs are localized noninvasively before the operation using novel method of electrocardiographic imaging. The method requires solution of the inverse problem of electrocardiography. Body surface potential maps (BSPMs) from 96 ECG leads describing the electrical activity of the heart and patient-specific inhomogeneous torso model computed from the CT images are used as input data for the inverse solution in terms of single dipole model representing the PVC focus. Noisy ECG signals can lead to faulty results of the inverse solution.
To investigate whether the exclusion of the noisy ECG leads improves the inverse solution, the leads with the signal-to-noise (SNR) ratio less than the defined value were excluded from the inverse computation. Four levels of the SNR were defined: 10dB, 20dB, 30dB, 40 dB. Localizations

of the PVCs by the inverse solution were computed for five patients and compared with the ablation points positions obtained during RFA.
Removal of the noisy ECG leads not located in the left anterior torso region (heart region) improved the PVCs localization whereas the elimination of the noisy ECG leads in the heart region caused up to 2 cm shift of the inverse PVC focus localization.
In conclusion, considering one BSPM a removal of the noisy ECG leads did not improve the PVC localization when the ECG leads were located in the heart region. The inverse solution obtained using also noisy ECG leads in the heart region provides more accurate results compared to the inverse solution computed for the input BSPM from ECG leads only with high SNR level.

Contribution ID: 1400
1. Diagnostic Imaging
01.19. Imaging bio–impedance and bioelectric sources

The Influence of the Thermoacoustic Effect for the Frequency of the Magnetoacoustic Signals

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Magnetoacoustic tomography (MAT) is an emerging electrical conductivity imaging which combines the high dielectric contrasts of tissues and excellent resolutions of ultrasonography. It is noticed that the MAT system without a static magnetic field is much similar to the thermoacoustic tomography (TAT) system. The thermoacoustic(TA) effect exists in the measurements of MAT. In this paper, acoustic signals of several materials with different conductivities have been analyzed in the time domain and the frequency domain, respectively. It is found that the TA effect is related to the frequency of the acoustic signals. The drop in the center frequencies of the acoustic signals could been explained by the TA effect of materials. The studies could contribute to optimize MAT method and improve MAT imaging quality.

Contribution ID: 1527
1. Diagnostic Imaging
01.19. Imaging bio–impedance and bioelectric sources

Effect of electrode gel application between patient’s skin and electrode belt on electrical impedance tomography of the thorax

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Electrical Impedance Tomography (EIT) is a non-invasive diagnostic technique used for imaging of the internal body structures and the functionality of individual tissues. This technique has been recently applied in clinical practice, especially in the field of respiratory care. Due to insignificant history of usages, the examination methods for this imaging technique are not yet standardized. The aim of this study is a realization of a series of pilot measurements which investigate the effect of the electrode gel application between the patient's skin and the electrode belt on the EIT image of thorax and thus contribute to the unification of the EIT measurement procedures. For measurements commercial system PulmoVista 500 (Dräger) was used. The result of this work which is based on the results of the pilot measurements, found that the electrode gel affects the record of EIT of thorax, but it is not yet possible to precisely quantify this effect. For this reason, the following recommendations for clinical practice are informative only. Application of the electrode

gel should be done individually under each electrode in adequate quantity to avoid conductive connection between neighbouring electrodes. Another output of this project is a measurement protocol that will be used to carry out a comprehensive study on healthy volunteers. This study will serve to obtain statistically evaluable results that would quantify the effect of the electrode gel on the EIT image of the thorax.

Contribution ID: 1165
1. Diagnostic Imaging
01.21. Other

Intelligent tool for the presumptive diagnosis of gastrointestinal pathologies based on digital processing of endoscopic images

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Gastrointestinal pathologies are detected when there is already an associated symptom and they need to resort to an endoscopy, although there are numbers of medical centers that do not all have the necessary equipment and specialists in the area of diagnosis, the tool developed for presumptive diagnosis it will help the doctors to identify a possible pathology through the digital analysis of the medical image, the prototype is configured to recognize: gastritis, hiatal hernia and esophagitis. In related published works it is revealed how digital filtering processes are used, computer vision tools, smoothing of images, changes of color spaces, study of textures, digital segmentation and fundamentally the experience of specialists in endoscopy for presumptive diagnosis. We already have some results of the tests carried out with the prototype, having an accuracy of approximately 62% in the pathology of gastritis, 75% in the pathology of hiatal hernia and 80.76% in esophagitis, classifiers have been used as k nearby neighbors, Random Forest and neural networks, has seen several alternatives for the prototype as: medical support, specialized education tool in endoscopy.

Contribution ID: 916
2. Image Processing
02.13. Keynote lecture

KEYNOTE LECTURE: Challenges in quantitative medical image analysis

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An ideal quantitative method should be reproducible (if repeated at a different time, using a different camera and software), with known reference range for the result which is preferably unified – that is, dependent on the fewest factors possible. Steps of the process include image acquisition, reconstruction, followed by arithmetic, physical and biological phases of processing, providing simple static measures, indices of changes, or parameters of model fitting.
Emission imaging (by gamma camera or PET) is inherently deteriorated by noise, attenuation, scatter, limited and position-dependent resolution, and physiological motion (heart beat and respiration). All these factors should be addressed to obtain the most accurate, precise and biologically meaningful results possible. We shall review the methods for, and limitations of SPECT and PET reconstruction with the embedded correction steps, and the principles how image quality may be measured and optimized.

Hybrid imaging and multimodality image processing, while offering the potential for improving our accuracy, may introduce additional sources of error, originating from misalignment, different circumstances, and propagating artifacts.
Take-home message of the review is that when utilizing sophisticated image processing algorithms, we should always be aware of the possible sources of error, and carefully validate the methods before introducing them to our clinical or research work.

Contribution ID: 1907
2. Image Processing
02.13. Keynote lecture

KEYNOTE LECTURE: Benchmarking of algorithms for biomedical image analysis

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Biologists and physicians have to be able to rely on the correctness of results obtained by automatic analysis of biomedical images. This, in turn, requires paying proper attention to quality control of the developed algorithms and software for this task. Both the medical image analysis and bioimage analysis communities are becoming increasingly aware of the strong need for benchmarking various image analysis methods in order to compare their performance and assess their suitability for specific applications. Reference benchmark datasets with ground truth (both simulated and real data annotated by experts) have become publicly available and challenges (competitions) are being organized in association with well-known conferences, such as ISBI and MICCAI (https://grand-challenge.org/).
This talk summarizes recent developments in this respect and describes common ways of measuring algorithm performance as well as providing guidelines for best practices for designing biomedical image analysis benchmarks and challenges, including proper dataset selection (training versus test sets, simulated versus real data), task description and defining corresponding evaluation metrics that can be used to rank performance.
Proper benchmarking of image analysis algorithms and software makes life easier not only for future developers (to learn the strengths and weaknesses of existing methods) but also for users (who can select methods that best suit their particular needs). Also reviewers can better assess the usefulness of a newly developed analysis method if it is compared to the best performing methods for a particular task on the same type of data using standard metrics.

Contribution ID: 56
2. Image Processing
02.01. Image reconstruction

Shading correction assisted iterative cone-beam CT reconstruction

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The recent advances in total variation (TV) technology enable accurate CT image reconstruction from highly under-sampled and noisy projection data. The standard iterative reconstruction algorithms, which work well in conventional CT imaging, fail to perform as expected in cone beam

CT (CBCT) applications, wherein the non-ideal physics issues, including scatter and beam hardening, are more severe. These physics issues result in large area of shading artifacts and deteriorate the piecewise constant property that are assumed in reconstructed images.
To overcome this obstacle, we incorporate a shading correction scheme into low-dose CBCT reconstruction. We modify the TV regularization term by adding a shading compensation image to the reconstructed image to compensate for the shading artifacts while leaving the data fidelity term intact. This compensation image is generated empirically using image segmentation and low-pass filtering, and updated in the iterative process whenever necessary. When the compensation image is determined, the objective function is minimized using the fast iterative shrinkage-thresholding algorithm accelerated on Graphic Processing Unit.
The proposed method is evaluated using CBCT projection data of the Catphan©600 phantom and two pelvis patients. Compared with the iterative reconstruction without shading correction, the proposed method reduces the overall CT number error from around 200 HU to be around 25 HU and increases the spatial uniformity by a factor of 20%, given the same number of sparsely sampled projections.
A clinically acceptable and stable three-dimensional iterative reconstruction algorithm for CBCT is proposed in this paper. Differing from the existing algorithms, this algorithm incorporates a shading correction scheme into the low-dose CBCT reconstruction and achieves more stable optimization path and more clinically acceptable reconstructed image. The method proposed by us does not rely on prior information and thus is practically attractive to the applications of low-dose CBCT imaging in the clinic.

Contribution ID: 286
2. Image Processing
02.01. Image reconstruction

An efficient multiple microbubbles detection method for fast ultrasound super-resolution imaging

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Introduction: Microbubble detection based ultrasound blood flow super-resolution microscopy has become one of the most popular research topics in ultrasound imaging. Prospectively, the new technique may provide an efficient and convenient way to diagnose tumors and evaluate treatments by offering physicians with microcirculation information.
However, it cost more than 20 minutes to obtain a super-resolution image with conventional ultrasound and 150 seconds with ultrafast plane wave ultrasound. The time consumption cannot satisfy clinical needs especially for abdominal organs imaging.
Methods: To accelerate the imaging speed, we developed an efficient microbubble detection method which increased the number of microbubbles detected per image by more than ten times compared with previous works. In spite of point spread function, we assumed that local maximum under certain conditions could approximately be the center of a microbubble. In this view, a modified two-dimensional local maximum detection detector was developed to locate microbubbles. With this detector, we could detect microbubbles at a high agent concentration in tissues. Both in vitro (50μm PDMS microvascular model) and in vivo (healthy New Zealand rabbits hind leg muscles and nude CD1 mice with human breast cancer) experiments were done to verified the feasibility of the new method with conventional ultrasound (Toshiba's Aplio 500).
Results

In vitro study showed significant improvement on spatial resolution compared with contrast-enhanced ultrasound and contrast-enhanced maximum intensity projection. In vivo study, we verified higher spatial resolution, small flow sensitivity and clearer microvascular structure with our method compared to color Doppler, power Doppler, superb micro-vascular imaging and contrast-enhanced maximum intensity projection. Moreover, we obtained super-resolution images in 3 minutes by one-time microbubble injection.
Discussion: In conclusion, super-resolution imaging speed is significantly accelerated with local maximum detector. The combination of the new detector with ultrafast ultrasound may hopefully reduce super-resolution imaging time into 10 seconds.

Contribution ID: 301
2. Image Processing
02.01. Image reconstruction

An investigation into applicability of emission tomography maximum – likelihood expectation – maximization reconstruction algorithm for transmission tomography

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Maximum – likelihood expectation – maximization (ML-EM) reconstruction algorithm is one of the leading statistical iterative reconstruction algorithms for emission tomography (ET) (Positron Emission Tomography (PET) and Single-Photon Emission Computed Tomography (SPECT)) and low–dose transmission tomography (TT) namely, CT. Many researches have proposed distinct algorithms for ET and TT. The underlying reason can be summarized as different noise property of TT with Poisson – distributed noise in ET. It is due to polychromatic x-rays used in TT, preprocessing and calibration steps before image formation and logarithm operation to obtain the line integrals of attenuation coefficients in TT. Application of dedicated algorithms make the reconstruction process more complicated and expensive. In order to use a single algorithm without deteriorating the quality of the reconstructed image, scaling factors have been proposed. They transform the non – Poisson distributed transmission sinogram to a Poisson distributed one to be suitable for ET algorithm application. The basis of this deduction is an assumption that blank count (I0) is noise–free and transmission count (I) is Poisson – distributed. As a result, the distribution of ln(I0/I), which correspond to the attenuation coefficients that form the image, is not Poisson – distributed anymore. Herein, 200 Monte Carlo simulations of a simple geometry have been run to record the I0 and I in one projection. After 1040 hours computer run, the distribution of I0, I and ln(I0/I) were compared to Poisson distributions with the same mean as the data. Using Kolmogorov–Smirnov test, it is shown that none of the three datasets are significantly different from Poisson distribution with significance level of 0.05. It can be concluded that at least for projection data produced by Monte Carlo simulation, which does not include electronic noise, the ET reconstruction algorithm can be applied for TT without being concerned about image quality decline.

Contribution ID: 476
2. Image Processing
02.01. Image reconstruction

A method for reconstruction SPECT image from few number of projection data

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Purpose: SPECT images reconstructed from few number of projection data are deteriorated by severe artifacts such as streak artifact in FBP or image distortion in OSEM. The purpose of this study is to develop and evaluate novel method for image reconstruction from few number of projection data where the image quality is equivalent to SPECT image reconstructed from normal number of projection data to shorten acquisition time of SPECT study.
Methods: Projection data of 24-view (15-degree step) of IB-10 brain phantom with 99mTc was acquired by GCA-7200(Toshiba, Japan). In addition, numerical phantom (Shepp phantom) was also used. Projection dataset of 12-view (30-degree step) were extracted from the 24-view data. We developed image reconstruction method using interpolation in the sinogram based on detector direction, and the asymmetric projection data acquisition method, where relatively large step angle could be employed and opposite side data is inserted each projection direction. To evaluate our method, NMSE and %RMSU were used.
Results: NMSE of IB-10 brain phantom images reconstructed from 12 views, 24 views and 24 views interpolated from 12 views were 0.04195, 0.01262 and 0.02198. NMSE of Shepp phantom images reconstructed from 12 views, 24 views and 24 views interpolated from 12 views were 0.02157, 0.004099 and 0.005970. NMSE of reconstructed images interpolated from 12-view was better than 12 view reconstructed images in both IB10 Brain phantom image and Shepp phantom image. %RMSU were 33.71% for 12 view reconstructed image, 38.35 % for 24 view reconstructed image, 38.02 % for reconstructed image interpolated from 12-view to 24-view.
Conclusions: Image quality of SPECT image reconstructed by our method was improved. Our method will contribute to shorten the acquisition time for both SPECT study and PET study.

Contribution ID: 514
2. Image Processing
02.01. Image reconstruction

Image reconstruction of interior region-of-interest tomography by using inverse geometry system

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Purpose: The inverse geometry computed tomography (IGCT) composed of multiple source and small size detector has several merits such as reduction of scatter effect and large volumetric imaging within one rotation without cone-beam artifact, compared to conventional cone-beam computed tomography (CBCT). By using this multi-source characteristics, we intend to present a selective and multiple interior region-of-interest (ROI) imaging method by using a designed source on-off sequence of IGCT.
Methods: All of the IGCT sources are operated one by one sequentially, and each projection in the shape of narrow cone-beam covers its own partial volume of full field of view (FOV) determined from system geometry. Thus, through controlling multi source operation, limited irradiation within ROI is possible and selective radon space data for ROI imaging can be acquired without additional X-ray filtration. With this feature, we designed a source on-off sequence for multi ROI-IGCT imaging, and projections of ROI-IGCT were generated by using the on-off sequence. Multi ROI-IGCT images were reconstructed by using filtered back-projection algorithm. All these imaging

process of our study has been performed by utilizing digital phantom and patient CT data. ROI-IGCT images of the phantom were compared to CBCT image and the phantom data for the image quality evaluation.
Results: Image quality of ROI-IGCT was comparable to that of CBCT. However, the distal axial-plane from the FOV center, large cone-angle region, ROI-IGCT showed uniform image quality without significant cone-beam artifact contrary to CBCT.
Conclusion: ROI-IGCT showed comparable image quality and has the capability to provide multi ROI image within a rotation. Projection of ROI-IGCT is performed by selective irradiation, hence unnecessary imaging dose to non-interest region can be reduced. In this regard, it seems to be useful for image guidance purpose in radiotherapy.

Contribution ID: 552
2. Image Processing
02.01. Image reconstruction

A novel methodology for accurate 3D reconstruction of coronary arterial bifurcations using quantitative coronary analysis

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Many methods have been proposed for the 3-dimensional (3D) reconstruction of coronaries arteries by combing information from two or more X-ray views of the coronary tree, since the 2D representation of coronary lesion using X-ray coronary angiographies is limited. Moreover, the computation of the hemodynamic parameters such as the endothelial shear stress (ESS) and the fractional flow reserve (FFR) is affected by the accuracy of the generated 3D coronary geometries. The aim of this study is to present a new semi-automated method for the accurate 3D reconstruction of coronary arterial bifurcations using biplane X-ray angiographies, while other approaches are able to reconstruct only arterial segments. X-ray angiography was acquired from ten patients and their data were used for the 3D reconstruction methodology. The proposed approach consists of the following steps. Initially, the 2D lumen borders and centerlines are detected. Then the 3D bifurcation path is extracted and the 3D lumen borders are positioned around the 3D bifurcation path and finally the main and side segments are intersected. Considering the X-ray angiography as the golden standard, we validated the proposed method based on the 2D versus the 3D bifurcation segment model. More specifically, in the current dataset our results indicate excellent correlation with the 2D angiography: $r = 0.959$, $p < 0.001$; $r = 0.961$, $p < 0.001$; $r = 0.84$, $p = 0.008$ and $r = 0.99$, $p < 0.001$ for the Reference Lumen Diameter (RLD), Minimal Lumen Diameter (MLD), Degree of Stenosis (DS) and Lesion Length (LL), respectively. Moreover the mean values of the Hausdorff Distance and the Dice Similarity between the 2D annotated borders and the forward projected borders are 2.52 ± 1.03 and 0.8962 ± 0.04.

Contribution ID: 572
2. Image Processing
02.01. Image reconstruction

A three-dimensional quantification of non-calcified plaque based on computed tomography coronary angiography images: comparison with virtual histology intravascular ultrasound

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The identification, quantification and characterization of coronary atherosclerotic plaque has a major influence on diagnosis and treatment of coronary artery disease (CAD). Recent studies have reported the ability of Computed Tomography Coronary Angiography (CTCA) to identify non-invasively coronary plaque features. The detection of non-calcified plaques (NCP) in CTCA is still a challenging problem due to their lower intensity values. We present a novel methodology for the identification of the plaque burden of the coronary artery and the volumetric quantification of NCP utilizing CTCA images in comparison with virtual histology intravascular ultrasound (VH-IVUS). The proposed methodology includes six steps: CTCA images pre-processing, vessel centerline extraction using Multistencil Fast Marching Method (MSFM), estimation of membership sigmoidal distribution functions for lumen and outer wall intensities, implementation of an extension of active contour models using prior shapes for the lumen and the outer wall segmentation, extraction of an adaptive intensity range for the detection of (NCP) in the plaque burden region based on the mean lumen intensity and finally detection and quantification of NCP. Bland–Altman analyses were performed to assess the agreement between the presented methodology and VH-IVUS. Assessment of NCP volume and NCP lesion length in 12 lesions indicated excellent correlation with VH-IVUS ($r = 0.915$, $p < 0.001$) and ($r= 0.942$, $p < 0.001$), respectively. Furthermore, the plaque burden is also well-correlated between the two modalities ($r=0.741$, $p=0.04$). The methodology is an innovative approach, which extract dynamic threshold for NCP detection, adapted to the lumen derived intensity. This approach is integrated in a dedicated software tool, which requires the minimal user interaction.

Contribution ID: 605
2. Image Processing
02.01. Image reconstruction

Iterative methods for fast reconstruction of undersampled dynamic contrast-enhanced MRI data

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This paper experimentally compares the performance of two state-of-the-art types of variational formulations for reconstruction from subsampled dynamic contrast-enhanced (DCE) MRI data. One approach models the shape of perfusion curves in time as a sum of a curve belonging to a low-dimensional space and a function sparse in a suitable domain (L+S model). The other approach is based on local regularization in both spatial and time domains. We are dealing with the specific situation of DCE-MRI acquisition with a 9.4T small animal scanner, working with a weaker signal

than human scanners because of a small number of coils that can be used for parallel acquisition and small voxels. Evaluation of the selected methods is done through subsampled reconstruction of radially-sampled DCE-MRI data. We assess the quality of reconstructed images with respect to time of reconstruction and achievable level of compression. Our analysis shows how compressed sensed MRI in the form of regularization can be used to increase the temporal resolution of acquisition while keeping sufficient signal-to-noise ratio and thus improve the precision of perfusion analysis.

Contribution ID: 1023
2. Image Processing
02.01. Image reconstruction

A fully reconfigurable 16-channel ultrasound transmit/receive system for biomedical imaging applications

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Although the development of new ultrasound (US) investigation methods can be evaluated from simulations tools and/or, more recently, using open research platforms, the experimental test of novel transmission (Tx) and reception (Rx) strategies may require the development of dedicated hardware systems. In this paper we present a 16-channel FPGA-based US system able to generate synthesized arbitrary waveforms up to 100 Vpp with simultaneous access to raw echo data. For maximum flexibility, two Intel Cyclone III FPGAs have been used to implement the reconfigurable system. The first FPGA is responsible for the management of the Tx segment, including the generation of digital 250 MHz pulse-width modulation (PWM) control signals for custom excitation waveforms with central frequency up to 20 MHz and programmable beam sequencing. The synthesized Tx sequences with arbitrary waveforms are stored in concatenated look-up tables (LUTs) in the FPGA memory and can be upload to the system. This segment includes a set of sixteen Microchip MD2131 high-speed US beamformer source drivers connected to conventional T/R switches for overload protection. The second FPGA provides a suitable scheme to control simultaneously two eight-channel fully integrated analog front-end AFE5805 (Texas Instruments Inc., USA), which include low-noise amplifier, variable gain amplifier, low-pass filter and a 12-bit 40 MHz ADC with LVDS outputs. The system can be connected to a computer for easy user control of Tx (amplitude, central frequency and bandwidth, phase adjustment, pulse repetition frequency, delay, among others) and Rx (sample frequency and AFE) parameters during pulse-echo experiments and to allow fast data transfer through a USB 2.0 connection. Initial results using a 3.2 MHz convex transducer and a commercial tissue mimicking phantom demonstrate the flexibility and viability of the proposed system to support the development and test of novel focusing beamforming techniques, including biomedical and NDT applications.

Contribution ID: 1055
2. Image Processing
02.01. Image reconstruction

A GPU-based cloud platform for limited-angle reconstruction of cone-beam computed tomography

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As cone-beam computed tomography (CBCT) becomes more and more popular in dental and radiation therapy applications, dose reduction for CBCT systems remains to be a topic under investigation. Limited angle reconstruction with iterative image reconstruction algorithms, such as total variation (TV) reduction methods, has shown promises by providing satisfactory image quality while reducing the required projection angles and hence the radiation dose. However, iterative reconstruction algorithms require much more computation power. To address this challenge, we propose a GPU-based system as a cloud computing environment to test and implement iterative reconstruction methods in this work. We have implemented both the client- and server-side programs for the cloud-based iterative reconstruction mechanism. On the client side, the software is configured to automatically upload the projection data to the cloud every time a new acquisition is completed. On the server side, we have implemented both the non-iterative and iterative algorithms for image reconstruction. Several iterative algorithms have been implemented as CUDA programs, including MLEM, SART and TV-based algorithms, etc. Graphical computing units (GPUs) are used to accelerate the image reconstruction. The testing cloud-computing environment was configured on a server equipped with eight GPU cards (GeForce 1080Ti, NVIDIA). In our preliminary evaluation, the cloud GPU-based system can be ten to forty times faster than a standalone CPU-based workstation to reconstruct an image volume. Such a significant acceleration is useful for testing novel iterative image reconstruction, as well as making future application of limited-angle reconstruction of clinical CBCT images a routine possibility. It could be optimistically expected that, with cloud- and GPU-based computing, iterative CBCT reconstruction methods can be developed and tested in a faster pace that may accelerate the actual application of limited angle reconstruction for CBCT dose reduction.

Contribution ID: 1150
2. Image Processing
02.01. Image reconstruction

Ultrasonic image reconstruction based on inverse problems using massively parallel processing on GPU.

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Ultrasonic image reconstruction based on inverse problems has shown to produce sharp and high-quality images by using more information about the acquisition process in its system model. This improvement increases the reconstruction computational cost, usually requiring to solve a large system, making real-time imaging very difficult. Parallel processing, especially through the use of modern graphics processing units (GPU) can significantly accelerate the processing, turning real-time imaging by inverse problems a viable option. One of the current issues is the amount of memory needed by current system models, which is beyond standard GPU capacity. This paper proposes to halve the memory requirement using the symmetry that exists in the system model. This new reduced-memory symmetric model can double the possible reconstructed image size utilizing the same GPU. Multi-GPU implementation is also discussed.

Contribution ID: 1274
2. Image Processing
02.01. Image reconstruction

Calibration of stereo radiography systems using a 3D printed phantom and localization markers

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This work propose a workflow for a stereo radiography (SR) system calibration for 3D reconstruction. For this work, we will be calibrating the CyberKnife (Accuray, Sunnyvalle CA) stereo kV X-ray imaging system. The goal is to estimate the intrinsic and extrinsic parameters of the imaging system using a perspective projection model. The intrinsic parameters are related to the focal length of the imaging system, to the detector characteristics and to its principal point. The extrinsic parameters express the transformation between the world coordinates and the SR imaging system coordinates.
We designed a 3D printed PLA array which can contain BBs markers used for patient tattoo localization on CT scans. The calibration phantom is then CT scanned to relatively localize each lead spheres in 3D to a reference point within the phantom. We then image the calibration phantom with the SR and extract the CyberKnife x-ray image pairs. Using direct linear transform (DLT), we calculate the geometrical transformation relating the 2D markers coordinates in the SR images to the 3D markers coordinates obtained from the previous CT scan. Therefore, we can can estimate the intrinsic and extrinsic parameters of the imaging system.
This calibration process allows us to determine the epipolar geometry relation between the two X-ray systems. Disparity maps are then generated for 3D reconstruction of landmarks located in each x-ray images. 3D models based on CT segmentation will be registered to the 2D landmarks for patient position. Offline motion analysis after the treatment is analysed. This workflow can be used as a new imaging tool for cumulative dose calculation and adaptive radio therapy. Non-linear calibration approaches will be studied.

Contribution ID: 1275
2. Image Processing
02.01. Image reconstruction

Prostate motion assessment for stereotactic body radiation therapy

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Prostate motion assessment for stereotactic body radiation therapy This work propose a method for prostate motion assessment after stereotactic body radiation therapy (SBRT). Patients received hypofractionated radiation treatement with the CyberKnife modality at the Centre hospitalier de l'Université de Montréal (CHUM). Offline analysis was perform on the data stored in the log files of each treatment fraction. Prostate motion was calculated by positioning implanted fiducial markers according to the position of the patient pelvis.
Our method uses the stereo radiographic images and the recorded tracking data acquired during the treatment fraction has a guideline for segmentation initialization. The region of interest which includes the fiducial markers and their label are obtained by reading the treatment log files. A new centroid position for each marker is estimated using a structure analysis with MATLAB image processing toolbox. Localization of the patient pelvis is then proceed by identifying both cotyloid cavities positions on each stereo radiographic image pair. The cavities are estimated as a sphere and their centroid is recorded. The treatment images are rigidly registered on a selected reference image using mean square optimization function allowing the calculation of the pelvis motion during the treatment. Using the log files information, we estimate the tridimensional position of each

fiducial markers and the cotyloid cavities centroids. We finally compute the distance between a tridimensional point between the cotyloid cavities centroids and each fiducial markers centroids.
10 fractions has been tested with our method. We found absolute displacements of the fiducials centroids according to the reference pelvis location of 1.0 ± 0.6mm SI, 0.5 ± 1.1 mm AP and 1.6 ± 1.4 mm LR. Differences between patients will be considered and intrafraction motion will be presented. Sporadic intrafraction motion are expected due bladder, rectal fillings and patient relaxation. More fractions will be tested.

Contribution ID: 1387
2. Image Processing
02.01. Image reconstruction

Accuracy Evaluation on 3D Reconstruction of Trans-femoral Residual Limb Model Using Basic Spline Interpolation

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In this paper, a study on 3D reconstruction of transfemoral residual limb based on Magnetic Resonance Imaging (MRI) using basic spline (B-Spline) interpolation feature is presented. Many researches have constructed a 3D model by using Non-Uniform Rational B-Spline (NURBS) approach but almost none of them has elaborated in detail the methodology used in the project and the accuracy of the model's volume against the residual limb volume. This study is focusing on optimization of residual limb model's volume by investigating the effect of spline points toward the volume value. The project is divided into 3 phases which are pre-segmentation, segmentation and 3D reconstruction but the study is focusing on segmentation phase where the spline points has been changed into 72, 36, 24 and 12 points where CAD software Creo Parametric (PTC) was used for the process. The higher number of spline points produced the most accuracy model's volume. The volume [mm3] of 3D model with specified number of spline points has been evaluated by compared it with the volume of 3D model created by image processing tools from MATLAB (Math Works). The results show the increment of accuracy for the volume value when the number of spline points is increased. The highest accuracy of volume value is when the model created with 72 spline points and the average accuracy percentage is 8.5% which achieved the hypothesis. The results indicate that CAD software as a technical drawing tools also can be use in designing 3D model of human anatomy with high accuracy in bio-medical field if a spline interpolation featured in the software.
Keywords: B-Spline, 3D Model, Transfemoral Prosthesis, Residual Limb

Contribution ID: 1896
2. Image Processing
02.01. Image reconstruction

Optimal 3D and multicolor localization microscopy by point-spread-function engineering

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Precise determination of the position of a single point source (e.g. fluorescent molecule, protein, quantum dot) is at the heart of microscopy methods such as single particle tracking and super-resolution localization microscopy ((F)PALM, STORM). Localizing a point source in all three dimensions (i.e. including depth) poses a significant challenge, since the depth of field of a standard high-NA microscope is fundamentally limited, and its point-spread-function (PSF),

namely, the shape that a point source creates in the image plane, contains little information about the emitter's depth. Various techniques exist that enable 3D localization, prominent among them being PSF engineering, in which the PSF of a microscope is modified to encode the depth (z position) of the source. This is achieved by shaping the wavefront of the light emitted from the sample, using a phase mask in the pupil (Fourier) plane of the microscope.
In this talk, I will describe how our search for the optimal PSF for 3D localization, using tools from estimation theory, led to the development of microscopy systems with unprecedented capabilities in terms of depth of field and spectral discrimination. Such methods enable fast, precise, non-destructive localization in thick samples and in multicolor. Applications of these novel advances will be demonstrated, including super-resolution imaging, tracking biomolecules in living cells and microfluidic flow profiling.

Contribution ID: 1078
2. Image Processing
02.02. Multi–modality data handling (hybrid systems, off–line fusion)

Comparison and fusion of different modalities for contactless vital signals assessment

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Continuously monitoring a patient's vital signals is valuable to detect health state deteriorations or fatal conditions before they occur. Today, this is only possible in intensive-, or intermediate-care units, which have limited capacities and are operated with high costs. Also, the presence of monitoring cables complicates the regeneration process, since it immobilizes the patient, can lead to skin damage and makes body care difficult. The contactless assessment of vital signals would be a promising possibility to monitor patients completely unobtrusively. Also, contactless vitals assessment could be beneficious in laboratory animal science. Today, animal friendly husbandry opposes the whish to monitor testing animals continuously to prevent undetected suffering. With contactless techniques, a continuous vitals assessment could become reality, without the need of constraining cables.
To find a minimal set of image sensors, capable of simultaneously measuring multiple vital signals, we conducted a non-clinical study with volunteering subjects. We assessed videos of the subjects using cameras sensitive for visual light, near-, short-wave-, and long-wave infrared. As reference measurement, all subjects were connected to a normal patient monitor during the recordings. Different regions of the body were filmed. We captured frontal and lateral shots of the face, as well as videos of the cubital fossa and lateral shots of the lower leg with and without blocked femoral arteries.
The possibility to detect heart rate, breath rate, temperature and perfusion was evaluated in all recorded spectra. We found that a fusion of visual visual-, near infrared and long-wave infrared images is the most promising approach to robustely monitor a sufficient set of vital signals. Whilst visual- and near infrared images are sufficient to measure the heart rate, we can extract perfusion, temperature and breathing frequency from long wave infrared images.

Contribution ID: 65
2. Image Processing
02.03. Quantitative image analysis

White matter fiber integrity loss to the limbic orbitofrontal networks in mild cognitive impairment.

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Background
Mild cognitive impairment with depression (MCID) is common and associated with disability and cognitive impairment, with high probability of relapse. Hypothesize that a sign of WM disintegration would be observed in MCID than MCI nondepression (MCIND), especially in frontal and limbic regions and patients with depression would show reduced GM density in the hippocampus, amygdala, anterior gyrus cingulate, and dorsolateral prefrontal cortex (DLPFC) and dorsomedial prefrontal cortex (DMPFC) the abnormalities of long association fiber tracts integrity are correlated with geriatric depression.
Methods
Forty-two subjects (20 nondepressed, 22 depressed) underwent DTI and cognitive assessment. Depression was initially assessed by means of the Korean version of the 30-item Geriatric Depression Scale (K-GDS). All patients scoring 19 or higher on the K-GDS were screened as depressed. An automated tract-based statistical analysis method was used to derive estimates of fractional anisotropy (FA) for each subject. Group effects and correlations with clinical features on DTI parameters were examined.
Results
We found cross-sectional differences in WM tract disintegration on posterior cingulum, splenium of corpus callosum, uncinate fasciculus, genu, thalamus, internal and external capsule of limbic in MCID. These results support changes in the structural integrity of neuronal cells in these specific important brain regions constituting a fronto-limbic-cerebellar network during depressive and in particular during the course of depression. The different parts of the frontal lobes have afferent and efferent connections with other neocortical, limbic, and subcortical regions and participate in the limbic–cortico–striatal–pallidal–thalamic circuits.
Conclusions
Findings are suggestive of loss of integrity in WM fiber within frontal, temporal and limbic regions, increasing the evidence that implicates disruptions to the limbic–orbitofrontal networks in the pathogenesis of MCID. These neuroanatomical circuits play an important role in the regulation and modulation of affect and emotion, and contribute to the pathogenesis of late-life depression.

Contribution ID: 170
2. Image Processing
02.03. Quantitative image analysis

Sperm motility analysis: a novel algorithm for tracking image sequences

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Motion analysis on quality assessment of semen samples has a good correlation with male fertility and it is one of the most affected parameter after cryopreservation / thawing. However, sperm tracking is quite complex due to cell collision, occlusion and missed detection. making it difficult to calculate motility parameters for biological studies. We present a novel algorithm for tracking image sequences for the evaluation of sperm motility. The proposed tracking algorithm extracts essential information from a frame by minimizing redundant data and generating an output whose order of magnitude smaller with respect to the number of pixels in the image.

The main idea of the proposed algorithm is to represent the signal as a concatenation of known functions instead of sequence of samples. In an oversampling condition, the value of the sample loses relative importance while the comparison of its value with the past samples allows inferring trajectory behaviors. Under this condition, the trajectories are smooth and the signal is proposed as originated by a generating function which contracts, dilates and adapts to follow the trajectory.
Uniform sampling is maintained but the signal is oversampled with respect to the Nyquist frequency. A redundant vector is obtained from which the algorithm is fed. First a segmentation based on adaptive linear interpolation is performed, then the segments are labeled reflecting the behavior within it. With this information, sequences of segments that identify global behaviors are detected.
The system was compared with the Microptic's Sperm Class Analyzer® according to the monitoring performance, evaluating the accuracy of the system and the percentage of fragmented paths to measure the reliability of the monitoring. The results show that the proposed method presented a better performance according to these indicators. Finally, motility percentages were found to corroborate the largest number of detected mobile trajectories of our method.

Contribution ID: 227
2. Image Processing
02.03. Quantitative image analysis

Statistical Guideline of Threshold Determination for Cardiac Spiral Wave Center Detection using Phase Variance Analysis

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Spiral wave (SW) plays a key role in generation and termination of fatal tachyarrhythmia. Although analysis of SW center dynamics is essential for the elucidation of its mechanism, the objective analysis method of SW center trajectory had not been proposed. In our previous study, we proposed a novel tracking method of SW center by using phase variance (PV) analysis. This method evaluates local variance of phase values around each point on a cardiac tissue to detect the position of SW center as the peak of PV map. This PV analysis significantly improved the detection accuracy of a meandering SW center and complex multiple SW centers. However, the detection algorithm still includes several parameters such as window size for the evaluation of phase variance and binarization threshold for the peak detection. Therefore, some guideline for proper determination of those parameters has been required.
In this study, we evaluated the determination method of the binarization threshold of the detection algorithm based on Rayleigh's test. Because PV is a statistical feature of angle values, the detection of SW center by binarization of PV map can be interpreted as a statistical test on which null hypothesis would be rejected at each point except around the SW center. Therefore, we hypothesized that appropriate threshold can be determined as the level of PV value with specific p-value on Rayleigh's test. To test this hypothesis, we compared the detection results with various window sizes (3, 9, 15, 21 pixels) and various thresholds (from 0.4 to 0.9). Optical mapping measurement data with single and four SW centers were evaluated. As a result, proper numbers of SW centers were detected with the thresholds corresponding to the p-value 0.05, even with the smallest window size (3 pixels). This result suggested that threshold determination based on Rayleigh's test is reasonable.

Contribution ID: 228

2. Image Processing
02.03. Quantitative image analysis

Development of a software tool for analysis of x-ray images: A case study in breast imaging

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X-ray radiation is routinely used in medical diagnosis of the human body. It acquires planar transmission images or series of such images that are then reconstructed, such as Digital Tomosynthesis and Computed Tomography. The development of new and improvement of existing x-ray imaging techniques continuously require phases of validation and extensive testing. This is especially true as ionizing radiation x-rays are harmful and may lead to the development of cancer and tissue necrosis. Image quality and radiation dose have to be balanced. Today, anthropomorphic phantoms are being developed and are potential candidates for human body and organ substitutes in research and optimization studies.
There are two main types of anthropomorphic phantoms – computational and physical. Both of them need to be validated before their exploitation as suitable tissue substitutes. A subjective comparison can be done by physicians. Alternatively, an objective comparison and validation can be achieved by using appropriate descriptors derived from the images, which requires dedicated software tools. Hypothesis for this test method is that simulated images of these models have similar properties to real cases for the aspects tested in a specific study. Present project is situated in our search for suitable materials and texture generation for the manufacturing of physical breast phantoms.
In this study, we describe the development and validation of an in-house software tool that computes a set of parameters from x-ray images, namely standard deviation, skewness and kurtosis, fractal and spectrum analysis. The tool imports images in common graphical formats, including DICOM and raw images, obtained either using real medical equipment or image simulators. The software development is implemented in MATLAB. A comparison of the parameters extracted from mammography images of the patients' left and right breasts was performed against values obtained in other studies and proved to be consistent.

Contribution ID: 411
2. Image Processing
02.03. Quantitative image analysis

Mammographic density estimation through permutation entropy

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The American College of Radiology, through its committee on BI-RADS (Breast Imaging Study Data and Reporting System), has concluded that breast density is more clinically important as an indicator of concealment of possible breast lesions than as a quantifier of cancer risk, due to the lack of robust descriptors for detecting different types of density.
In this work, new descriptors for mammographic density estimation based on the Permutation Entropy (PE) algorithm are developed and tested. PE is a measure of complexity initially proposed for chaotic time series, particularly in the presence of dynamic and observational noise. Therefore,

we propose different novel algorithms to adapt the concept of PE from time series to images, to characterize the level of roughness. Each algorithm gives a different numerical descriptor, which makes possible to describe an image through a characteristic vector.
168 mammograms were obtained from the Digital Database for Screening Mammography database. They were acquired by different scanners with different spatial resolution, considering gray levels of 12 or 16 bits. All mammograms have their relevant report, describing the breast tissue, according to a specialist using the BI-RADS reporting system.
Once the characteristic vector for each mammogram was obtained, we trained a multilayer feedforward neural network as a classifier, to evaluate the potentiality of the set of descriptors as characterizers of the mammographic density, in accordance with the BI-RADS nomenclature.
The results show that these descriptors have remarkable success rates in the classification of densities and especially they generalize with good coincidence percentages for cases of extreme densities. The categorization of extremely dense breasts is of special interest because of their clinical importance to assign more intensive monitoring or more complex studies to the patients who present it.

Contribution ID: 430
2. Image Processing
02.03. Quantitative image analysis

Multivariate analysis of MR texture parameters for rectal cancer patient staging

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Colorectal cancer is the third most common cancer worldwide and rectal cancer accounts for about a third of all colorectal malignancies. Nowadays, the therapy for locally advanced rectal cancers is: neoadjuvant chemo-radiotherapy (CRT) followed by radical surgery. Although the local pelvic recurrence rate is lower than 10%, this therapeutic approach
is an over-treatment of the patients who completely respond (CR) to CRT, they could benefit from either less invasive surgery (ie, transanal endoscopic microsurgery) or “wait-and-watch” strategy. Also the patients who do not respond to the treatment (non-responders, NR) whose early identification (2–3 weeks after the start of neoadjuvant CRT) might help clinicians in referring them to alternative treatments.
Magnetic Resonance Imaging (MRI) is the gold standard for preoperative staging and re-staging of rectal cancer however it is hard to asses the CRT patient response only on the basis of the MRI visual inspection. With the aim of discriminating CR and NR patients prior or immediately after the start of CRT we developed a Texture Analysis (TA) of T2 weighted images of the entire volume of rectal cancer acquired pre, intermediate and after the treatment of 55 patients with a 3T MR. All the patients had a histologically confirmed rectal adenocarcinoma and locally advanced tumour stages II (cT3-4, N0, M0) and III (cT1-4, N+, M0). The extracted TA parameters have been used to build a classifier using multivariate analysis, it allows to discriminate CR and NR. The receiver operating characteristic (ROC) curve of such a classifier has an area greater than 0.8 for both the subsamples identifications.

Contribution ID: 443

2. Image Processing
02.03. Quantitative image analysis

Quantification of brain lesions in MRI induced bymetallic nanoparticles in patients with Multiple Sclerosis

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Multiple sclerosis (MS) is a neuro-inflammatory and neuro-degenerative disease resulting in demyelization process of neurons. Although intensely studied, the causes of MS is still an open question. Studies show that it is possibly arising from a combination of genetic, environmental and infectious factors to trigger the inflammatory process. Exposure to metals can be considered as an external agent, presenting a toxicity that can trigger the inflammatory process. In general, population is exposed to metal under nanoparticle (NPs) form, since it is presenting in air, cosmetical and food. Because of their small size, metallic NPs have the potential to penetrate the human body by inhalation, injection or epithelial penetration eventually crossing the blood brain barrier and potentially causing neurotoxicity and neurodegeneration of the central nervous system.
Radiologically, areas where demyelination may occur can be observed by magnetic resonance imaging (MRI). New techniques in the visual detection of sclerotic lesions have been reported in literature, but is still needed to quantify the multiple sclerosis affected area to perform further evaluations in the lesions observed in the MRI potentially caused due toxicity of the metallic nanoparticles.
The aim of the present study was to implement a program developed in MatLab to quantify sclerotic lesions in magnetic resonance images, possibly triggered by the accumulation of metallic nanoparticles. In order to simulate brain inflammatory process different volumes and concentrations of metallic nanoparticles were apply in a brain homogeneous phantom.
The results of this work are important because MRI brain lesions in multiple sclerosis patients could be compared with the images generated from the phantom. This way, was possible to follow if demyelination process was possibly induced by metallic nanoparticles in brain sclerotic lesions. In future studies, metallic nanoparticles quantification could help in determining the degree of toxicity in neurodegenerative diseases.

Contribution ID: 558
2. Image Processing
02.03. Quantitative image analysis

Basic study for 3D kinematic measurement of patella from single-plane fluoroscopic image using intensity-based 2D/3D registration

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The 3D measurement of dynamic knee kinematics under in vivo conditions is highly valuable for understanding the effects of joint diseases, dysfunction and for evaluating the outcome of surgical

procedures. For artificial knee implants, to achieve 3D measurement of the dynamic kinematics, 2D/3D registration techniques which use X-ray fluoroscopic images and computer-aided design model of the implants have been applied to clinical cases. These fluoroscopic techniques have also been applied for motion measurement in joints without implants in recent years, where 3D bone models created from CT or MRI images are utilized.
In previous studies, however, the pose estimation accuracy for patella was not sufficient for analyzing 3D knee kinematics, particularly out-of-plane rotation error was relatively large because of small shape and poor geometrical feature of patella. Therefore, this study presents a method to determine 3D kinematics of patella using single-plane fluoroscopic image.
The 3D pose of patella is estimated using an intensity-based 2D/3D registration technique, which uses a digitally reconstructed radiography (DRR) image created from 3D bone volume model. The 3D bone volume model for patella was created using CT scan data from a single subject. The 3D pose of the patella model is estimating by maximizing similarity measures between the DRR and fluoroscopic images iteratively with an optimization technique.
In order to validate the pose estimation accuracy of patella including femur and tibia/fibura using the intensity-based 2D/3D registration, computer simulation test was performed. A set of synthetic silhouette images was created for each knee model in known typical orientations, and the test was carried out using three similarity measure methods. The result of computer simulation test showed that the root mean square errors were around 1.0 mm, 1.0 degree except for out-of-plane translation, and the reliability and feasibility of present method was demonstrated.

Contribution ID: 591
2. Image Processing
02.03. Quantitative image analysis

Structural and functional connectivity of anterior nuclei of thalamus for epileptic patients in deep brain surgery

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Epilepsy is the one of the neurological disorder which is overwhelmingly encountered among people of all ages through the world, approximately 50 million people are worldwide suffering from epilepsy. Recent studies indicate that anterior nucleus of the thalamus (ANT) is an encouraging target for deep brain stimulation in order to control and reduce epileptic seizures. ANT is segregated from the rest of the thalamus by Y shaped internal medullary lamina and consists of three subdivisions which are anteroventral (AV), anterodorsal (AD), anteromedial (AM) nuclei. Experimental studies show that each subdivision of the ANT presents different patterns of connectivity relating the hippocampus, mammillary bodies and neocortex, nevertheless the mechanism of the ANT still remains bewildering and also an adequate quantitative and statistical examination has not been comprehensively carried out concerning structural and functional connectivity of the ANT in deep brain stimulation for epilepsy.
We have implanted deep brain stimulation electrodes for 30 patients so far. The clinical outcomes have been studied for 5 years. Diffusion MRI has been acquired from 12 patients with b = 1000 s/mm2, both 30 and 20 gradient directions at both 3 T and 1.5 T. We investigate whether it is possible to analyze connectivity from ANT to medial temporal lobes, anterior cingulate cortex and medial prefrontal cortex which are prospective key connections and they are clinically observed by our research group beside the circuit of Papez. We reveal structural connectivity pattern based on probabilistic tractography approach, inferred from non-invasive Diffusion MRI and we also study statistical patterns of dynamic connections among these regions considering functional connectivity

based on functional MRI with EEG. Ultimately, we measure the density of connections among regions of interest and correlate the measurement to the epileptic characteristics of each patient.

Contribution ID: 642
2. Image Processing
02.03. Quantitative image analysis

Quantitative assessment of contusion muscles by ultrasound parameters and shear-wave velocity

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Muscular contusion is one of the most common injuries for professional athletes and ordinary persons. Depending on the degree of severity, contusion could especially affect the professional athletes' daily life and career greatly. It thus is essential to develop a modality capable of in situ diagnosing the degree of contusion noninvasively and quantitatively, and that leads current study to the assessment of contusion using high-frequency ultrasound signal and image parameters. Experiments were arranged to assess the contusion and recovery status of tissues for 21 days from the murine gastrocnemius muscles (MGM) of Sprague Dawley (SD) rats. The contusion in the MGM of a rat's leg was formed by a lab-design impact platform which allows a 600-g mass to be fallen from a 30-cm height of wire suspension. Three-dimensional 30 MHz ultrasound signals and images were acquired for estimating the volume and variation of muscular contusion with echogenicity and statistical analysis. Furthermore, changes of elastic property were evaluated by detecting the shear-wave velocity (SWV) in the contusion tissue using a pair of 5 MHz push and 20 MHz detect transducers. Shortly after the impact, the echogenicity and SWV of contusion tissues tended to respectively be lower and higher than those of control tissues. High resolution images also reveal the volume and composition, including clots, blood, and collagen, of contusion tissue. After the 9th day of impact, all ultrasound parameters as well as images of contusion tissues are getting close to the values and features of control groups. Results of this study indicated that ultrasound parameters and SWV were able to be applied to sensitively and quantitatively assess the degree of contusion.

Contribution ID: 693
2. Image Processing
02.03. Quantitative image analysis

The method of estimation of proliferation index in samples from patients with Diffuse Large B-cell Lymphoma

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The proliferation index (PI) is an important feature used in neoplasm diagnosis. It shows the percentage of immunopositive nuclei (proliferating cells' nuclei) to the whole number of nuclei in selected region. The localization of the antigens Ki67 is visualized with 3,3'-Diaminobenzidine, while the other nuclei are visualized with Haematoxylin (DAB&H). The automated quantification of

PI is dependent on the architecture of tissue section and the type of disease, which results in several methods published so far. In this study the method is dedicated to patients diagnosed with Diffuse Large B-cell Lymphoma (DLBCL), an aggressive diseases which boasts high mortality rate. The neoplasm is located mostly in various lymph nodes, but also in skin, tonsils, breasts, etc.
The proposed method (called MetpiKi67 - METhod of Proliferation Index of Ki67) for local evaluation of PI performs color separation followed by object extraction and validation. To calculate the statistic features of extracted objects, the following sources of information are used: three channels of RGB, three channels of Lab color space, brown channel and three layers acquired with color deconvolution into haematoxylin and DAB layers. Objects with statistical parameters out of range are discarded, while these which fulfill the size and shape criteria for being merged nuclei are divided with watershed performed locally on specially modified of haematoxylin layers.
11 digital slides from patients diagnosed in Pathology Department of the Military Institute of Medicine with diagnosis and PI estimated by experienced pathologist was used in retrospective study to verify proposed method.
Proposed method performs well under visual inspection and comparison with the experienced pathologist's quantifications' results. However, the accuracy of nuclei area determination is unsuitable and will be the aim of further investigation.
Acknowledgements:
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Contribution ID: 839
2. Image Processing
02.03. Quantitative image analysis

Quantitative assessment of strabismus and selected vision related anomalies

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Decreased vision, double vision, eye fatigue and strain associated with strabismus often require no-surgical or surgical options which may lead to overcorrection or under correction with a need for a follow up surgery. Therefore, quantitative assessment of the degree of strabismus can serve as very useful tool for deciding on therapeutic options and evaluation of their outcomes. Further, US focused statistics indicate that 4% of the population has strabismus while some global estimates attribute this anomaly only to .034% of world population. These contrasting statistics further lead to a necessity of having an uniform quantitative tool for a broader application to determine the scope and the degree of this anomaly in different populations. At this point variety of tests are used including Hirschberg test, Cover test, and Central Corneal Light Reflex Ratio.
Therefore, the developed technique allows automatic quantitative detection of a presence of possible strabismus and calculation of linear and vertical deviations of eyes in digital images. In particular, the proposed algorithm was organized in seven stages: (1) face matching (2) face detection and alignment (3) extraction of region of interest (4) locating the iris of both eyes and their center positions (5) selection of reference points in the eyes (6) calculation of linear and vertical deviations (7) making prediction using pre-trained regression model. This methodology has 94% of accuracy, 84% of sensitivity and 30% of specificity as tested on 128 images.
In particular, the outcome encompasses a methodology for two graphical user interfaces which have real time as well as local image processing capability; a bounding box approach to make the face of a person aligned; and determination of numerical linear and vertical deviations of the eyes. While the deviation of normal eyes is close to zero, the higher numbers indicate pre-strabismus or strabismus conditions respectively.

Contribution ID: 850

2. Image Processing
02.03. Quantitative image analysis

In vitro flow quantification of turbulent flow following aortal valve

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Phase contrast sequence for flow quantification is designed to measure constant velocity flow accurately. Turbulent flow following aortal valve challanges the assesment with presumed underestimation, which was to be quantified in this experiment.
The measurement was performed in vitro using plastic tube phantom with a valve-simulating triangular aperture. A pump with adjustable output was used to circulate water at five different flux rates through the phantom. Flux was measured for several slices perpendicular to flow both prior to valve and covering 9 cm region after the aperture.
Immediately after the valve, an increase of 15 % in flux was observed. The value decreased to flux prior to the aperture at 4 cm downstream, not depending significantly on the actual pump output. Velocity dispersion across the tube lumen recovered after 8 cm, as well as peak velocity. Negative flux occured, vanishing at 2 cm after the aperture.
Surprisingly, flux gets overestimated in obtained turbulent flow. This suggests not to quantify flow in region directly following the valve, although minor deviations from constant velocity flow are tolerable. This does not apply for peak velocity measurement which is more sensitive to an accelerated flow. Further knowledge about flow profile and characteristics would be beneficial for understanding the reason for flux overestimation. The phenomena seems not to be dependent on flow power.
Supported by the Ministry of Health of the Czech Republic (project number 15-27178A).

Contribution ID: 903
2. Image Processing
02.03. Quantitative image analysis

Quantitative image analysis in precision medicine: Just-enough interaction paradigm

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Accurate and reliable image quantification is of paramount importance in medical image analysis and a pre-requisite to using imaging in precision medicine. With a widespread use of 3D/4D imaging modalities like MR, MDCT, ultrasound, or OCT in routine clinical practice, physicians are faced with ever-increasing amounts of image data to analyze and quantitative outcomes of such analyses are increasingly important. Yet, daily interpretation of clinical images is still typically performed visually and qualitatively, with quantitative clinical analysis being an exception rather than the norm. Since performing organ/object segmentations in 3D or 4D is infeasible for a human observer in clinical setting due to the time constraints, quantitative and highly automated analysis methods must be developed. For clinical acceptance, the method must be robust and must offer close-to 100% success rate – possibly using minimal expert-user guidance following the Just-Enough Interaction (JEI) paradigm. Our method for simultaneous segmentation of multiple interacting surfaces belonging to multiple interacting objects will be presented. The reported method is part of the family of graph-based image segmentation methods dubbed LOGISMOS for Layered Optimal Graph Image Segmentation of Multiple Objects and Surfaces. This family of methods guarantees solution optimality with directly applicability to n-D problems. To solve the

issue of close-to 100% performance on clinical data, the JEI paradigm is inherently tied to the LOGISMOS approach and allows highly efficient minimal (just-enough) user interaction to refine the automated segmentation. Clinically acceptable results are obtained in each and every analyzed scan with no or only small increase in human analyst effort. On average, JEI offers about a 10-fold speed-up in 3D compared to conventional slice-by-slice editing. The performance of the minimally-guided JEI method will be demonstrated on pulmonary CT, aortic CT and MR, knee-joint MR, cancer CT & MR, and coronary IVUS & OCT image data.

Contribution ID: 1328
2. Image Processing
02.03. Quantitative image analysis

Quantification of pulmonary blood flow using low-dose computed tomography

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Purpose: Quantitative regional pulmonary perfusion is important for applications such as diagnosis and management of pulmonary nodules, chronic obstructive pulmonary disease (COPD), pulmonary hypertension, and pulmonary embolism. The purpose of this study is to develop a clinically viable technique for quantitative measurement of pulmonary blood flow from a low-dose dynamic computed tomography (CT) using a first-pass analysis (FPA) technique.
Methods: An angioplasty balloon was placed in a branch of the left pulmonary artery of six swine (40-50 kg) under fluoroscopic guidance to induce several levels of embolism. Reference fluorescence microspheres and intravenous contrast (370 mg/mL iodine, 25 mL, 5 mL/s) were injected centrally and 20 volume scans were acquired using a 320-slice CT scanner at 100 kVp. After segmentation of the lung tissue, perfusion measurements were made in ml/min/g with the FPA technique using only two volume scans. The two volume scans were systematically selected simulating a prospective acquisition protocol for only two volume scans. Perfusion measurements in different lobes of the entire lung were compared with fluorescence microsphere measurements as the reference standard.
Results: The result of the FPA blood flow (PCT) measurements in mL/min/g was in good agreement with the reference microsphere blood flow (PMic) measurements (PCT = 0.80PMic + 1.34, Pearson R = 0.90). The occluded regions from different lobes could be easily visualized in the CT perfusion map. The effective radiation dose for the two volume scans necessary for the FPA technique was 2.6 mSv, which is substantially lower than the effective dose of the current dynamic perfusion techniques. The radiation dose can be further reduced by optimization of scanning parameters.
Conclusion: The results indicate that accurate pulmonary blood flow measurement can be made using a first-pass analysis technique. This technique can be used for physiological assessment of pulmonary disease.

Contribution ID: 1452
2. Image Processing
02.03. Quantitative image analysis

Accurate 4D flow MRI post processing for blood flow rate quantification in cerebral arteries

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Accurate and fast blood flow measurements in cerebral arteries are important. In conventional 2D PCMRI, each vessel segment is measured separately, and arteries must be localised during the investigation. With 4D flow MRI, time resolved blood flow from all cerebral arteries can be obtained in less than 10 minutes. However, to fully benefit from this technique, we need reliable automatic post-processing methods. Our objective was to develop and evaluate a new automatic method for segmentation and flow quantification for 4D flow MRI.
We used 4D flow- and conventional 2D PCMRI to measure blood flow in the nine large arteries connecting to the circle of Willis in 21 elderly subjects (13 women, 70-86 years). Flow rates in 4D flow MRI were quantified at the same location as the manually analysed 2D PCMRI data by matching of scanner coordinates. An algorithm for post-processing of 4D flow MRI data was developed, which generated double-oblique cross-sections of the artery and segmented lumen by applying a local threshold, defined as a percentage of the vessel peak intensity. We stepped through a range of increasingly conservative thresholds (19-24%) to find the optimal threshold, minimising the difference between 4D and 2D.
Flow was 110+/-60 ml/min (mean+/-SD, n=182 arteries). Mean difference and standard deviation between 4D flow- and 2D PCMRI, for the different thresholds, was 4.1+/-14.4 ml/min, 2.6+/-14.3 ml/min, 1.1+/-14.3 ml/min, -0.4+/-14.2 ml/min, -1.8+/-14.3 ml/min and -3.3+/-14.3 ml/min for threshold 19%, 20%, 21%, 22%, 23% and 24% respectively. For threshold 21-23%, the mean difference was not significant (p=0.31, 0.73, 0.09). The correlation between the 4D and 2D was 0.97 ($p<0.001$) for all thresholds.
4D flow MRI and the new post-processing algorithm enabled highly accurate blood flow rate measurements. The high degree of automation should stimulate translation of intracranial 4D flow MRI to clinical applications.

Contribution ID: 1492
2. Image Processing
02.03. Quantitative image analysis

Joint adaptive beamforming to enhance noise suppression for medical ultrasound imaging

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In this work we suggest a combination of two beamformers (BF) to improve the array noise-suppression habilities using the moments of the eigenvalues (EV) of the covariance matrix (CM) of data. This procedure allows estimating the level of the signal-to-noise ratio (SNR) based on a threshold. The eigenspace based minimum variance (EBMV) BF suffers from input signal with low SNR, while with high SNR, the Dominant Mode Rejection (DMR) BF output degrades thus, the random matrix theory (RMT) is used based on the principle that the EV of CM allow predicting the actual moments of the EV so that the SNR level of the proper input data is determined. The RTM allows solutions of the EV function ranging from [0-1], where values [0.1-0.2] are critical for threshold selection that determines which BF to apply. The higher threshold values are associated with the input signal with higher SNR level so that the ESBMV BF is applied, otherwise, the DMR is applied. The raw data of the multipurpose phantom (84-317) were acquired with a constant f-number of 0.75 using the Verasonics ultrasound system, 128-element linear array transducer L11-4v, 6.25 MHz and pitch of 0.308 mm and for data processing the sampling rate of 40 MHz. The performance of the proposed BF was evaluated in terms of lateral resolution using the full width at half maximum (FWHM) and Peak Side Lobe Level (PSL) and contrast (CR). In terms of

FWMH(mm), values of 1.75, 1.06, 1.14 and 0.83 for delay-and-sum (DAS), DMR, ESBMV and DMR+ESBMV were found, respectively, while in terms of PSL(dB), -17.15, -17.68, -18.13 and -18.36 were found, respectively. The CR values in (dB) were 11.56, 19.40, 19.34 and 20.88, respectively. Based on these results, we can conclude that the proposed approach can improve the image quality.

Contribution ID: 1882
2. Image Processing
02.03. Quantitative image analysis

A method to detect potentially malignant skin lesions through image segmentation

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Melanoma is the type of skin cancer responsible for most deaths from skin cancer, and it is of high importance to be detected at an early stage. The aim of this paper was the design of a system to analyze the mole's characteristics, based on the ABCDE criteria for identifying potentially malignant skin lesions. The system was validated with 92 base images (27 benign and 65 malignant melanomas from DermIS - Dermatology Information System). The methods to extract the main features: asymmetry, border, color, and texture may obtain relevant information of skin lesions successfully.

Contribution ID: 385
2. Image Processing
02.04. Statistical image analysis (parametric and non-parametric tests and mapping)

Examination of the spatial structure of pigs melanoma in tissue sections based on histology and mass spectrometry

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Following our work on the description of the differences in spatial metal (Cu, Zn) distribution among the various developmental stages of pigs melanoma, we intend to study the spatial structure of the melanoma in several parallel tissue sections. The pigs melanoma was examined in 10 tissue samples obtained each from an individual animal of age between 4 and 22 weeks. The tissue sections were measured by light microscopy and laser ablation ion inductively coupled plasma mass spectrometry (LA-ICP-MS). The resulting data (metal concentration maps, microscopy image and histology annotation) are aligned by the means of the image registration and further processed in order to eliminate the effect of the uneven thickness of the tissue sections.
The exploratory analysis of the tissue sections indicates there is clearly a pattern in the spatial structure (distribution of the melanoma cells). Different projections of the spatial structure of the melanoma are obtained by the different measurement methods. The proposed work aims at (1) the description of the melanoma spatial structure in relationship to the capabilities of the different measurement methods (modality, resolution, spatial covariance); (2) identification of the possible

consequences of the spatial structure on the annotation of the tissue sections by an expert; (3) finding the relationships between the spatial structure observed by the different measurement methods and its possible application to the image registration procedure; (4) as well as better understanding the processes taking place during melanoma cell life-cycle.

Contribution ID: 817
2. Image Processing
02.04. Statistical image analysis (parametric and non-parametric tests and mapping)

Ultrasound imaging for microcirculation assessment based on amplitude modulation and Nakagami parameter ratio with microbubbles

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Contrast-enhanced ultrasound (CEUS) imaging with the microbubbles has been widely used in estimating the blood flow of microcirculation via measurements of time–intensity curve (TIC) and time–Nakagami parameter curve (TNC). Compare to TIC, TNC was found to be with a better tissue clutter tolerance due to that Nakagami parameter describes the shape of statistical distribution of ultrasonic envelopes backscattered from a region-of-interest (ROI) region. TNC is less affected by backscattering intensity and that however its reproducibility can be affected by acoustic properties of surrounding tissues and measurement conditions. Moreover, the backscattering properties of microbubbles are highly dependent upon acoustic pressure amplitude. Therefore, current study proposed to assess microcirculation with a window-modulated compounding Nakagami ratio imaging (WMCR) and to the time-Nakagami-parameter-ratio curve (TNRC) which uses amplitude modulation and Nakagami parameter ratio from backscattered signals. Two alternative incident acoustic pressure amplitudes, including 2.86 MPa and 4.37 MPa, were arranged for measuring the TNRC of microbubble perfusions in phantom and rat gastrocnemius muscle in vivo. The relative standard deviation (RSD) of TNRC at different scan times was found to be less than 1% that is significantly lower than TIC and TNC. Furthermore, this study also proposed the use of a fusion of CEUS B-mode imaging with WMCR imaging to allow for a clear visualization and quantification in the perfusion area of microbubbles and surrounding tissue structures. These results suggest that the Nakagami ratio based technique can be used as a complementary tool with the conventional TIC and TNC to improve measurement of perfusion in the microcirculation.

Contribution ID: 119
2. Image Processing
02.05. Computer–aided diagnosis (CAD)

A Colored Computer Aided Diagnosis System for Breast Mammography Based on the Wavelet Decomposition Technique

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Breast Cancer is the most common and life threatening cancer among women. Mammography is the process of using low-energy X-rays to examine the human breast. It is one of the best examination procedures for early detection of breast cancer. Mammograms are the most difficult of radiological images to interpret since they are of low contrast. Radiologists typically diagnose breast abnormalities and indicate their regions from mammograms. Sometimes due to small masses or breast density radiologists may miss the suspicious regions, so the diagnosis can fail. Therefore, efforts in developing Computer Aided Detection/Diagnosis (CAD) algorithms for

mammogram analysis will assist radiologist in images interpretation for accurate diagnosis and efficient detection of cancer cells in the earlier stages. This study developed an algorithm to analyze mammograms automatically with colors, in order to detect the abnormal breast tissue. It proposed the use of the Discrete Wavelet Decomposition (DWD) technique using symlet wavelet to find out this detection. Different sets of proposed combination techniques based on the DWD technique were used in order to obtain the best accuracy in breast tissues classification. The study showed that the combination between the un-decimated DWD technique and the Spatial Gray Level Dependency Matrix (SGLDM) achieved the best result. It achieved 98.8% accuracy, 95.0% sensitivity. This accuracy has been verified with the ground truth given in the mini-MIAS database. This algorithm will help to spare women unnecessary and stressful biopsies.

Contribution ID: 163
2. Image Processing
02.05. Computer–aided diagnosis (CAD)

Digital image processing for objective videokymography

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There are many existing methodologies for diagnostics and treatment of communication disorders, and often they are still subjective in terms of an examiner view. We have focused on the objective evaluation of vocal fold vibrations and their irregularities. Videokymographic cameras are good for evaluation of non-periodic pattern. They have the same time resolution as high speed cameras (HSC), often taken as the first choice, but they scan just smaller subset of lines of the scene and thus are able to capture much longer time interval than HSC and with better image quality. An objective evaluation of collected data can privided by means of computer aided analysis, when characteristics of vibration patterns are estimated using digital image processing and feature detection. We have proposed to process videokymographic data using software based on algorithms for scene analysis. Image processing facilitates the examination and help to objectively estimate characteristics of the vibration patterns. During the often unconformable data acquisition the content of the video stream is automatically evaluated and information-rich parts are preselected and unwanted artifacts are suppressed. Firstly vibration structures (vocal folds borders) are detected, then parameters, capturing present phase, amplitude, left-right correspondence etc. are computed. Numerical representation of vocal fold behavior objectively describes main characteristics and enables to quantify the grades of disease, which can increase the insight into the dynamics of the regeneration. Individual steps of parameter computation are compared the performance of experts (18 sets) to verify robustness of the proposed system. The deterministic approach to parameter evaluation lessens the uncertainty in the tissue categorization.

Contribution ID: 277
2. Image Processing
02.05. Computer–aided diagnosis (CAD)

Computer-aided malignancy discrimination of colon tumor using convolutional neural network

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In recent years, the number of cancer patients and its morbidity have increased year by year, because of Western dietary habits in Japan. Our laboratory has dealt with a malignancy diagnosis system of colon cancer by pathological indexes such as N/C, pseudostratified grand and so on. The false-negative increases in the discriminant results, when both benignant and malignant tumor exist in one image in the previous study. In order to solve the problem, we have divided the whole image into many small regions and perform the diagnosis for each small image by a convolutional neural network called Alexnet. However, the discriminant results was not sufficient for actual clinical practice. It the most ultimate problem that we cannot understand what property of the tumors the Alexnet recognizes. Therefore, the aim of this study is that the Alexnet used for the tumor diagnosis and meanwhile a visualization of inner parameters in the network is made after the training. The Group 1, 3 and 5 in group classification are used in this study. The positive predictive value (PPV) is important value for Group 1, and the sensitivity is important for Group 3 and 5. In the results, PPV of Group 1 reaches 94.0%, and the sensitivity of Group 3 and 5 become 89.7% and 85.6% in fine-tuning, respectively. And PPV of Group 1 and the sensitivity of Group 3 and 5 are 91.7%, 82.9% and 81.6% in full-training, respectively. Besides, in the visualization of inner part of Alexnet, The visualized inner parameter images of Group 1 respond to the whole tissue, the visualized images of Group 3 respond specially to glandular parts. From the obtained results, the visualized inner parameter of neural network can explain a discriminant criteria for malignancy of colon tumor.

Contribution ID: 285
2. Image Processing
02.05. Computer–aided diagnosis (CAD)

Automatic identification of muscular diseases via only hematoxylin and eosin stained histopathological image with convolutional neural networks

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Purpose:
Muscular diseases, especially skeletal muscle diseases, are a heterogeneous group of diseases. The confirmatory diagnosis of muscular diseases is primarily dependent on the histopathological sections derived from muscle biopsy, whose types are more than 20, like H&E stained histopathological image, MGT stained histopathological image, COX stained histopathological image. It is estimated that muscular diseases would affect 940800 patients on account of the large population of China. And the pathology images are always as large as 400 million (17k×24k) pixels. Thus, the process for many pathologists is error-prone and labor intensive. Moreover, it takes a long time to become an eligible neuromuscular expert proficient in muscle pathology. We aimed to identify muscular diseases via only H&E stained histopathological image, for saving medical cost and not reducing diagnostic quality.
Method:
This paper presents a framework to automatically identify muscular disorders in megapixel microscopy images sized 17k×24k pixels with segmentation and convolutional neural networks. To verify its feasibility, we obtained 85 histopathological images from 51 patients including 5 groups corresponding to 5 kinds of muscular diseases and 1 group of normal subjects. Ground truth for histopathological images was provided via a set of histopathological images and genomics of those patients. The CNN was trained over a large number of image patches from tissue region in histopathological images to learn a hierarchical part-based representation. 70% of the patches were used for training set, the rest of patches were for test set.

Result:
We achieve 92% average accuracy for 5 kinds of muscular diseases and normal subject with only H&E staining pathology images.
Conclusion:
These results demonstrated the feasibility of identification of muscular diseases combining segmentation and CNN via only H&E stained histopathological image, which has potential value in the clinical application.

Contribution ID: 553
2. Image Processing
02.05. Computer–aided diagnosis (CAD)

Characterization of breast lesions using BI-RADS features for B-mode ultrasound

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The purpose of this work was to evaluate computable features from the Breast Imaging Reporting and Data System BI-RADS in a computer-aided diagnosis (CAD) system. The ultrasound database consisted of 206 lesions (144 benign and 62 malignant) proved by percutaneous biopsy. A radiologist manually delineated the contour of the lesions. We extracted ten features based on the BI-RADS lexicon and selected based on classification performance using a “bottom-up” approach for five machine learning methods. The classifier with the highest area under the receiver operating characteristic (ROC) curve (AUC) was the support vector machine (SVM) with 0.84. It achieved 71.43% of sensitivity and 76.90% of specificity. Lesion margin and orientation were optimum features in all the machine learning methods. In conclusion, the computerized BI-RADS features can effectively aid the distinction between benign and malignant masses in breast ultrasound.

Contribution ID: 749
2. Image Processing
02.05. Computer–aided diagnosis (CAD)

Fully automatic CAD system for segmentation and classification of spinal metastatic lesions in CT data

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Our contribution presents a research progress in our long–term project that deals with the spine analysis in computed tomography (CT) data. A fully automatic computer–aided diagnosis (CAD) system enabling the simultaneous segmentation and classification of metastatic tissues that can occur in vertebrae of oncological patients is presented. A task of the proposed CAD system is to

segment metastatic lesions, and classify them into two categories – osteolytic and osteoblastic. These lesions, especially osteolytic, are ill–defined and is difficult to directly detect them with information about voxel intensity only. A usage of several local texture and shape features turned out to be useful for correct classification, however the exact determination of relevant image features is an uneasy task. For this reason, the feature determination has been solved by automatic feature extraction provided by a deep convolutional neural network (CNN).
The CAD system is composed of pre–processing and the CNN classifier. The pre–processing performs data re–sampling, filtration and centring that are dependent on the patient and CT scan protocol. The volumetric data are further transformed to the stack of three mutually orthogonal slices. The CNN classifier is formed by a specific architecture, which contains 17 layers trained from scratch.
The CNN has been trained and evaluated on a database of 17 cases containing 377 vertebrae from thoraco–lumbar or whole–spine CT scans. Both types of lesions were annotated by two independent radiologists. Results are obtained by a leave–one–out cross–validation, where mean sensitivity is greater than 92 % with approximately 3 false positive detections per lesion for both types of lesions. It has been proven that achieved results are, in most cases, better than those by other so far published methods.

Contribution ID: 750
2. Image Processing
02.05. Computer–aided diagnosis (CAD)

Fully automatic CAD system for spine localisation and vertebra segmentation in CT data

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In this abstract, we describe a fully automatic CAD system for the spine detection in CT data followed by vertebra identification and segmentation. Because our research within the long-term project is targeted at pathological cases that contains severely deformed vertebrae, it turned out to be a complicated task. Nevertheless, the significant progress has been made in the development of the presented CAD system. There are several basic problems: spine detection including the determination of a spinal axis in deformed spinal CT data, next a localisation of individual vertebrae and their identification of types in the case of an incomplete spine and eventually the final vertebra segmentation.
The detection of the spine, specifically its ends, based on a matched filter is followed by tracing of spinal cord canal by the maximum circle method. Next, the adaptive analysis of brightness profiles along spine axis leading to intervertebral disc localisation has been proposed. Based on the expert validation, the mean disc error distance of the algorithm is 1.37 mm. The discs thus obtained are subsequently identified via comparing adjacent vertebrae and statistical kernel PCA model of vertebrae optimised by the dynamic programming, this way achieving sensitivity 93.8 %. The final vertebra segmentation is provided by deformation of the whole spine intensity model utilising a multilevel registration technique. By the subjective strict expert validation, the algorithm provides 68 % of fully correct vertebra segmentations.
Considering the complexity of the problem, our proposed CAD system combining several advanced methods of the image processing is at least comparable with to this date published

algorithms. Based on results of the expert validation, it seems to be routinely usable and fully usable in the following automatic spine bone lesion analysis.

Contribution ID: 790
2. Image Processing
02.05. Computer–aided diagnosis (CAD)

Application of low-cost 3D printing for production of CT-based individual surgery supplies

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The main problem addressed in this paper is the use and evaluation of low-cost additive manufacturing (3D printing) techniques and CT images as tools for manufacture of usable and individualized, anatomically correct models, assisting surgeons in their daily work. The authors formulate own methodology of design and additive manufacturing of medical products on the basis of medical imaging data. A specific case was selected – a surgical lower jaw template for use in the middle of operation. Two Fused Deposition Modeling machines – professional and low-cost – were used to manufacture the same product, which was later evaluated, inspected for accuracy (by 3D scanning) and used during the surgery.
By two 3D printing processes comparison it was found that the low cost comes at a price of lower accuracy and increased demand for process supervision. The authors obtained a fully usable medical product used during an actual reconstruction surgery. Partial clinical results are presented - use of 3D printed templates helped reduce surgery time and generally improved the patient recovery process.

Contribution ID: 977
2. Image Processing
02.05. Computer–aided diagnosis (CAD)

Prediction of Alzheimer's disease in mild cognitive impairment using sulcal morphology and cortical thickness

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Mild cognitive impairment (MCI) is an intermediate condition between normal ageing and dementia, and a substantial risk factor for subsequent conversion to Alzheimer's disease (AD). AD is an irreversible neurodegenerative disorder, characterized by a progressive brain atrophy, which leads to a gradual loss of cognitive functions and eventual death. While not all MCI patients develop AD during their life, a significant number does indeed progress to AD. There is therefore an urging need to accurately quantify and evaluate the patterns of AD-specific atrophy in MCI using diagnostic imaging. The purpose of this study was to predict future AD-conversion in patients with MCI using machine learning with sulcal morphology and cortical thickness measures as classification features. 32 sulci per subject were extracted in BrainVISA from 1.5T T1-weighted MRI scans of 90 MCI-converters and 104 non-converters, obtained from the ADNI database. We computed sulcal depths, lengths, mean and Gaussian curvatures, and medial surface areas, as well as cortical thickness measurements, extracted with FreeSurfer. The extracted features were used in support vector machine classification, with linear and Gaussian kernels, to identify the structural patterns distinguishing the future converters from the stable subjects. The linear kernel

classifier trained with these features was able to predict 87.0% of MCI subjects as future converters, with an 89.7% sensitivity, and 84.4% specificity (0.94 AUC), using 10-fold cross-validation. These results using sulcal and cortical features are superior to the state-of-the-art methods. The most discriminating predictive features were observed in the temporal and frontal lobes in the left hemispheres, as well as from the entorhinal cortices, which is consistent with findings reported in literature. However, we also observed structural changes in the cingulate and calcarine cortices, suggesting that the atrophy in the limbic and occipital lobes may be linked to future conversion from amnestic MCI to AD.

Contribution ID: 1082
2. Image Processing
02.05. Computer–aided diagnosis (CAD)

Early Detection of Tuberculosis using Chest X-Ray (CXR): CLAHE and ICA

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Tuberculosis (TB) is one of the most deadly diseases in the world. Accuracy and speed of diagnosis is very important because early treatment will prevent more infections and fatal effects. In addition, rapid diagnosis reduces the risk of transmission from an infected patient to other individuals significantly.
Chest X-Ray (CXR) is one of the methods to diagnose TB. TB is characterized by the existence of lesions and infiltrates in lungs that appear as nodules (white patches) in CXR. Generally, CXR is used in early stage diagnosis preceding microbiological test on TB-suspected patients. CXR can indicate abnormalities in lungs and show the extent of infection. However, the interpretations of CXR can vary from one individual to another individual, from one radiologist to another, as a person is prone to process information subjectively. In addition, the abnormalities that indicate TB are less specific and hard to observe.
Therefore, Computer-aided Diagnosis (CADx) is needed to assist doctors and radiologists in interpreting CXR. Hopefully, TB diagnosis can be done more accurately and rapidly. In this paper, several image processing methods are used to conduct early detection of TB using CXR.
The pre-processing stage consists of homomorphic filter to eliminate non-uniform illumination, histogram equalization, median filter for image denoising, Contrast-Limited Adaptive Histogram Equalization (CLAHE) to improve local contrast in image, and Independent Component Analysis (ICA) to separate ribs and soft tissues. Segmentation is conducted using Active Contour Method. Feature extraction is performed by analyzing the image texture through first order statistical features. The last stage is classification using Support Vector Machine (SVM) to divide the image into 2 classes.

Contribution ID: 1278
2. Image Processing
02.05. Computer–aided diagnosis (CAD)

Lung Nodules Classification of CT Images Using Cascade Artificial Neural Network

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Lung cancer is the most common of malignant tumors. Early detection is the main factor to determine the survival of patients affected by this disease. Furthermore, the correct classification is important to define the most appropriate therapeutic approach as well as suggest the prognosis and the clinical disease evolution. Among the exams used to detect lung cancer, computed tomography has been indicated. However, CT images are complex and even experts medical are subject to fault detection or classification. In order to assist the detection of malignant tumors, computer-aided diagnosis systems have been developed to reduce the amount of false positives biopsies. In this work it was developed an automatic classification system of pulmonary nodules on CT images using Artificial Neural Networks. Morphological, texture and intensity features were extracted from lung nodules cut tomographic images using elliptical regions of interest that they were subsequently segmented by Otsu method. These features were selected through statistical tests that compare populations (T test of Student and U test of Mann-Whitney); from which it originated a ranking. The features after selected, were inserted in Artificial Neural Networks (backpropagation) to compose two types of classification; one to classify nodules in malignant and benign (network 1); and network 2 classifies two types of malignancies, featuring a cascade classifier. The best networks were associated and its performance was measured by the area under the ROC curve, the network 1 and network 2 achieved performance equal to 0.901 and 0.892 respectively.

Contribution ID: 1643
2. Image Processing
02.05. Computer–aided diagnosis (CAD)

Evaluation of region convolution neural networks for breast lesion detection in mammography images

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Introduction
Recently availability of large scale mammography databases enable researchers to evaluates advanced tumor detection applying deep convolution networks (DCN) to mammography images which is one of the common used imaging modalities for early breast cancer. With the recent advance of deep learning, the performance of tumor detection has been developed by a great extent, especially using R-CNNs or Region convolution neural networks. This study evaluates the performance of a simple faster R-CNN detector for mammography lesion detection using a MIAS databases.
M&M
The proposed methods has been comprised in following steps:(1) Data preparation and preprocessing of input images(2) Design and train a faster R-CNN detector,(3) Evaluate Detector Using Test Set. Preprocessing step includes region extraction and contrast enhancement. Dataset were randomly has been divided into training, testing (respectively 80% and 20% of the total images). We have design a CNN layer using Matlab Neural Network Toolbox™ functionality. For object detector evaluation we calculate average precision and precision/recall (PR) ratios.
Results
In this study we have reached, the average precision of 0.6. The use of more training data can improve the average precision, at the cost of longer training time.Our results from using deeper network using extra series convolution layer did not improve detection results since the network

was not able to detect any region which may impose extra layers should be carefully designed and added. We will evaluate this in future applying different designs other that series networks.
Conclusion
There are many studies showing reasonable performance of convolution neural networks on mammography lesion detection but using faster R-CNN detectors is new in this field. This study shows that the detection precision of R-CNN is promising for mammography lesion detection. more research using larger databases will help to improve the accuracy of detection using faster R-CNN detectors.

Contribution ID: 14
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Restoration of full data from sparse data in low dose chest digital tomosynthesis by using deep convolutional neural network

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Chest digital tomosynthesis (CDT) provides a limited amount of image information required for diagnosis than CT, and the patient dose is higher than that of chest radiography. Therefore, CDT, which has no definite advantages in terms of image quality and radiation dose compared with CT and radiography, has not been actively used in clinical applications. In this regard, it is necessary to reduce the patient dose of CDT to the dose level of radiography in order to increase the usefulness of CDT. In this study, we investigated a new approach for acquiring low dose CDT image by using deep convolutional neural network.
We used the prototype CDT system and anthropomorphic chest phantom. Proposed method focused on restoring reconstructed image from sparse sampled data to full sampled data . Deep learning model that we used in this study was U-net. Input and output image for developed model is reconstructed image acquired with 11 and 81 projections, respectively.
Proposed method effectively restored degraded image quality. Signal to noise ratio measured according to anatomical location was improved by2 times when using the propose method. Effective dose acquired with sparse sampling data was approximately 0.12 mSv and it is almost similar compare to chest radiography (0.1 mSv) according to report in RSNA.
We investigated a new approach to reconstruct tomosynthesis image with sparse projection data. The model based iterative reconstruction (MBIR) method has been used as the conventional sparse sampling reconstruction method. However, MBIR requires high computational power and long computation times, which limits its applicability in clinical applications requiring fast 3D image reconstruction. From this point of view, it is expected that the proposed model, which is learned to reconstruct the full sampling data from the sparse sampling data will be able to generate excellent image quality with fast computing time.

Contribution ID: 198
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Machine learning techniques for classification of breast cancer

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Objective: Machine learning techniques are proven to be very beneficial in disease diagnosis over the past decade. This paper presents results of development and comparison of different Artificial Neural Network (ANN) architectures for classification of breast cancer.
Methodology: A data set for system development and testing was obtained from UCI Machine Learning Repository and contains 569 samples describing characteristics of the cell nuclei present in the digitized image of a fine needle aspirate (FNA) of a breast mass. Single layer and multi-layer, linear and non-linear neural network architectures were evaluated in this research.
Results: Results depict that a single layer neural network with 20 neuron has the highest classification accuracy (99.5%). The accuracy of multi-layer architectures was significantly lower, and valued in range of 74.9% to 86.3% where the average was 81.37%. Single layer architectures performed with an average accuracy of 86.2%.
Conclusion: A developed system with a proven accuracy can be used in the future in laboratory conditions as a promising method for early classification diagnosis for breast cancer.

Contribution ID: 304
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Reduction of CT ring artifacts using morphological edge detection and fuzzy neural network

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Purpose: CT ring artifacts influence the quality and facticity of images and interfere the clinical diagnosis, so reducing ring artifacts has become the research focus. Nowadays many interpolation methods have been applied in post-processing domain, but the performances of these methods mostly depend on the property of the object. Therefore we proposed a new interpolation method which based on Takagi-Sugen fuzzy and Radial Basis Function Neural Network system.
Materials and Methods: We detected the image edges by new morphological edge detection operator ($\beta(A)=[A(x,y)\circ B_1(m,n)]\cdot B_1(m,n)-A(x,y)\circ B_2(m,n)$, where B is structural element and A is pending image). Next we did enhancement processing by gray level transformation. The artifacts were then located by morphological hole filling and pixel connectivity method. A hybrid of bicubic and polynomial fitting interpolation was performed to compensate artifact region. Besides, the interpolated data were trained by the combination of Fuzzy-RBFNN system. Finally, we acquired the results. In this experiment, we used 2 head data and 2 chest data with complicate artifact structures from a CBCT scanner. The peak signal to noise ratio(PSNR) and mean gradient(MG) were used to quantitatively compare wavelet-Fourier method and interpolation method without neural network.
Results: The performance of proposed method presented much better results based on image observation compared with the Fourier method and interpolation method. For objective analysis, the highest PSNR and MG were showed by a proposed method.
Conclusion: Proposed method can accurately locate the positions of the artifacts and effectively reduce artifacts. In addition, it’s proved that fuzzy neural network system can improve the performance of interpolation for removing the ring artifacts.

Contribution ID: 333
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Development of a new method to reduce large motion artifacts for DSA used by Deep Learning

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Contribution ID: 469
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Development of a new method to reduce large motion artifacts for DSA used by Deep Learning

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Purpose:
Digital subtraction angiography (DSA) is useful for IVR. However, DSA image is severely affected by motion artifacts. Because heavy motion artifacts due to the breathing and the heart beating of the patient decrease vessel visibility on DSA images. The purpose of this study is to develop a new DSA method especially for large motion artifacts and with enhancement of small vessels by using Deep Learning technique.
Method and Material:
Thirty series of abdominal artery angiograph and 29 series of coronary artery angiograph datasets (512x512) were included in this study. We used convolutional neural network (CNN) model to produce “mask images”. The CNN model consisted of three to five convolutional layers. The CNN model was also including 64x64 input units and 64x64 output units.
To obtain “image patches” consisted of 64x64 pixels as teaching data for training the model, we made 42,050 “image patches” by cropping from 512x512 images. The model was trained using a learning data set involving contrast-enhanced vessel image as input data and plain X-ray image as teaching data.
The mask images for DSA were constructed from image derived by inputting angiograms to the model. DSA images were finally obtained by subtracting the mask images from the live images.
Results:
The experimental result demonstrated that coronary arteries and abdominal artery were clearly visualized on DSA images with extremely low-level motion artifacts compared to conventional DSA. Results of subjective evaluation by two physicians showed DSA image has very high image quality than that of conventional DSA on all of cases. Even when the C-arm was moved during image acquisition, coronary arteries were clearly visible on DSA images with the proposed method.
Conclusion:
A method for coronary DSA reducing motion artifacts was proposed. This method will be very helpful for the motion artifacts.

Contribution ID: 775
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Label-free nuclear staining reconstruction in quantitative phase images using deep learning

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Fluorescence microscopy is a golden standard for contemporary biological studies. However, fluorescent dyes cross-react with biological processes. Therefore, a label-free approach is desirable. Unfortunately, routine microscopic techniques (phase contrast, DIC) suffer from artifacts in the image, making segmentation task difficult. On the other hand, Quantitative-Phase (QP) images from holographic microscope provide artifact free data, that represent the dry mass distribution in the sample. Additionally, it is possible capture QP images simultaneously with fluorescence staining.
The aim of this study is to create artificial, fluorescence-like nuclei labeling from QP images using Convolution Neural Network (CNN). The dataset has been created with prostatic cell line PNT1A using nuclear staining with Hoechst 33258, which is selective to DNA. This approach therefore enables creating a training set with tens of thousands of cells without the need of manual annotations. CNN trained on QP with fluorescence colored images is then applied at label-free data to produce images similar to fluorescence labeling. These images then can be used for nuclei segmentation and other analysis.
For the purpose of creating such synthetic fluorescence fully convolutional network has been used, particularly SegNet architecture with Least Squares Error (LSE) loss for regression. We observed high correlation of 0.39 between QP and fluorescence images (correlation between segmented nucleus pixels of Hoechst and QP), which confirms the possibility of transformation between these images. Based on preliminary results, we are able to achieve quantitatively sufficient nuclei images for nuclei segmentation.
In summary, this approach can provide an easy-to-obtain annotated dataset for CNN training, which is then able to produce fluorescence like images usable for segmentation of nuclei in numerous biological applications (e.g. identification of polyploid cancer cells, identification of aneuploidy – Down Syndrome, etc.).

Contribution ID: 780
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Comparison of pixel-wise feature classification and convolutional neural network for retinal blood-vessel segmentation in video-data

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Glaucoma is a serious retinal illness, where early treatment is essential to prevent its progress. Thus, screening method for identification of glaucoma risk is highly needed. One of the possibilities is identification of the scale and magnitude of the pulsations of retinal veins with video-ophthalmoscope, where the first important step for its analysis is blood-vessel segmentation. There are many segmentation techniques for stationary blood-vessel data, but our video-data are rather specific.
One of the classical approaches for segmentation of retinal blood vessels is the extraction of some specifically designed features followed by a supervised pixel-wise classification, where the most

used classifier is the random forest (RF). Besides others, we test combinations of Gabor filters, matched filters and morphologically processed images as features. This approach leads to the segmentation with limited accuracy.
On the other hand, Convolution Neural Network (CNN) is a method with state-of-art performance for segmentation of retinal blood vessels. Better performance of CNN has been proven; however, it needs a large amount of training data and it is highly time consuming to create a database with labels for a specific task. Based on preliminary results with U-net architecture trained on a limited amount of training data, CNN does not outperform RF classifier with different settings and creation of adversarial examples.
The purpose of this study is a comparison of segmentation performance of retinal blood vessels with a CNN against RF classifier with feature extraction, with increasing number of training images. Based on this comparison we can acquire the best performing method for our data and moreover we create statements about the amount of data needed for CNN's.

Contribution ID: 814
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Evaluation of facial attractiveness for purposes of plastic surgery using machine-learning methods and image analysis

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Many current studies conclude that facial attractiveness perception is data-based and irrespective of the perceiver. However, the ways how to analyse associations between facial geometric image data and its visual impact always exceeded power of classical statistical methods. In this study, we have applied machine-learning method to identify geometric features of a face associated with increase of facial attractiveness after undergoing rhinoplasty. Futhermore, we explored how accurate classification of faces into sets of facial emotions and their facial manifestations is, since categorization of human faces into somatotypes should take into consideration the fact that total face impression is also dependent on expressed facial emotion.
Both profile and portrait facial image data were collected for each of a patient (n = 50), processed, landmarked and analysed using R language. Multivariate linear regression was performed to select predictors increasing facial attractiveness after undergoing rhinoplasty. The sets of used facial emotions and other facial manifestation originate from Ekman-Friesen FACS scale, but was improved substantially. Bayesian naive classifiers, regression trees (CART) and neural networks were learned to allow assigning a new face image data into one of facial emotions (and somatotype).
Enlargement both of a nasolabial and nasofrontal angle within rhinoplasty were determined as statistically significant predictors increasing facial attractiveness ($p < 0.05$). Neural networks manifested the highest predictive accuracy of a new face categorization into facial emotions (somatotype). Geometrical shape of mouth, then eyebrows and finally eyes affect in descending order an intensity of a classified emotion, as was identified using decision trees.
We performed machine-learning analyses to point out which facial geometric features, based on large data evidence, affect facial attractiveness the most, and therefore should preferentially be treated within plastic surgeries. Additionally, classification and clustering methods indicated new possible facial somatotypes based both on facial geometry and expressed emotions.

Contribution ID: 1003
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Fingerprint liveness detection

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A novel image descriptor for fingerprint liveness detection using the combination of chosen set of discriminant features applied on given fingerprint image is proposed in this paper. The discriminant features selection is based on ability to use this algorithm on the vast majority of the real and fake fingerprint types with maximal precision.
Used discriminant features are for example orientation certainty level, energy concentration on the power spectrum, local orientation quality, spectral magnitude and phase error etc.
Also novel algorithm for preprocessing of fingerprint images is described. It propose the way of two different enhancement levels of image. First one is using standard sharpening mask with central pixel value of 9. Output of this enhancement is used for image binary transformation which is later used for detection of morphological descriptor features. The second one works on principle of over sharpening using sharpening mask with powered central pixel value of 10. Such approach eliminates background noise around fingerprint and is used for image segmentation.
In proposed approach the neural network to liveness detection is used. Proposed approach is tested on LivDet database which contains vast variety of problematic fingerprint images.

Contribution ID: 1040
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Synimage: a computational tool for automated detection of genetic syndrome using facial images

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BACKGROUND: The Congenital Heart Disease (CHD) is one of the most common malformations observed at birth and it represents an important health problem. Patients with CHD may have morphological features which are used to identify genetic syndromes in a physical exam. However, there is subjectivity in the professional analysis, which can lead to a late diagnosis, aggravating the patient's health condition. he main objective is to develop a mobile system based on facial image analysis to help neonatal care professional in the diagnosis of CHD-related genetic syndromes. METHODS: A dataset composed of 170 pictures of children, available on the internet, were created. 50% of the pictured were of children with Down syndrome and the other 50% were kept as control group. The faces were segmented using a trained object detector and after then applying an ensemble of regression trees to obtain the facial landmarks for feature extraction. The extracted features were 8 distances and 16 angles between the landmarks. RESULTS: Better results were obtained applying a Support Vector Machine with a Polynomial Kernel on the feature dataset resulting in an accuracy up to 82.35% using a 20-fold cross-validation. CONCLUSIONS: The results showed that it is possible to build the proposed software, however, there is still need to identify and extract additional features from the images to increase the classification accuracy as well as include other genetic syndromes in the dataset.

Contribution ID: 1072
2. Image Processing

02.07. Machine learning (neural networks, deep learning, ...)

Development of automated method for determination of difficulty level of treatment planning for IMRT-treated prostate cancer using convolutional neural network

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Radiotherapy quality has been greatly improved by high precision such as intensity modulated radiation therapy (IMRT). Some researches have been conducted to increase plan quality by automated knowledge-based radiotherapy planning, but there are still few reports using deep learning method. Thus, in this study, we developed and evaluated the feasibility of the automated method for determination of difficulty level of treatment planning for IMRT-treated prostate cancer patients using convolutional neural network (CNN). This approach was the first step of applying deep learning to automated radiotherapy planning process.
Randomly selected sixty prostate cancer patients treated with IMRT (Goal: target dose 80Gy/40Fr) were studied. All treatment plans were divided into two difficulty levels by experienced medical physicists: low difficulty (meet dose constraints) and high difficulty (not meet dose constraints). We proposed CNN-based automatic determination method for determination of the two difficulty levels. An AlexNet CNN that pre-trained on a large scale natural image database ImageNet was built as our determination model of difficulty levels. Our proposed CNN model was fine-tuned all layers (conv1-fc8) on treatment planning dataset using a supervised learning approach. To fine-tune our model efficiently, mini-batch stochastic gradient descent with momentum was employed. To investigate the impact of input data format on determination accuracy, two dataset formats were used: planning CT image and structure labels that were derived from DICOM RT structures. Five-fold cross-validation was used for validation, and determination accuracy was used as performance metric.
The determination accuracy of CNN fine-tuned on CT images dataset, CNN fine-tuned on structure labels was 56.7±9.7% and 70.0±11.3%, respectively. This result showed that CNN fine-tuned on structure labels improved the determination accuracy than on CT images.
Our result showed the potential of CNN for determination of difficulty level of treatment planning for IMRT-treated prostate cancer patient.

Contribution ID: 1091
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Fully automatic deep learning based segmentation of bone-cartilage interface from micro-CT images of human osteochondral samples

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Histopathological grading of articular cartilage from thin tissue sections is the gold standard method in osteoarthritis (OA) research, with multiple known drawbacks. We have previously developed a semi-quantitative three-dimensional (3D) grading method of OA from phosphotungstic-acid (PTA) -stained human osteochondral samples using micro-computed tomography (µCT). Our ultimate goal is to automate the grading process, which requires accurate segmentation of bone-cartilage (BC) interface. The drawback of PTA staining is the loss of X-ray attenuation contrast at the BC interface, which is an important anatomical landmark. In this study, we tackled this problem by developing a deep learning -based 2-stage segmentation method for the BC interface.
Our segmentation approach combines both 2D and 3D fully-convolutional neural networks (CNN). The first block employs a CNN architecture UNet to find an approximate BC interface from 2D slices. The second block refines the initial segmentation in 3D using a shallow volumetric network, which is utilizing the mask approximation and the original µCT stack data. We compared our method and the state-of-the-art volumetric CNN architecture VNet on an independent test set. The performance of the two CNNs was assessed by comparing the dice coefficients around the BC interface edges.
Mean dice scores obtained using our method and VNet were 0.90 and 0.88, respectively, with standard deviations 0.029 and 0.028. The method contributes towards automatic 3D histopathological grading of OA, which will be the focus of our future work.

Contribution ID: 1095
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Electronic portal imaging devices using artificial neural networks

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Introduction: In this work, Artificial Neural Networks (ANN) are used in External Beam Radiotherapy, especially for dosimetry purposes using Electronic Portal Imaging Device (EPID), which needs frequent calibration and complex setting of dedicated software.
This work is preliminarily oriented towards quality assurance of conformational radiotherapy and intensity-modulated radiotherapy (IMRT). This first step will allow adjusting ANN before their implementation in more complex treatments and in-vivo dosimetry.
Materials and Methods: Like humans, artificial neural networks work via two phases – learning and recognition. The supervised learning phase entails the creation of “neurons” by linking input and output data. The recognition phase consists of using input data to predict output data.
During the learning phase, EPID signals and desired absorbed dose distributions (taken from treatment planning system - TPS) are used as the neural network’s input and output, respectively. Once the learning is complete, new EPID signal can be used to predict the delivered absorbed dose distribution, allowing comparison with the TPS.
Results: Learning was performed using 11 input/output datasets from IMRT treatments. All of the used datasets (both EPID inputs and absorbed dose distribution outputs) consisted of 384× 512 pixels. Learning can be time consuming but once the ANN has been fixed, its use during the recognition phase will be instantaneous.
The gamma index, γ, was used to evaluate the difference between the ANN calculated and planned distributions. γ gives the number of pixels (as a percentage) that respect a given objective.

γ (2%, 2mm) for Head and Neck instance was found to be 99.7%, highlighting the ANN capability to predict the absorbed dose distribution based on EPIDs.
Conclusion: Generalising the neural network by increasing the number of datasets used during the learning phase, whilst maintaining elevated performance, will be the focus of future work regarding the IMRT quality assurance part.

Contribution ID: 1139
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Video-based surgical tool classification in endoscopic cholecystectomies

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Background: Tool classification plays a significant role in analyzing surgical workflow of minimally invasive surgeries for developing intelligent context-aware systems that can assist the surgical team and optimize operating room scheduling. A Convolutional Neural Network (CNN) which is a powerful image classification technique has been used for tool detection in endoscopic videos. However, variation in the frequent appearance of the surgical tools results in imbalanced data. Training the CNN using this data leads to biasing the CNN model towards tools more frequent in use. In this paper, we address this issue and propose a method to classify surgical tools based on weighted CNN.
Method: Weighted neural network was used to compensate the performance bias of the CNN model resulted from imbalanced training data. The pre-trained model AlexNet was fine-tuned for the tool classification task after setting different weighting factors for the loss functions of the tools. Each weighting factor is proportional to the percentage of tool co-occurrence in the training data. Moreover, the resulting model was retrained on a small set of balanced training data with a fewer number of iterations.
Result: Precision of the scissors was the lowest among the seven surgical tools being classified and by using the weighted model it was enhanced by more than 15%. Accuracy and precision of the other tools were also improved except the grasper which had the highest precision (91%). The experimental results of the final model showed an average precision of 80% and an average accuracy of 94%.
Conclusion: The results show improvement in the performance of the CNN model for classifying surgical tools in cholecystectomy videos. Essentially, the proposed method reinforces training generalization of the CNN model and reduces the influence of imbalanced data to obtain better classification performance for all surgical tools.

Contribution ID: 1140
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Phase recognition in laparoscopic videos: comparing Hierarchical HMM with simple HMM

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Background: surgical workflow analysis is an important topic that has been studied widely over the past decade because of its various applications related to future operating rooms. For instance, designing a context-aware system that provides valuable knowledge to improve patient treatment and reduce medical errors. Different forms of Hidden Markov Models (HMM) have been proposed

to model surgical procedures. However, simple HMM is still easier to use and adapt to different datasets and procedures rather than more complicated HHMM.
Method: the purpose of this work is to compare Hierarchical HMM (HHMM) to simple HMM for surgical phase recognition. A convolutional neural network (CNN) architecture called EndoNet was proposed by Twinanda et al. 2016. This CNN was fine-tuned using the Caffe framework. The fine-tuned model was then used to carry out the phase recognition. To consider temporal aspects of the surgery, CNN responses were passed as input to a simple HMM to solve the phase classification task. Finally, the recognition results were compared to the results presented by Twinanda where HHMM was used.
Result: the Cholec80 dataset containing 80 cholecystectomy videos with the tool and phase annotations was used for evaluation. The dataset was partitioned into two equal subgroups. One subgroup was used to fine-tune the CNN and train HMM, and the other was used for testing. The total phase recognition accuracy in offline mode using simple HMM was 86% compared to 92% obtained using HHMM. In online mode, the total recognition accuracy was 76% using simple HMM while it was 81.7% using HHMM.
Conclusion: a context-aware system can help the surgical team inside the OR to improve the quality of healthcare. This work shows that the performance of phase recognition using simple HMM in both online and offline modes is relatively close to the HHMM performance.

Contribution ID: 1200
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Fingerprint liveness detection

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In this paper, a novel image descriptor for fingerprint liveness detection using the combination of chosen set of discriminant features is proposed. The features selection is based on the ability to use this algorithm on the vast majority of the real/fake fingerprint types with maximal possible precision.
Used discriminant features are orientation certainty level, energy concentration of the power spectrum, local orientation quality, spectral magnitude and phase error and others.
Also, a novel algorithm for preprocessing of fingerprint images is introduced. It proposes combination of two different enhancement levels of image. First one is using standard sharpening mask with central pixel value of 9. The output of this enhancement is used for image binary transformation which is later used for detection of descriptor morphological features. The second one works on principle of image oversharpening using sharpening mask with central pixel value of 10. This step eliminates background noise around fingerprint and is further used for image segmentation.
In proposed approach, a neural network for liveness detection is used. The proposed approach is tested on LivDet database which contains vast variety of problematic fingerprint images.

Contribution ID: 1316
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Efficient multiclass Support Vector Machine for the classification of embryo time-lapse images using distance function optimization

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Novel techniques for imaging human embryo growth continuously during IVF treatment have brought on the possibility of monitoring dynamic traits during in vitro culture. The timing of mitotic divisions is one such trait with importance for embryo health, the understanding of individual cell development, cell tracking and cell lineage computation. One way to detect timing of divisions is to classify images in each image sequence according to number of cells. This is a challenging computational task, especially when the sequences used are captured using non-invasive imaging techniques. Difficulties include variable light conditions, sample contamination, high sample variability, lack of contrast enhancing agents and sometimes overlapping objects in the sample. In addition, multi-class classification based on image features must be achieved, and this is a common problem in medical image analysis. One typical method is to perform pair wise classification of images using a binary classifier. However, with multiple classes, the number of calculations necessary will increase with the square of the number of classes. We propose a performance optimization technique for cases where the distance function in feature space can be expected to have a predetermined shape and apply it to the case of classifying embryo images based on the number of cells per image. The classification is optimized by performing pair wise classification in the order of decreasing distance between classes in feature space. Using 12 basic features for classification, using a multi-class Support Vector Machine, we report a classification accuracy of 89.4% up to the 4 cell stage and 74.9% up to the 8 cell stage. This gives a performance (speed) improvement of up to 73% for the higher class spaces relative to a standard Directional Acyclic Graph-SVM.

Contribution ID: 1430
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Brain tumor classification in mri images using convolutional neural network

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Background: Three common types of brain tumor are Glioma, Meningioma, and Pituitary. Misdiagnosis of brain tumor will give the tumor an opportunity to grow and decrease the chance of survival among patients. One conventional method to differentiate brain tumors is by inspecting the MRI images of the patient’s brain. For large amount of data, this method is time consuming and the probability of human error will increase.
Method: In this study, we created an image-processing program using Convolutional Neural Network (CNN) algorithm that could classify brain tumor images into three categories, which is Glioma, Meningioma, and Pituitary.We are using the simplest architecture of CNN which consist of one convolution, maxpooling, flattening layer, and fully connection with one hidden layer. The CNN is trained with brain tumor dataset consisting of 3064 T-1 weighted CE-MRI images publicly available via figshare (https://doi.org/10.6084/m9.figshare.1512427.v5).
Conclusion: This CNN classifier can classify brain tumor into three different types, Glioma, Meningioma, and Pituitary with an accuracy of 95.30% which is higher than the latest result on the same dataset, i.e. 94.68% using adaptive fischer kernel (http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0157112). The system may support doctors in providing more accurate diagnosis of brain tumors.

Contribution ID: 1482

2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Automatic characterization of plaques and tissue in IVOCT images using a multi-step convolutional neural network framework

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Intravascular optical coherence tomography (IVOCT) is an imaging technique of great interest because it can contribute in diagnosing and preventing atherosclerosis due to its ability to provide in-vivo insight of coronary arteries' anatomy. The substantial number of slices which are obtained per artery, makes it laborious for medical experts to classify image regions of interest. We propose a framework based on Convolutional Neural Networks (CNN) for classification of regions of intravascular OCT images in 4 categories: fibrous tissue, mixed plaque, lipid plaque, calcification. The framework consists of 2 main parts. In the first part, square patches (32x 32 pixels) of OCT images are classified as fibrous tissue or plaque using a CNN which was designed for texture classification. In the second part, larger regions consisting of adjacent patches which are classified as plaque in the first part, are classified in 3 categories: lipid, calcium, mixed. Region classification is implemented by an AlexNet version re-trained on images artificially constructed to depict only the core of the plaque region which is considered as its blueprint. Various simple steps like thresholding and morphological operations are used through the framework, mainly to exclude background from analysis and to merge patches into regions. While the overall performance of the framework was only evaluated by visual inspection, the two networks demonstrated high accuracy in classifying patches and specially constructed input (95% and 89% respectively). There are several improvements proposed for further research such as the use of 3D or/and images expressed in polar coordinates, altering patches and regions extraction, and using different CNN architectures.

Contribution ID: 1863
2. Image Processing
02.07. Machine learning (neural networks, deep learning, ...)

Red and white blood cell classification using artificial neural networks

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Blood cell classification is a hot research topic for scientists working on medical diagnosis uses medical imaging. Manually performed cell classification is performed by doctors who have domain expertise. In fact, it is a real life problem to find actually required doctors who have an expertise in this domain. Doctors per patients ratio (DPPR) is smaller value in medical hospitals and finding required professionals in suburbans makes it harder to handle this test. Therefore, it requires a bio-engineering solution for the detection of cell types and cell abnormalities for the decreasing number of DPPR in the future. In this study, we have worked with an oncology hospital to classify cell types using computer vision. A huge cell database is created for the training artificial neural networks and there are pre and post processing algorithms for the efficiency. It performs the first step for the detection of 6 main cell types (erythrocyte, lymphocyte, platelets, neutrophil, monocytes , eosinophils). Since the image taken from slide after peripheral blood smear contains

many types of cells, we have developed a segmentation algorithm and then put the possible windows to Artificial Neural Networks (ANN). As a result, it marks the resulting cell types for each slide image. Evaluation of the performance of the algorithm is handled with the doctors who have domain expertise. Training and testing is performed using an approximate number of 10000 cell images with 6 labels. Evaluation is done with 50 images per slide. The evaluation results for each type of cell is given as with the percentage of 0.88, 0.95, 0.91, 0.93, 0.87, 0.91.

Contribution ID: 89
2. Image Processing
02.08. Image processing, display and visualization

Metal artifact reduction by morphological filtering in computed tomography

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When metal implants are present in the field of measurement, artifacts are generated over images degrading their quality. Metal artifact reduction (MAR) methods produce images with improved quality leading to confident and reliable clinical diagnosis. Although, there are many methods developed, no general solution has been adopted by the scientific community.
A morphological image filtering approach for metal artifact reduction (MIFMAR) is proposed in the present work for image quality improvement. The performance of the present algorithm was compared with three well-known MAR methods: linear interpolation (LI), normalized metal artifact reduction (NMAR) and frequency split metal artifact reduction (FSMAR). Methods were applied to images acquired from a phantom as well as 30 clinical studies of patients with metallic implants. Image quality was evaluated by three experienced radiologists completely blinded to the information about if the image was processed or not to suppress artifacts. They graded image quality in a five points-scale, where zero is an index of clear artifact presence, and five, a whole artifact suppression. Image quality on images were compared using the non-parametric Friedman-ANOVA test. Inter-observer agreement was evaluated using linear-weighted κ test.
MIFMAR ensured efficient reduction of metal artifacts, preserving all tissue structures and details. Image quality and diagnostic value scores improved significantly ($p < 0.05$) respect non processed images and respect the other tested methods with good inter-observer agreement. MIFMAR was also computationally inexpensive compared with other methods and does not use the raw CT data.

Contribution ID: 498
2. Image Processing
02.08. Image processing, display and visualization

Identification of optimum filter size of Butterworth filter implemented in spatial domain

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Background:
Size of filter plays important role in image noise removal. The present study investigates the effect of the size of Butterworth filter on image noise removal.
Methodology:

A digital phantom with image matrix size 128 x 128 was created. It consists of 8 objects (three squares, one circle, three solitary rectangular bars, and one triangle made up of 6 rectangular bars, mimicking hot spots) of different sizes. Gaussian noise with variance ranging from 0.003 to 0.15 incremented at the rate 0.003 was added to the phantom image, thus creating 50 noisy images. Butterworth filters of 3,5,7,9 and 11 pixel size in spatial domain were applied to noisy images. The output image quality was assessed both subjectively and objectively using peak signal to noise ratio (PSNR). The experiment was performed using Matlab R2013b installed on personal computer.
Result and Conclusion:
With increase in size of the filter, there was increase in the amount of noise removed from the image. 7-pixel size filter removes maximum amount of noise in the image without excessive distortion of the structure present in the image. Better image quality i.e. sharp image with very minimum edge distortion was noticed with 3-pixel size filter; however, amount of noise removal was least in comparison to 5, 7, 9 and 11 pixel size filter. The maximum noise removal, maximum edge distortion, and elimination of objects of size less than the filter size was found with 11-pixel size filter.

Contribution ID: 993
2. Image Processing
02.08. Image processing, display and visualization

An efficient cascaded FPGA-based digital equiripple FIR filter for ultrasound imaging applications

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In this paper, we present the design and implementation of an efficient FPGA-based digital low-pass equiripple FIR filter for ultrasound imaging applications using the Intel DSP Builder toolbox. The proposed hardware-based cascaded filter takes advantage of the symmetry proprieties of the conventional FIR filter to reduce the hardware cost and complexity by about half. The tapped delay line filter was built within the Simulink environment combined with the DSP Builder, allowing complete model simulation and automatic hardware description language code generation. In order to demonstrate the feasibility and flexibility of our design, we employed four symmetrical 8-tap cascaded FIR filter structures to implement a 64-tap DLPF filter. As input data we used raw data (sampled at 40 MHz with 12-bit resolution) obtained from a tissue-mimicking phantom and acquired by a 128-channel ultrasound system, developed by our group, connected to a convex transducer (AT3C52B). The fractional coefficient values were calculated assuming a pass band frequency of 3.2 MHz, a stop band frequency of 8 MHz, and a stop band attenuation of -50db. The experimental implementation was done on a Terasic DE4-230 board using an Intel Stratix IV EP4SGX230 FPGA with a Nios-II soft-processor running at 100 MHz. The accuracy of the model was analyzed by using the normalized root mean square error (NRMSE) cost function for comparison with the Parks-McClellan algorithm in Matlab. Excellent agreement was achieved between the simulation and experimental results. The FPGA utilization was approximately 5% and the calculated NRMSE was 0.18%, corroborating the effectiveness of the hardware design. Moreover, our model is capable to generate filtered data at every clock cycle after 64 (1.6 μs) clock cycle latency with a maximum operating frequency of 328 MHz. These results demonstrate the potential of our model for real-time biomedical ultrasound imaging, including multichannel noise reduction and speckle filtering.

Contribution ID: 1344
2. Image Processing
02.08. Image processing, display and visualization

A computational tool for enhancing ischemic stroke in computed tomography examinations

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Stroke is a cardiovascular disease that currently ranks in the fifth position among all causes of death worldwide. Computed tomography is the first radiologic examination performed in emergency decisions to diagnose stroke. The earliest signs of ischemic stroke are quite subtle in CT, thus image-processing tools can be used to enhance ischemic areas and to aid physicians during diagnosis. This study aimed to enhance the ischemic stroke visual perception in computed tomography examinations. A cohort of 45 exams was used during this study, with 28 patients previously diagnosed with ischemic stroke and 17 control patients. Stroke cases were obtained within 4.5 hours of symptom onset and with mean NIHSS of 13.6±5.5. The complete series of non-enhanced images were obtained in DICOM format and all processing was performed in Matlab software R2017a. The main steps of the computed algorithm were as follows: an image averaging was performed to reduce the noise and redundant information within each slice; then a variational decomposition model was applied to keep the relevant component for our analysis; then three different segmentation methods were used to enhance the ischemic stroke area. The segmentation methods used were expectation maximization method, K-means, and mean-shift. We determined a test to evaluate the performance of six observers (physicians) in a clinical environment with and without the aid of enhanced images. According to the opinion of the observers who participated in this study, the enhanced images were particularly useful when displayed together with the original images. The overall sensitivity of the observer's analysis was 64.5% and changed to 89.6% after the evaluation of the enhanced images with the expectation maximization method. The overall specificity was 83.3% and increased to 91.7%. The improvement was even more remarkable for the three least experienced physicians.

Contribution ID: 1766
2. Image Processing
02.08. Image processing, display and visualization

Variability of the eye accommodation response after sustained work with volumetric image

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In the last decade healthcare has experienced and implemented countless technological innovations and three-dimensional (3D) imaging technique is one of them. Volumetric display is an innovative technology that creates real 3D image by illuminating points in three-dimensional space to generate volumetric images (Osmanis, 2016), that can be valuable tool for healthcare professionals when detection of anatomical abnormalities is necessary. Despite that volumetric image technology has eliminated mismatch between eye vergence and accommodation that has been highlighted as a typical cause of visual discomfort after viewing stereoscopic images (Bando

et al., 2012), we still must consider possibility of visual fatigue after any prolonged near work including work with volumetric image. Visual fatigue links up a wide range of visual symptoms including asthenopia, soreness of the eyes and headaches.
Six young adults aged 22 to 28 years (mean age±SD, 26±2 years) gave informed consent to voluntarily participate in the study. We used eccentric photorefractor PowerRef3 to measure eye accommodation, accommodation variability and pupil size before work with volumetric image (baseline measurement), after three sequential search task sessions (each ~10 min long) and after 5 min rest post-task. Volumetric display we used consists of 20 non polarizing liquid crystal diffusers 39.5 cm wide and 29.5 cm tall. X, Y, Z resolution was 1024x768x20 physical pixels (1024x768x100 perceivable pixels), with a refresh rate of 60 Hz. The distance between two sequential planes was 5.04 mm, the width of each screen was 1.1 mm.
Mean accommodation response variability after work with volumetric display was 0.08±0.04 D and remained stable during all experiment sessions (Wilcoxson signed rank test, $p<0.05$). This amount of response variability suggest that volumetric display did not cause conflicting aftereffects for eyes focusing mechanism. Large variability would suggest confusion about how much the accommodation system need to relax or contract for given distance.

Contribution ID: 18
2. Image Processing
02.09. Image processing, segmentation and registration

Implementation of support tools for the presumptive diagnosis of glaucoma through identification and processing of medical images

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In medicine, the diagnosis of diseases by means of image processing has had great acceptability and credibility, which is why it has been able to explore in depth the theme, taking advantage of mainly which is a non-invasive method within the clinical study. Glaucoma is considered as a group of diseases that damages the optic nerve to the point of causing blindness in the eye, with the disadvantage of in most cases do not exhibit early symptoms. Through this work, the processing biomedical images to locate the parameters considered most relevant within images obtained from the back of the eye to make the determination of the existence or not of Glaucoma, a disease that mainly affects physically the dimensions and proportions of the cup and the optical disk. It gets the value of the Reason cup/disk and is additional to the characteristics of the rule ISNT, both parameters considered of great importance in the diagnosis of glaucoma

Contribution ID: 112
2. Image Processing
02.09. Image processing, segmentation and registration

Precise eye modeling based on image registration between OCT and CT in the external beam radiotherapy of intraocular tumors

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Purpose: External beam radiation therapy (EBRT) is currently accepted as the primary treatment modality for intraocular tumors. However, radiation-associated toxicities due to sophisticated ocular

anatomy and shape variability of organs at risk (OAR) is a major concern. The purpose of this work is to develop a precise 3D eye modeling approach based on optical coherence tomography (OCT) technique for highly conformal dose distribution and thus to reduce the normal tissue complication probability.
Methods: An automatic algorithm including boundary segmentation, image registration, and optical correction was developed to segment the anterior segment from OCT images based on the graph theory and dynamic programming technique. Reconstructed anterior segment from OCT was then fused with segmented anterior segment from CT images to model a 3D full-eye. Final high precision registration was achieved by searching the best match between the OCT and CT images using a XOR operation. Standard schematic-eye and clinical patient datasets were used to validated and evaluated this automatic algorithm.
Results: The automatic segmentation of the anterior segment including cornea, iris, limbus and crystalline lens were acquired successfully. No significant differences were found between the automatic and manual measurements for all anterior segmentations. The average segmentation error and computational cost were approximately 0.2± 0.1 mm and 46±2 s (all the codes were written by MATLAB and run on a PC computer equipped with Intel Core processor i7-7500U 2.9GHz), respectively. Moreover, the proposed registration algorithm was able to correct the axial, sagittal and coronal displacements in the input images and revealed a mean registration error of 0.16 ± 0.05◦ in 96 ± 2 s for different angles.
Conclusions: This study demonstrated the 3D eye modeling approach based on OCT technique is accurate, reliability, and robustness, and may improve curative effect for intraocular tumors.

Contribution ID: 207
2. Image Processing
02.09. Image processing, segmentation and registration

Method for contrast enhancement of ultrasound image by using portable ultrasound device

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In this study, we propose probabilistic edge map (PEM) for the contrast enhancement for portable ultrasound images based on an automatic alien algorithm. Before performing ultrasound image registration, a mean structure similarity measure is used to confirm whether the images between the reference frame and the previous frames were obtained in the same area. After confirming that the same area is detected in the same diagnosis area, the confirmed images are subjected to sequential registration using rigid body registration. Sequential registration is performed by registering the first frame to the second frame, and by registering the registered image to the third frame. Second, a canny edge detection algorithm extracts the edge of each registered frame. Each registered edge obtained is assigned a higher weight as the acquisition time reaches that of the reference image or a lower weight, if is farther from the reference image. Third, the PEM of the reference image is calculated from the summation of the weighted edge images into one edge image. Next, the contrast value to be emphasized is set and assigned to the blurred probabilistic edge map. Finally, the PEM is applied to the reference image for contrast enhancement.
The result of the contrast-to-noise ratio within Region of interest (ROI) evaluation was 3.352 for the original image, which was improved to 3.801 after the algorithm application. Nevertheless speckle index was preserved when PEM was interconnected with contrast enhancement study. It meant that PEM would contribute to make an improvement of portable ultrasound image.
These results indicated that the proposed method improved the liver phantom contrast. In future experiments, we will evaluate the proposed method through in vivo studies of liver and improve this probabilistic edge-map-based algorithm.

Contribution ID: 257
2. Image Processing
02.09. Image processing, segmentation and registration

An energy-minimizing region-based active contour model with edge information for image segmentation

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The purpose of this work is to develop an energy-minimizing active contour model for image segmentation. The proposed algorithm is composed of an energy function (including both region- and edge-based information) and a contour model equation. After initialization, the contour equation is iteratively updated according to the energy (E) and to the sum of squares of the directional derivatives of the contour itself, and spatially expanded through the convolution with a Gaussian kernel. Regularization is obtained using the Heaviside function. At each iteration, image parameters related to image intensity, variance and derivatives are calculated inside, outside, and along the contour. These contributions take part in the energy equation, and are designed to minimize the global energy of the contour as it approaches the boundaries between the object of interest and the background. Convergence (i.e. the stopping criterion for the iterative contour update) is obtained when the global energy virtually equals zero ($E<0.001$). The contour model was applied to a reference noise-free phantom image with a contrast of 1. The same phantom was then generated multiple times with different contrast values and with two types of noise separately added (Gaussian, mean=0, std=0.05, and speckle, mean=0, variance=0.05), and the model accuracy was evaluated for all cases. Segmentation of the noisy phantoms resulted in a reasonably accurate registration with the reference phantom as long as the contrast was higher than 0.33 (highest Hausdorff distance of 1.1 and 1.7 pixels for speckle and Gaussian noise, respectively). This newly developed active contour model could provide a consistent image segmentation tool which does not depend on initialization, can easily overcome non-uniformities and noisy areas, and can efficiently avoid local minima without the need for additional forces or user-selectable parameters. Therefore, it can be used for segmentation of possibly noisy anatomical structures on real medical image data.

Contribution ID: 478
2. Image Processing
02.09. Image processing, segmentation and registration

Skin lesion images segmentation by use of the c-means fuzzy method

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Skin cancer is a malignant neoplasm most common in the world. This type of cancer is usually divided into two groups: melanoma and non-melanoma, which can be differentiated through digital analysis processing. The basis of this processing is the segmentation of the images, which consists of the subdivision of the pixels into multiple regions that present common characteristics, such as: region of lesion and skin. This work describes a clustering method called c-means fuzzy, utilized for skin lesion dermatoscopic image segmentation. This type of segmentation is based on the method of region grow that differs from conventional clusterization methods by the use of the concept of fuzzy numbers, once that it is appropriate to deal with uncertainties referent to image regions (clusters). The method consists in calculating the pixel pertinence degree in relation to the regions that it can pertain, defined by a given neighborhood. In this work this method was applied

in some images of skin lesion that are: melanomas and nevus; obtaining three clusters class to each image. These clusters were used to calculate two threshold values. These thresholds were applied in the binarization algorithm to image segmentation. With aim of verify the efficiency of the method, the segmented images through c-means fuzzy method was compared with same images segmented by Otsu algorithm. The segmentation obtained by the FCM algorithm was visibly better than that obtained by Otsu algorithm, this occurs due to the fuzzy numbers influence, where a pixel can pertain to more than one region, but with different pertinence degree.

Contribution ID: 488
2. Image Processing
02.09. Image processing, segmentation and registration

Segmentation and 3D-modelling of single-rooted teeth from CBCT data: An automatic strategy based on root canal segmentation and surface deformation

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Background: Cone-Beam CT imaging is becoming a standard in dento-maxillofacial radiology for the three-dimensional representation of teeth and adjacent bony structures. CBCT provides high-resolution images, while considerably reducing the radiation dose administered to the patient in comparison to conventional CT-scan. The segmentation task in those images is impaired by teeth and jawbone’s complex anatomy: that is the presence of highly connected and morphologically distinctive structures. Hence, this research aims to design an automatic method that creates reliable 3D models of teeth from CBCT images
Method: In this research, we first use a pre-partitioning algorithm based on an oriented-graph strategy. Each separating plane’s position is optimised in respect with a cost function that penalizes plane cutting through teeth, allowing a robust definition of sub-volumes enclosing each tooth. Root canal is then extracted from these sub-volumes by conventional image processing techniques, being morphological flood-fill operations. Our premise is that the latter structure is an adequate reflection of the tooth morphology and topology, and that we can use it as an in situ prior for a surface deformation algorithm. We employ a Hierarchical Surface Deformation algorithm to allow the root canal model to grow in the 3D volume, while constraining the surface evolution with respect to the dental contact zones identified in the pre-partitioning step. Our algorithm is applied on single-rooted teeth, and provides 3D models that can be either used for global visualization or as an input for a more detailed segmentation.
Results: Our preliminary results include quantitative comparison of our results with manually contoured ground truth on 50 randomly selected slices from 5 CBCT cases (Dice's coefficient = 0.914±0.058, mean Hausdorff distance = 0.370±0.103 mm). In future steps, we plan to carry out a more thorough validation using appropriate 3D metrics, while taking intra- and inter-observer bias into account.

Contribution ID: 489
2. Image Processing
02.09. Image processing, segmentation and registration

A novel approach to analyze transient image series in active dynamic thermography of superficial skin tissue

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Active dynamic thermography involves external stimulation in the form of cold stress, heat, and pressure that is applied over the skin tissue and the resulting transient images are captured using a non-contact Infrared (IR) thermal camera. This is one of the non-invasive methods to achieve high contrast thermal images. Application of the external stimulation leads to thermal recovery of the tissue to normal condition through a transient phenomenon. The thermal images captured during this transient phase shows improved target feature contrast. Subtracting the sequential images from the reference image (with no excitation) can bring additional contrast. However, the decision to evaluate the best contrast image is still an issue. In the present study, a novel approach is proposed to reconstruct a single thermal image from the transient image series. First, an external cooling through a cooling pad, with continuous ice water circulation (5 ± 0.5 degrees Celcius), is applied on the left forearm of a human subject (IRB: SHS-NTU/014/2016) and the transient images are captured subsequently (ambient temperature = 23 ± 0.5 degrees Celcius). Based on the thermal recovery rate, unique tissue activity ratio is calculated at each pixel, from which a single thermal image is reconstructed. This is the equivalent best contrast image with a properly segmented blood vessel. Further, the direction of blood flow and diameter of the vessel is extracted from this image. This novel method to analyze the transient image series in active dynamic thermography can be applied to vessel characterization, venous diseases or skin cancer diagnosis through non-invasive medical thermal imaging.

Contribution ID: 494
2. Image Processing
02.09. Image processing, segmentation and registration

Automatic Segmentation of Oral Magnetic Resonance Image Based on Shape Prior Active Contour Model and Fuzzy C-means Clustering

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In this study, we applied image segmentation algorithm to automatically segment the tongue contour from the oral magnetic resonance images (MRI) in order to construct a three dimensional (3-D) tongue in real human size and to study the anatomical structures of tongue muscles and reconstruct these 2-D slice results into a 3-D tongue. We adopted shape prior and fuzzy clustering knowledge into level set algorithm to enhance the pixel contrast of the first slice of each subject with fuzzy clustering to let level set contour evolve easier. For each non-first slice, we calculated the initial contour from the segmented tongue contour of the previous slice, and the segmented tongue contour of the previous slice also worked as the shape prior energy term to improve the current contour evolution. After contour evolutions, we used gradient vector flow snake to smooth the contour, and achieved automatic segmentation of oral MRIs. The results of this study were evaluated with the ground truth of tongue with the similarity index, percentage of difference and root mean square error. The similarity index is more sensitive to the accuracy of the segmented results among other evaluation methods, and the average similarity index of 8 subjects was 0.898 which indicated the similarity of the segmented results of this study is quite promising when compared to the ground truth, and the shape of the reconstructed 3-D tongue is similar to the one segmented with manual approach. This study used fuzzy clustering could improve the segmented results of level set for the first slice of each subject and the segmented tongue contour of the previous slice as a shape prior term successfully, and also calculated initial contour automatically to enhance the result of original level set method.

Contribution ID: 525
2. Image Processing
02.09. Image processing, segmentation and registration

Multimodality image fusion of the liver using structure-guided deformable image registration in Velocity AI - what is the preferred approach?

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Radiation therapy commonly utilises information obtained from multiple imaging modalities requiring rigid and deformable image registration (DIR) to align image volumes. Structure-guided DIR in Velocity AI (Varian Medical Systems, Inc Palo Alto, CA) employs structure outlines on both image sets to better register the volume encompassed. In the case of liver, this method of registration can curtail the influence of entire image volume on the liver itself.The purpose of our study is to determine the performance of structure-guided DIR for the fusion of multimodality images, specifically planning CT and post stereotactic body radiation therapy (SBRT) MRI on the liver versus separate segments of the liver.
Nine patients' planning CTs and post-SBRT MRI scans were obtained. The liver contours were checked by a radiation oncologist on both scans who then also contoured the following three interior liver structures: left lobe (LL), portal region (PR), and vena cava with the liver segment (VCL). To better determine the performance of DIR on the remaining liver volume, the three contoured structures were subtracted from the liver contour to obtain a cropped structure (CS). Images were registered using structure-guided DIR for each patient: 1) using just the liver contours (one registration), 2) using individual interior liver structures (four registrations), 3) using individual interior liver structures along with the liver contour (four registrations). The Dice coefficient of similarity (DSC), measuring the overlapped volume of two structures multiplied by two and normalised to the sum of the volumes was calculated.
For case 1, the median DSC (range) for the LL, PR, VCL, and CS (for nine patients) were 0.86(0.58-0.90), 0.64(0.03-0.76), 0.76(0.43-0.84), 0.89(0.86-0.94); case 2) 0.86(0.46-0.90), 0.55(0.03-0.71), 0.72(0.48-0.84), 0.90(0.86-0.98); case 3) 0.86(0.54-0.90), 0.54(0.03-0.61), 0.72(0.48-0.81), 0.90(0.86-0.94). Registration using liver contour alone consistently demonstrated larger median DSC, suggesting the preferred method of structure-guided DIR for liver.

Contribution ID: 546
2. Image Processing
02.09. Image processing, segmentation and registration

Probabilistic fiber-tracking of the human cholinergic system

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The cholinergic system of the human brain consists of several subsystems originating from the basal forebrain, in particular from the nucleus basalis of Meynert, and from the brainstem. As the widespread projections

from the basal forebrain to the cortex play an important role in learning, declarative and procedural memory and many other cognitive processes that are significantly impaired in senile disorders such as Alzheimer¹s disease and Dementia with Lewy Bodies, it is favourable to assess the affected pathways and cortical regions in vivo.
For these reasons, we attempted to employ exploratory probabilistic fiber-tracking methods using the diffusion-tensor imaging (DTI) and a prior anatomical knowledge to identify the main cholinergic pathways in a large cohort of around 300 subjects.
We designed a complex pipeline of image processing steps that pre-processes the DTI neuroimaging data and tracks pathways rising from the basal forebrain and its subregions using stereotaxic cytoarchitectonic maps.
Without applying a set of strong conditions on the course of the cholinergic projections, as previously done in similar studies, our preliminary analysis identified the most prominent cholinergic pathways.
In this manner, our findings are not limited to several chosen regions of interests but proposes a map of significant white matter connections into the whole cortex and delineates its cortical regions belonging to this system.

Contribution ID: 645
2. Image Processing
02.09. Image processing, segmentation and registration

Comparing SPM12 unified segmentation with CAT12 segmentation pipelines: a brain tissue volume-based prediction study

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Brain tissue volumes have been widely used as biomarkers both in health (e.g. distinguishing a young from an old brain) and in neuropsychiatry (e.g. distinguishing a patient’s brain from a healthy one). Several well established preprocessing pipelines designed to segment structural brain images are currently available. Here, we compare the influence of two preprocessing pipelines in the performance of prediction models using grey (GM) and white (WM) matters attributes. The first one is based on a classical unified segmentation (UniSeg) implemented in the Statistical Parametric Mapping (SPM12) toolbox, which uses tissue probability maps as a guide for tissue segmentation. The second one uses a hypothesis-free approach for tissue segmentation and is implemented in Computational Anatomy Toolbox (CAT12), an add-on to SPM12 toolbox. T1-weighted structural MRI images from 316 healthy subjects (average age of 45.1 years, ranging from 18 to 94; 119 males(M)) and 100 patients with AD (average age of 76.8 years, ranging from 62 to 96; 41 M) from the OASIS-brain database were used. Image preprocessing was performed in parallel using UniSeg and CAT12 pipeline and included tissue segmentation in GM and WM, spatial normalization, modulation and smoothing. GM and WM global volumes were further measured. Finally, two prediction models were estimated per pipeline. For the first one, GM and WM volumes of healthy subjects were linearly regressed against age. For the second one, GM and WM volumes of AD patients and 96 age-matched healthy subjects were entered in a logistic classification model. The performance of both models was similar between UniSeg and CAT12 pipelines (Linear regression: adjusted R2 = 0.82 (UniSeg) and 0.80 (CAT12); Logistic classification: accuracy = 64% (UniSeg) and 67% (CAT12)). Our findings demonstrate that both

pipelines give similar prediction performance when either predicting age in healthy subjects or classifying patients with AD against healthy subjects.

Contribution ID: 736
2. Image Processing
02.09. Image processing, segmentation and registration

Blood vessel segmentation in retinal fundus camera images using convolutional neural networks

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In this conference paper, we present segmentation of the retinal vascularization using convolutional neural networks.
Segmentation is one of the key problems in biomedical image processing. In retinal fundus camera images, segmentation is mostly needed for diabetic retinopathy diagnostics, which is a leading cause of blindness or for further processing like image fusion. We present a novel approach to retinal blood vessel segmentation by using convolutional neural networks with semantic segmentation. Convolutional neural networks consists of several convolutional layers, mostly followed by pooling layers and fully connected layers. These networks were recently heavily used for classification problems. For semantic segmentation, the output layer should have the same number of neurons as is image dimension. Convolutional networks in each pooling layer decrease size of the processed image, thus a set of deconvolution layers is used to pixelwise segmentation of the image. For a dataset, we are using DRIVE (Digital retinal images for vessel extraction) database, which contains retinal fundus images and their labeled masks. Each image in the database has in each dimension several thousands of pixels, thus to speed up execution and number of training samples we divide images into subregions of 256x256 pixels that we use for network training. To avoid overfitting, we have divided the dataset into training, validation and testing sets. Training is performed as fine-tuning of pretrained networks on a different dataset because basic features extracted from the image in early convolutional layers are independent on image nature. To speed up the training process, parallel processing on a graphics card is performed. Currently achieved results show a promising method for retinal blood vessel detection, but at this time more possible architectures are needed to be tested.

Contribution ID: 746
2. Image Processing
02.09. Image processing, segmentation and registration

First validation of semi-automatic liver segmentation algorithm

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Purpose: Selective internal radiotherapy (SIRT) of liver malignancies requires a careful evaluation of the patient including liver size, tumour burden, hepatic arterial vessel supply, and liver lung shunt. The segmentation of the liver is a time-consuming step to the physician. In this work, we validated an interactive software tool, which provides a semi-automatic segmentation of anatomical 3-dimensional datasets, in this case contrast-enhanced abdominal CT scans.
Methods: A physician with experience in manual liver segmentation for SIRT dosimetry employed dosimetry software (DosePlan, SurgicEye GmbH, Germany) to segment the contrast-enhanced CT

datasets for ten patients and documented the completion time. The software provides an interactive segmentation based on user-defined initial seeds of the foreground and background regions of several slices in orthogonal views. The segmented region is then computed based on these seeds by a graph-based segmentation algorithm. Ten out of the 130 public datasets from the “Liver Tumor Segmentation Challenge” were used, including the provided ground truth segmentation of the liver, which was acquired by a board-certified radiologist and verified by another expert. While no timings are provided for these datasets, timing data based on 35 manual liver segmentations yielded 32:48 +/- 6:54 min. Segmentation quality vs. the ground truth was evaluated using the Sørensen–Dice coefficient.
Results: The average Sørensen–Dice score for the reader was 92.9%, with a standard deviation of 1.5%. The average time to segment the entire liver using the interactive algorithm was 8:45 +/- 1:13 min, a factor of 3.8 times faster compared to the manual slice-by-slice delineation. The main deviations in the segmentations were in the areas of the gall bladder, vena cava and hepatic vascular network.
Conclusion: Employing the semi-automatic segmentation algorithm, segmentations of the liver can be achieved with a very high accuracy of >92% in under 9 min, greatly speeding up the physician’s workflow.

Contribution ID: 832
2. Image Processing
02.09. Image processing, segmentation and registration

Hyperdense middle cerebral artery segmentation in non contrast computed tomography

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The hyperdense middle cerebral artery (MCA) sign refers to focal increased density of the MCA in Non-Contrast Computed Tomography (NCCT) and is the earliest sign of acute ischemic stroke. In this paper we present the implementation of a method that allows the automatic segmentation of the hyperdense MCA in NCCT pathological clinical cases, as a first phase in the development of a tool that will support the early detection of cerebral infarction. A fully automated algorithm was proposed for the delimitation of volumes of interest and segmentation of the hyperdense MCA. Volumes of interest were defined according to the anatomical location of the suprasellar cistern, and features of the hyperdense MCA were extracted according to its Hounsfield Units and entropy. The segmentation was carried out using a model of active contours (snakes). The results show an accuracy of 98%.

Contribution ID: 915
2. Image Processing
02.09. Image processing, segmentation and registration

Identification of scars after chronic spinal cord injury - based on structural MRI

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Purpose:
To investigate the identification of scar tissue in chronic spinal cord injury based on conventional structural Magnetic Resonance (MR) images. The objective is to use the result of identification as a basis for accurate excision of scar in spinal cord injury repair surgery.
Methods:
The identification of scar in MR images is achieved by establishing a two-step recognition method consisting of segmentation and classification. The MR images are pre-segmentation by the active contour models based region-scalable fitting (RSF) and then the pixels of the image were divided into scar and normal tissue using a trained classification model. Scars were labeled by pathological sections of the spinal cord. A total of 472 features were extracted from the gray features, the improved LBP features, the gray gradient features and the texture features using wavelet transform and gray level co-occurrence matrix. Three feature selection algorithms [Infinite Feature Selection (Inf-FS), Support Vector Machine methods - Recursive Feature Elimination (SVM-RFE) and Fisher coefficient] and four classification models [Gaussian Discriminant Analysis (GDA), K-Nearest Neighbor (KNN), Support Vector Machine (SVM), Adaboost] were compared to obtain the best feature selection method and classification model for distinguishing between scar tissue and normal tissue.
Results:
High classification accuracy (AUC>0.9) was obtained using active contour model and classification model in an approach based on conventional MRI to differentiate between scar tissue and normal tissue. By cross-validation, the highest classification accuracy evaluated over test sets was achieved with the Inf-FS and the GDA. Receiver operating characteristic curves provided area-under-the-curve(mean±standard deviation) of 0.94±0.06 in the test sets.
Conclusion:
High-precision identification of scar tissue in chronic spinal cord injury can be achieved based on conventional structural phase MR images.

Contribution ID: 941
2. Image Processing
02.09. Image processing, segmentation and registration

An automatic detection and tracking system for full extraction of morphology and dynamic of golgi tubules analysis

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A systematic analysis of molecular and cellular biology requires numerical quantification, which is very importance to expose underlying mechanism from high content image. Effects of labor experience and time consumption are caused by manual inspection, whereas semi-automatic and automatic applications have more fast and convenient. They are not perfect for suitable the special and unique biological phenomena due to complicated dynamic properties and quality of raw images, especially a kind of skeletal structure such as tubules, microtubules, and Golgi tubules. A challenge is that it is hard to establish a proper tracking system to extract meaningful information behind imaging data because the morphology and dynamic of change of Golgi tubular carries various protein affecting during their complex trafficking, forward undergo fission/fusion and backward moving for absorption to Golgi body and ER. This study presents an automatic detection and tracking system for full extraction of morphology and dynamic of Golgi Tubules analysis with adaptive local thresholding and Otsu for characterized segmentation and k-nearest neighbor for dynamics tracking methods. Based on general requirements from biological experts, our system can extract morphological features and properties of motility of Golgi tubules, correlation of (1) individual particle indices, area, length, tip, centroid, and fission/fusion types, (2) time of Golgi body disappearing, (3) total of tracked tubules, (4) displacement and velocity values, and (5) growth rate. Moreover, a novel tracking map (6) was developed to easily visual for interpretation, corresponding of particle indices and where fission and fusion occurring as same as graphing change over time of (7) particle trajectory, (8) mean square displacement, (9) centroid, and (10) step of length increasing or decreasing, displacement, and velocity. Hence, with tracking accuracy and quantitative analysis we have, this system is able to absolutely serve the skeleton tracking analysis in particular Golgi tubules.

Contribution ID: 1099
2. Image Processing
02.09. Image processing, segmentation and registration

Automatic Segmentation of Bone CT Image using Deep Convolutional Neural Network

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Computer Tomography Images play a crucial role in determination of bone abnormalities like osteoporosis, bone cancer, tuberculosis of bone etc. and is of great significance to medical computer aided diagnosis and treatment. For isolating the interest area of bone image from background, image analysis and segmentation are needed to be performed. These processes ultimately help in separating the region of interest from other part of image. The most commonly used technique in segmentation of CT image is Thresholding, which can be either global or automatic. As deep convolution neural network is successfully applied for analysis of visual images. By applying deep convolutional neural network the detection of abnormalities in medical images will become faster and accurate.In this paper, we propose a fast, robust and automatic segmentation methodology for bone CT image, using deep convolution neural network. In this work, bone CT dataset in DICOM format of different age groups with abnormalities like bone cancer, osteoporosis etc. are taken from hospitals and online resources. Then after preprocessing, the image thresholding is applied on the medical image data set to identify the region of interest (ROI) and deep convolution neural network is applied for classification and analysis. The validations of images are done with different validation techniques with standard datasets and result is projected on 3D platform for better visualization. The output obtained by this, will allow the medical practitioner for detection of the abnormalities in bone at a very early stage and finding the shortest path to apply invasive procedure to the region of interest from the outer surface of the patient. This will also help the doctor for setting protocol before they performed surgical intervention.
Keywords:- Bone, Computer Tomography, Deep Convolution Neural Network

Contribution ID: 1105
2. Image Processing
02.09. Image processing, segmentation and registration

A modified histogram-based model for skull removal from magnetic resonance images

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Determining the precise location and volume information of abnormal tissue (i.e. tumor/hemorrhage etc.) and especially detecting abnormal activities in brain; plays an important role in diagnosis. Specifying the borders of tissues in high precision is critical for accurate treatment planning. For this reason, automatic segmentation algorithms provide experts a complementary tool. Popular methods as Brain Extraction Tool (BET), Robust learning-based brain extraction system (ROBEX) are implemented for extraction of intracranial area of the brain. This study proposes a modified skull extraction method. An MRI image is divided into three regions: background, intracranial area, skull. The histogram of an MRI image is analyzed and 3 different mapping for each class is generated based on energy characteristics, histogram peak to peak distances, introduced T-value shift. Using these mappings, MRI image is transformed into different binary images. Then connected component analysis is applied for defining skull region. Final smoothining of intracranial area-skull boundary is completed by region growing beginning with a seed point located at the center of the gravity of the image and combination of 3 segmented binary images. High accuracy segmentation of brain-skull boundary will contribute to both diagnosis and treatment of lesions, such as Epidural Hematoma which is located close to this boundary, by improving the stability and precision of detecting and counturing lesions.

Contribution ID: 1128
2. Image Processing
02.09. Image processing, segmentation and registration

Performance comparison of segmentation algorithms for image quality degraded mr images

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Medical image segmentation is one of the most important research areas of clinical diagnosis. Especially, brain is the most critical organ that is tracked, investigated and analyzed mostly by using Magnetic Resonance Imaging (MRI). Developing a highly accurate automated segmentation of brain region is a very difficult task due to involving noise and deviation. In recent years, various image segmentation techniques have been developed in the literature such as clustering, thresholding (intensity-based), active contours (surface-based), expectation maximization (probability-based). In this study, these commonly used algorithms are handled in order to see the performance of the segmentation while degrading the image quality and saving from memory for brain MR images. For this purpose, the level of acceptable degradation is obtained by compressing MR slice images with different quality factors by using JPEG algorithm. Peak signal to noise ratio (PSNR), bits per pixel (BPP), mean, variance parameters of the MR images are used to characterize the corresponding compressed image degradation quality. On the other hand, segmented intracranial area, white matter (WM), gray matter (GM) regions are compared with the non-compressed MR images for various compression ratios. Then, the area overlap ratio for these regions are obtained in order to get segmentation performance results. It is believed that detected optimum parameters can be used as prior indicators to determine which segmentation algorithm (or which group, i.e. intensity or surface-based) should be chosen. Besides, it will be able to occupy less space in memory by compressing image for appropriate parameters.

Contribution ID: 1154
2. Image Processing

02.09. Image processing, segmentation and registration

Reliability of a new semi-automatic delineation of tumor region for analysis of characteristics of head and neck squamous cell carcinoma

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Purpose
Delineation of tumor region on magnetic resonance images is crucial to characterize tumors. We have developed a new semi-automatic method to delineate head and neck squamous cell carcinoma (HNSCC) on Gd-enhanced T1-weighted images. In this study, we evaluated this delineation method with a manual method operated by an experienced radiologist.
Materials and Methods
The HNSCC tumors enhanced by Gd contrast agent on T1-weighted images were delineated by using our semi-automatic method (T1-auto ROI: region of interest). An experienced radiologist encircled the tumors on those T1-weighted images (T1-rad ROI) and the diffusion weighted images (DWI) (DWI-rad ROI), respectively. The necrotic areas in all ROIs were removed by thresholding. We calculated the dice similarity coefficient (DSC) of every pair of T1-auto, T1-rad and DWI-rad ROIs. The T1-auto ROIs and the T1-rad ROIs were placed on respective DWI with b values (0, 200, 400, 800, 1000, 2000 s/mm2) and the ADC values were calculated. These ADC values were compared with those obtained from the signal intensity of DWI-rad ROI.
Results
Our semi-automatic method encircled the HNSCC on Gd-enhanced T1-weighted images as similar as an experienced radiologist (DSC = 0.88). The DSC between T1-auto and DWI-rad ROIs decreased as 0.78 as well as that between T1-rad and DWI-rad ROIs even drawn by the same radiologist. Although this DSC value indicates the existence of some amount of discordance between DWI-rad ROIs and ROIs on T1 weighted images, this discordance did not give rise to a discernible difference of the obtained ADC values; standard deviation was averagely 1.1%.
Conclusions
Our semi-automatic method delineates tumor as likely as an experienced radiologist on Gd-enhanced T1-weighted images, and the delineated tumor ROI could be applied to DWI for the analysis of tumor characteristics quantitatively.

Contribution ID: 1332
2. Image Processing
02.09. Image processing, segmentation and registration

An automated colony counter for serial-dilution culture method

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Serial-dilution method is used for estimating the concentration of unknown sample by counting the number of microorganism colonies cultured from serial dilutions of the sample, and then backtracking the measured counts to the unknown concentration. This project designs the portable device for evaluating number of bacterial colonies on solid culture media (Colony Forming Units, CFU). For software system, this portable device has an analytical program based on digital image processing. The captured image using webcam camera of the colony on the culture media is first preprocessed using Gaussian smoothening filter. The filtered image is then converted to binary image using automatic thresholding technique. The circular Hough transform is applied to

determine the region of interest (ROI) of the colony on the solid culture. Morphological processing is then performed on the ROI to remove speckling noise. Image labeling is then used to detect the unconnected colonies which are then further counted to determine the number of microorganism colonies. For the connected colonies, a watershed segmentation schemes is proposed to detect the boundaries of the each colony in the connected colonies. The image processing is performed on the MATLAB platform. The experimental results of 10-fold serial dilution of portable device demonstrate an accuracy of 88.64% when compared with visual inspection.

Contribution ID: 1343
2. Image Processing
02.09. Image processing, segmentation and registration

Optimization of rsfMRI parameters in the method Seed Corelation Analysis (SCA) in cerebellum

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The aim of this study: The purpose of the work is to use the method Seed Corelation Analysis (SCA) in Resting-state Functional MRI (rsFMRI) for cerebellum and optimalization in DPARSF toolbox (ang. Data Processing Assistant for Resting-State fMRI).
BOLD fMRI was acquired with a Siemens Magnetom Skyra 3-Tesla scanner using a whole – brain, gradient-echo echo planar sequence with a 32-channel head coil. We used data from 20 subjects. The functional images were obtained using an EPI sequence with the following parameters: TR/TE=2000/35ms, voxel resolution=3x3x3 mm, 30 axial slices, thickness = 3mm. In addition, a T1-weighted sagittal three-dimensional magnetization-prepared rapid gradient echo(MPRAGE) sequence was acquired, covering the entire brain : 192 slice, TR=2300 ms, TE= 2.11 ms. The functional and anatomical image manual corregistrations were performed using SPM8 toolbox under MATLAB R2014b software. Next DPARSF basic edition was used for different parameters: smoothing 3-8mm FWHM Gaussian kernel and range value of frequencies : 0.01-0.04, 0.04-0.08, 0.08-0.12 and 0.1-0.2.
Results: 12 pairs of ROIs in cerebellum were analysed. Based on the connectivity matrix, maximum correlation values of 2 arbitrarily selected ROIs were found. For example, for pairs (ROIs) from ROI in lat. Cerebellum (coordinate: 21, -64, -22) and med. Cerebellum (coordinate: -16, -64, -21) for FWHM 5, ALFF 0.01-0.08 and sphere of radius 8 mm we obtained the highest correlation. It was observed that the change of one parameter in the DPASRF analysis indicates change in the functional connectivity.
Conclusion: Analysis in DPARSF toolbox show that highest correlation of functional connectivity FC in studies area cerebellum can be found for ALFF 0.01-0.04, spherical interest areas (ROIs) with that radius of 8mm and smoothing 8mm. It should be noted that for pair of ROIs with r=3mm and r=4mm the same values of FC in the all performed analysis were obtained.

Contribution ID: 1345
2. Image Processing
02.09. Image processing, segmentation and registration

Automatic identification and extraction of pectoral muscle in digital mammography

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Women with increased mammographic density have a four- to sixfold increase in their risk of developing breast cancer. Mammography is a worldwide image modality used to diagnose breast cancer and can be used to measure breast density (BD). In clinical routine, radiologist performs image evaluations through BIRADS assessment. However, this method has inter and intraindividual variability.
An automatic method to measure BD could relieve radiologist's workload by providing a first aid opinion. However, pectoral muscle (PM) is a high density tissue, with similar characteristics of fibroglandular tissues, which makes hard the task to automatically quantify BD.
The aim of this work was to develop an automatic algorithm to segment and extract PM in digital mammograms.
The database consisted of thirty medio-lateral oblique incidence digital mammography from São Paulo Medical School.
The algorithm, developed in Matlab® software, uses image processing tools to automatically segment and extract the pectoral muscle. Firstly, it was applied thresholding technique to remove non-biological information from the image. Then, the Hough transform is applied, to find the limit of the PM, followed by active contour method. A seed of active contour is applied in the limit of PM found by Hough transform.
An experienced radiologist manually performed the PM segmentation. Both methods, manual and automatic, were compared using the Jaccard index and Bland-Altman statistics.
The comparison between manual and the developed automatic method presented a Jaccard similarity coefficient greater than 90% for all analyzed images, showing the efficiency and accuracy of segmentation of the proposed method. The Bland-Altman statistics, compared both methods in relation to the area of segmented PM. The statistic showed data within the 95% confidence interval, enhancing the accuracy of segmentation compared to the manual method. Thus, the method proved to be accurate and robust, segmenting rapidly and freely from intra and inter-observer variability

Contribution ID: 1346
2. Image Processing
02.09. Image processing, segmentation and registration

Biometrics based on facial landmark with application in person identification

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Biometric characteristics such as palm print, face, hand and finger geometry, fingerprint, Iris, etc. are mostly popular used in security systems over the traditional secure measures, password or ID cards. The biometric systems are more reliable because they cannot easily be lost, stolen, shared and duplicated. In this research we propose the biometric for person identification based on facial landmark pattern. Our landmarks are those associated with eyes mouth and nose. To extract facial landmarks, we first use Haar cascade algorithm to detect the face ROI following by Haar cascade algorithm for the eye, mouth and nose ROI determination. To find landmark associated with the

eye, we convert eye ROI image to binary image using thresholding algorithm. To exclude the eyebrow region, we apply horizontal projection. The project data will then be used to separate the eyebrow region from the eye region. To detect eye-related landmark, vertical projection is applied. With the vertical projection data, the outermost pixel can be identified and the associated eye landmark can be determined. The similar technique can then be used to identify landmarks associated with the nose and mouth area. Given the correspond landmarks on the reference face and the query face, geometric transformation can be determined using normal equation bases on minimized mean squared error. The two faces are then aligned. To provide the quantitative measurement, the two aligned face are converted to edge image using canny edge algorithm. The distance map error between the two aligned edge facial images is then used to identify the query face. The purposed algorithm for person identification was tested on the face database resulting in a very high accuracy.

Contribution ID: 1398
2. Image Processing
02.09. Image processing, segmentation and registration

A classification and segmentation combined two-stage CNN model for automatic segmentation of brainstem

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Abstract. Background: Accurate segmentation of brainstem in MRI images not only can prevent brainstem from being damaged in neurosurgery, but also is the basis for treatment of brainstem tumors. Currently, brainstem segmentation is mainly based on atlas registration or CNN using patches, which need long prediction time and get high false positive. We proposed a classification and segmentation combined two-stage CNN model of brainstem segmentation to improve the prediction accuracy and reduce computation time. Method: Firstly, a classification-CNN model was used to classify each MRI image to judge whether the transverse section image has brainstem. Based the classified images, we proposed a segmentation CNN model to segment brainstem based on the whole image rather than patches. In addition, considering that whole image based segmentation task is a big problem of class unbalance, we solved this problem by changing loss and giving the label weight coefficients to get more accurate results. Results: we have 210 cases of head MRI images, including 135 cases of brainstem tumor and 75 normal cases. We randomly selected 168 cases as the training and validation set, and the others as the test set. The results of the test were 95.19%(Dice, normal), 94.34%(Dice, tumor). Conclusion: The results demonstrated that our method can get more segmentation accuracy and less time for the segmentation task of brainstem than some state of art methods. The results of segmentation can be applied to preoperative planning and surgical navigation perfectly.
Keywords: Deep Learning, Image Classification, Brainstem segmentation.

Contribution ID: 1454
2. Image Processing
02.09. Image processing, segmentation and registration

Identity Verification Using Geometry of Human hands

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Biometric identification systems are available in various methods. This research focuses on the development of hand identification and hand geometry using hand features, including the length of the hand, length and width of each finger, size of palm. We use radius distance methods to find the position of the fingertip and the concave of the finger from the hand contour. The radius distance method is highly flexible, accurately detecting the curves of fingertip and concave of finger. We use these reference points to identify the characteristics of individual hands. The original image, we got from the acquisition system, which we set up ourselves and the system is cheap. The experimental results demonstrate the efficiency of the proposed method.

Contribution ID: 1620
2. Image Processing
02.09. Image processing, segmentation and registration

Detection of low wall motion and comparison study with scar tissue using 4D left ventricle cardiac images

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The myocardial contraction creates an effective cardiovascular pumping system. While regional dysfunction of
myocardium leads to the functional abnormality of cardiac wall motion that is one of the risk factors for ventricular
remodeling. It helps in the early phase detecting abnormalities of wall motion while wall motion of cardiac cycle makes
difficult to observe without any physical reference point. In this research, we find to characterize regional systolic
function abnormalities. In-house developed 4D image processing software that extracts the wall motion of left ventricle
from a 4D cardiac image. We created 10 frames of 3D heart model that contains long axis as the reference for predicting
left ventricle wall motion. We tested our model with Scar tissue to the 4D cardiac model of the left ventricle, low motion area as the non-invasive method of early detection. The detection in wall motion could effectively reflect the dysfunction of the myocardium. Thus, this study provides a new approach to assess the degree and site dysfunction area of myocardium.

Contribution ID: 1789
2. Image Processing
02.09. Image processing, segmentation and registration

Evaluation of user-guided deformable image registration for thoracic images

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[Purpose] User-guided deformable image registration (DIR) has allowed user to actively participate in DIR process, and is expected to improve DIR accuracy. The purpose of this study was to determine the user-guided DIR accuracy for thoracic images.
[Methods]Four-dimensional CT images of 10 thoracic cancer patients were used. Dataset for these patients were provided by DIR-lab and included a coordinate list of anatomical landmarks. Four medical physicists of different institutions performed DIR between peak-inhale and peak-exhale images with/without user-guided DIR tool, Reg Refine implemented in MIM Maestro (MIM software). The registration accuracy was quantified using target registration errors (TRE) for 300 anatomical landmarks in each patient.
[Results] The average TRE with Reg Refine for three medical physicists were 1.48 mm, 1.80 mm, 3.46 mm and 3.56 mm, respectively, whereas TRE without Reg Refine were 3.27 mm, 3.45 mm, 3.55 mm and 3.27 mm, respectively. For example, in the largest displacement case (3D displacement: 14.99 mm), TRE with Reg Refine were 1.51 mm, 2.77 mm, 10.32 mm and 9.93 mm, respectively, whereas TRE without Reg Refine were 8.73 mm, 10.28 mm, 10.45 mm and 8.73 mm, respectively. For average time consumption, user-guided DIR were 10.0 min, 6.7 min, 7.1 min and 8.0 min, respectively.
[Conclusion]This study has demonstrated that user-guided DIR have potential to improve DIR accuracy with moderate required time (<10 min). In particular, for the largest displacement, user-guided DIR is more effectively for the improvement of DIR accuracy. However, 2 of 4 users could not have much improvement of DIR accuracy, indicating necessity for training prior to use user-guided DIR.

Contribution ID: 118
2. Image Processing
02.10. Functional neuroimaging and neuronavigation

Diffusion MRI tractography of thalamocortical and optical radiation tracts: comparison between probabilistic fiber tracking and evoked potential in epileptic patients

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The purpose of this study was to evaluate the accuracy of the probabilistic tracking method of diffusion tensor imaging fiber tractography (DTI-FT), compared to imaging-represented electrophysiology data in epileptic patients who underwent stereoelectroncephalography (SEEG).
We identified 13 epileptic patients (mean age 26±11) who underwent DTI acquisition (1.5T Philips Achieva Scanner, 65 non collinear diffusion gradient directions). These data were obtained with other brain MR sequences, used for SEEG planning.
Depending on electrodes location, we recorded tibial and median somatosensory-evoked potentials (SEP) in 8 patients and flash-visual evoked potential (VEP) in 12. The thalamocortical (THC) and optical radiation (OR) tracts were blindly reconstructed using a probabilistic algorithm implemented in FSL 5.0.6, using two ROIs corresponding to the sensory thalamus and white matter (WM) lying underneath the somatosensory cortex for the THC, and the lateral geniculate body and WM lying next to the calcarine cortex for the OR. The 3D tractographies were then compared to the position of SEEG electrodes contacts, on which evoked potentials (EPs) were recorded.
Comparison between DTI-FT and EPs shown that a superposition of the neurophysiological recording contacts and the tracts resulted in 11 out of 13 patients (85%). On particular, we obtained correspondence in the reconstruction of 5 on 7 THC and 8 on 12 OR.

This study is a preliminary one, suggesting that EPs recorded during SEEG monitoring can be considered as a valuable tool to validate the probabilistic tracking method in the reconstruction of THC and OR tracts.

Contribution ID: 484
2. Image Processing
02.10. Functional neuroimaging and neuronavigation

Application of Dual Depth Selective Filter to fNIRS to Improve Signal Quality and Localization of Blood Perfusion in Brain Cortex

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fNIRS (functional near infrared spectroscopy) systems are widely used as feasible functional neuroimaging tools. The fNIRS system measures relative light attenuation between light source and receiver on head surface, based on the principle of neuro-vascular coupling. For conventional fNIRS, the signals are considered as being due to the neural activity in brain cortex, and simply mapped on midpoint between these optodes. However, it is pointed out that the targeted neural activity signals obtained by fNIRS are contaminated by significant skin blood perfusion signals, since the algorithm is based on the simple space mapping. To improve the signal quality arising from the localized brain activation, our group introduced depth-selective filter (DSF). The filter comprises a depth-selective algorithm that uses linear inverse problem methods based on the diffusion equation. The filter has two variations, DSF1 for signal from deep region and DSF2 for signal from shallow region The features of the filter algorithm has been verified through the simulation and phantom experiment. In this study, some experimental results of oxygenated and deoxygenated hemoglobin signals of shallow region and deep region from human forehead using during neuro-task such as verbal fluency tasks and mental arithmetic tasks are demonstrated. The results show that the filter algorithm effectively discriminates between the superficial skin perfusion signal and the deep target signal even though the original shallow signals are often overwhelmingly stronger than the signals from deep region. The filtered deep signal shows that task-related oxyhemoglobin increase is enhanced and localized in observing space, compared to the original signal. Furthermore, as a secondary effect, the parallel display of the shallow signal and deep signal helps us to assess the performance of the experiment because the skin perfusion is controlled by the autonomic nerve system, which tends to fluctuate depending on physical and emotional conditions of the subject.

Contribution ID: 557
2. Image Processing
02.10. Functional neuroimaging and neuronavigation

Head motion analysis in functional resting state fMRI data: characterization of multiple sclerosis patients' principal movements and noise causes

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Nowadays, studies with functional MRI (fMRI) became very useful and interesting to evaluate the human brain networks and their interactions. It is a reliable technique but its elaboration is complicated by the several noise sources. One of these derived by involuntary patient movement during the scanning, in particular motion of the head could be creating various problems, introducing misalignment of one volume to the next and thus measurement inaccuracies. Therefore, this type of noise must be corrected to avoid distortion of signals that can bring to incorrected data interpretation. An interesting step in this field can be represented by a characterization of the movements based on the considered pathology. In this way, ad hoc protocol could be realized in order to minimize the distortions derived by the major movements interested in the pathology. Our work aim was to study the kind of head motion in Multiple Sclerosis (MS) patients, compared to healthy controls, by giving a first contribute of a personalized future strategy for the motion correction. We have extracted 15 movement parameters by the fMRI elaboration (translational displacements along X, Y, and Z axes, rotational displacements along phi (roll), theta (pitch) and psi (yaw) axes, temporal signal to noise ratio (tSNR), root-mean-square (RMS) from the x, y and z parameters, the Euler-Angle(EA) from phi, theta and psi angles and deviation standard (std) for the three translational and rotational displacements). Unpaired t-test showed a greater value in psi rotation into SM patients respect the controls and Support Vector Machine (SVM) with recursive elimination feature (rfe) presented the same parameter as the most important feature into classification. This finding could be an important step into characterizing fMRI study in MS, focusing on the strategies to minimize this movement, e.g. using particular bare sit or the right filter into pre-processing step.

Contribution ID: 1428
2. Image Processing
02.10. Functional neuroimaging and neuronavigation

Spectral entropy of synchronous ultra-fast fMRI, EEG, and NIRS data in drug-resistant epilepsy

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Epilepsy causes measurable irregularity in various brain signals, as well as autonomic functions like heart rate variability and respiration. Imaging dynamic neuronal signals utilizing simultaneously acquired ultra-fast functional magnetic resonance imaging (fMRI) called magnetic resonance encephalography (MREG), direct-current electroencephalography (DC-EEG), and near-infrared spectroscopy (NIRS) can provide a more comprehensive way of analyzing epilepsy-related changes in the human brain. The study aimed at examining whether irregularity measure called spectral entropy (SE) as a joint measure of synchronous multimodal brain signals could reveal epilepsy-related alterations in signal fluctuations.
Ten patients with drug-resistant epilepsy (DRE) and ten healthy controls (HC) were scanned with 10 Hz whole brain MREG sequence with Siemens 3T Skyra in combination with EEG, NIRS, and cardiorespiratory signals. After standard preprocessing, SE was estimated from (fullband (0-5 Hz, FB), near FB (0.08-5 Hz, NFB), very-low frequency (0.009-0.08 Hz, VLF), respiratory (0.12-0.4 Hz),

and cardiac frequency (0.7-1.6 Hz) bands of MREG, DC-EEG, and NIRS. Global dynamic fluctuations in MREG and NIRS were analyzed in windows of 2 minutes with 50% overlap.
Right thalamus, cingulate gyrus, inferior frontal gyrus, and frontal pole showed significantly higher SE-MREG in DRE patients compared to HC. In DRE patients, SE in cortical NIRS was significantly lower in FB, NFB, cardiac and respiratory frequency. Suiting the MREG and NIRS results, DRE patients showed a significant increase in SE-EEG in FB in fronto-central (FC2) and parieto-occipital (Poz) regions, accompanied with a significant decrease in respiratory frequency in frontal pole (Fp1, Fp2), parietal (P3) and occipital (O2, Oz) poles.
Together EEG and MREG in the region of anterior cingulate gyrus, and EEG and NIRS findings in respiratory frequency support altered parasympathetic respiratory function and possibly disturbed respiratory pulsation mechanism in the brain of DRE patients.

Contribution ID: 90
2. Image Processing
02.11. Radiomics

Multiregional Radiomics Phenotypes at MR Imaging Predict MGMT Promoter Methylation in Glioblastoma

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Objectives: O6-methylguanine-DNA methyltransferase (MGMT) promotor methylation has been used as an important predictive molecular marker in clinical settings for glioblastoma patients. Currently, the detection of MGMT methylation status relies on genetic profiling approaches, requiring tissue obtained via biopsy or surgical resection. Intratumor heterogeneity poses clear barriers to biopsy-based method. Recent advances in imaging-genomics permit correlating imaging phenotypes with molecular data. This study aimed to build a reliable radiomics model from multiregional and multiparametric magnetic resonance imaging (MRI) for pretreatment prediction of MGMT methylation status in Glioblastoma.
Methods: In this retrospective study, high-throughput multiregional radiomics features were automatically extracted from multiparametric MRI, including location features, geometry features, intensity features and texture features. A deep convolutional neural network was used for automatic segmentation of multiple tumor subregions, including the necrosis, enhancement area, non-enhancement area and edema. A machine learning method was used to select a minimal set of all-relevant features. Based on these selected features, a radiomics model were built by using a random forest classifier for MGMT methylation prediction from a primary cohort (133 patients) and tested on an independent validation cohort (60 patients). Predictive models combing radiomics features and clinical factors were built and evaluated. The radiomics model was assessed on subgroups stratified by clinical factors.
Results: The radiomics model with 6 all-relevant features allowed pretreatment prediction of MGMT methylation (AUC=0.88, accuracy=80%). Combing clinical factors with radiomics features did not benefit the prediction performance. The radiomics model significantly outperformed the clinical features in all stratified analysis.
Conclusions: Radiomics model built from multiregional and multiparameter MRI may serve as a potential imaging biomarker for pretreatment prediction of MGMT methylation in GBM. The

proposed radiomics model could provide a tool to guide preoperative patient care and made a step forward radiomics-based precision medicine for GBM patients.

Contribution ID: 221
2. Image Processing
02.11. Radiomics

Preoperative Prediction of Early Recurrence in Intrahepatic Cholangiocarcinoma after partial hepatectomy

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Purpose: To develop and validate a radiomics nomogram based on radiomics features and clinical characteristics for preoperatively prediction early recurrence (ER) of intrahepatic cholangiocarcinoma (ICC) after partial hepatectomy.
Patients and Methods: In this study, a prediction model was developed in a training cohort involving 139 ICC patients recorded from January 2010 to June 2014. Radiomics features were extracted from contrast-enhanced magnetic resonance imaging (MRI) arterial-phase images. Feature selection and radiomics signature construction were completed using Spearman's rank correlation test and LASSO regression. Combining with clinical characteristics, a radiomics nomogram was developed by the multivariable logistic regression model. Nomogram performance was assessed in terms of classification and calibration. Decision curve analysis (DCA) was performed in both training and validation cohorts to estimate the clinical usefulness. An independent validation cohort involved 70 patients, recorded from July 2014 to March 2016. An internal validation was also performed.
Results: The radiomics signature, consisting of 9 features, showed significant differences between ER group and non-ER group ($P < 0.01$, both in training and validation cohorts). The AUC of the radiomics signature for the training and validation cohort was 0.82 (95% CI, 0.74 to 0.88), 0.77 (95% CI, 0.65 to 0.86), respectively. The AUC of the radiomics nomogram combining the radiomics signature and clinical stage was 0.90 (95% CI, 0.83 to 0.94) in the training cohort, 0.86 (95% CI, 0.76 to 0.93) in the validation cohort. The calibration curves of the nomogram presented good agreement of ER probability between prediction and observation in both training and validation cohorts. Besides, the DCA curve confirmed the clinical usefulness of the radiomics nomogram.
Conclusion: The radiomics nomogram, a non-invasive preoperative prediction model, is capable of predicting early recurrence of ICC after partial hepatectomy.

Contribution ID: 223
2. Image Processing
02.11. Radiomics

Scatter corrected cone-beam CT for radiomics in SBRT: a feasibility study

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Background and purpose: The brilliant therapeutic effect and longer patient survival time has made stereotactic body radiation therapy(SBRT) the major technology in radiation therapy. In the therapy procedure, cone-beam computed tomography (CBCT) imaging is routinely performed for patient

set-up and positioning verification. CBCT images also have valuable information about day-to-day changes of the lesion during the treatment procedure, which may have huge potential influence in the therapy outcome. In this study, we perform scatter correction on CBCT and analyze the radiomics features from scatter corrected CBCT to explore its feasibility for radiomics analysis in SBRT.
Materials and method: The dataset consisted of 12 patients with two-stage abdomen CBCT and planning CT images. Firstly, the scatter artifacts are suppressed using a customized ultrafast Monte Carlo simulation based scatter correction algorithm. The regions of interest (ROIs) are contoured randomly in CBCT, planning CT and uncorrected CBCT images to extract the radiomics features. A total number of 263 radiomic features which include 59 unfiltered and 204 wavelet-filtered features are calculated. The Spearman's correlation coefficients (CC) are calculated for statistical analysis.
Results: The percentages of robust features (PRF) (CC>0.8) are improved by 15.6% and 11.0% in two stages respectively after the scatter correction. Specifically, for the features after applying low-pass filter in both x and y directions (LL-wavelet-filtered features), the PRFs increase from 5.88%, 15.7% to 41.2% and 37.3%, respectively.
Conclusion: The result shows that effective scatter artifacts correction could improve the correlation between CBCT features and planning CT features. The LL-wavelet-filtered features are improved most. The features extracted from CBCT images have the possibility to be used in radiomics.

Contribution ID: 287
2. Image Processing
02.11. Radiomics

The Preoperative Prediction of Histologic Grade in Pancreatic Neuroendocrine Tumor using Radiomics Nomogram

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Background and purpose: To develop and validate radiomics nomogram for preoperative prediction of G1 and G2/3 tumor in patients with pancreatic neuroendocrine tumor (pNETs).
Material and Methods: A total of 137 patients underwent contrast enhanced CT from two hospitals were included in this study and the arterial phase of contrast enhanced CT was used for radiomics feature extraction. The patients from the first hospital (n=86) were used as training set and those from the second hospital (n=51) were selected as the independent validation set. The Mann-Whitney U test and lasso regression were used for data dimension reduction and radiomics signature building. A logistic regression model was constructed by combing radiomics signature with clinical factors and presented in nomogram. The receiver operating characteristic (ROC), area under ROC curve (AUC), calibration curve and decision curve analysis (DCA) were used for assessing the diagnostic value of the nomogram.
Results: A total of 467 radiomics features including histogram-based, texture-based and wavelet-based features were extracted. The radiomics signature was finally constructed by combing eight selected radiomics features. The radiomics signature showed good performance in predicting tumor grade (AUC=0.870, CI: 0.780-0.933 (training), AUC=0.862, CI : 0.736-0.942 (validation), P<0.001). Among the clinical factors combination, the radiomics signature and TNM stage showed the best performance (AUC=0.907, CI: 0.826-0.959 (training), AUC=0.891, CI : 0.772-0.961

(validation), P<0.001). The calibration curve showed good agreement between the predicted probability and the actual rate. The result of DCA demonstrated the clinical usefulness of radiomics nomogram.
Conclusion: The nomogram incorporating radiomics signature and tumor stage can be conveniently used to facilitate the preoperative prediction of G1 and G2/3 tumor in patients with pNETs.

Contribution ID: 980
2. Image Processing
02.11. Radiomics

Predicting H3 K27M Mutation Status of Brainstem Gliomas from Multi-Modality MR Images using Deep Learning

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Abstract. Objective: Brainstem gliomas (BSGs) is a cancerous glioma tumor in the brainstem. Some analysis of BSGs demonstrates that H3 K27M mutation is present at the original site and spread throughout the whole course of disease. Therefore, predicting H3 K27M mutation status, which can be used as a qualified biomarker for diagnosis and therapy selection for BSGs patients, is crucial. In this study, we predict the H3 K27M mutation status from multi-modality MR images using convolutional neural networks (CNN), which could be a noninvasive alternative to surgical biopsy and histopathological analysis. Method: Our method consists of three main steps: image registration, image pre-processing (ROI-selection) and classification of H3 K27M mutation status using CNN. We included a total of 152 BSGs patients (H3 K27M mutation status:92 mutants and 60 wild type), each who had three modality MR images: preoperative T1, post-contrast T1 (T1C) and T2 images. We randomly split our data into training (65 mutants and 33 wild type), validation (12 mutants and 12 wild type), and test (15 mutants and 15 wild type) cohorts. We augmented the training data to counter un-balance class and overfitting problem with data augmentation method in training processing. In addition, we proposed a CNN based classification model for our prediction task of H3 K27M mutation status of BSGs. Finally, we evaluated the importance of different modalities of MR images and multi-scale CNN architectures in our method. Results: The results of the best performing configuration on the test cohort were 93.3% (accuracy), 88.24% (specificity), and 100% (sensitivity). Conclusion: CNN based deep learning method provides promising results for predicting H3 K27M mutation status noninvasively based on multi-modality MR images. Significance: It would allow selecting effective diagnosis and therapy selection for BSGs patients without the need for surgical biopsy.
Keywords: Deep Learning, Brainstem Gliomas, Mutation Prediction.

Contribution ID: 1041
2. Image Processing
02.11. Radiomics

Radiomic signatures for prediction of pathological response following neoadjuvant chemoradiotherapy in esophageal cancer

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Purpose/Objective(s): Neoadjuvant chemoradiotherapy (NACRT) followed by esophagectomy is the standard of care for locally advanced esophageal cancer. Radiomic signatures were developed to predict pathological complete response (pCR) following NACRT.
Material/Methods: 68 patients underwent esophagectomy after 50.4 to 56 Gy with concurrent 5-FU and Cisplatin were retrospectively studied following an IRB protocol using baseline 18F-fluorodeoxyglucose Positron Emission Tomography (PET) and Computed Tomography (CT) scans. A total of 126 features were extracted from the segmented primary disease individually from PET and CT images using an in-house algorithm. Prediction signatures based on PET and/or CT features were constructed and validated using machine learning. Moreover, signatures based on composite features using the following formula, αPET+(1-α)CT, $0<\alpha<1$, were also built. Cox regression hazard was used to assess association with relapse free survival (RFS).
Results: pCR was observed in 34 (50%) patients. On univariate analysis, 16 PET and 14 CT features were found to independently predict pCR. Four predictive signatures were built using CT, PET and combining CT and PET features. Individually, both CT and PET had good predictive power with AUC of 0.74 and 0.73, respectively. Combined CT+PET features resulted in a significantly improved predictive power, AUC=0.856. Good discrimination (82.6%) was observed in validation dataset (1/3 of cohort). The best signature used composite features with optimized α=0.8 and leave-one-out validation resulted in AUC=0.872 and 76.5% accuracy in validation. When using 2/3 of cohort for training resulted in AUC=0.955 and 87% accuracy in validation. Stratifying patients with low vs. high radiomic signature score predicted RFS: median RFS 80.1 vs. 40.1 months; and 2-year RFS 77.4% vs. 52.6% [hazard ratio=2.24, 95%CI:1.01-5.58], respectively.
Conclusion: The developed composite radiomic signature was highly predictive of pCR following NACRT. Further validation in larger data sets is warranted to further evaluate whether the signature can predict clinical outcomes.

Contribution ID: 1052
2. Image Processing
02.11. Radiomics

Analysis of radiomics in leukemia images with artificial intelligence

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Radiomics is an advance cancer analysis technique, for instance, it analyzes shape, texture of cancer cells, among others things. The analysis was accomplished analyzing images of leukemia infected cells, employing artificial intelligence which could foretell when the metastasis accomplishes or the reaction of cells to different drugs.
Deep learning architecture was implemented in the development of the project, based on dynamic neural networks.
Cancer cells have motion, this motion generates a scheme in regard of time and its frequency, neural networks estimate this motion generating a prediction based on metastasis or reactions to certain drugs.

Contribution ID: 1086

2. Image Processing
02.11. Radiomics

Identifying of Cancer Prognosis in Lung Cancer by Integrating CT-based radiomics

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Purpose: Radiomics is a new approach to extract quantitative features from image data. In the field of radiotherapy, predicting prognosis using computed-tomography (CT) images of cancer patients is attracting attention, but there are still few reports on this research. Therefore, in this sturdy, we tested the hypothesis: radiomic features could predict the cancer prognosis for lung cancer patients with stereotactic body radiotherapy (SBRT).
Materials and methods: Forty lung cancer patients treated with SBRT were analyzed. Patients received a dose of 6.25-12 Gy×4-8 fractions. Pre-treatment CT images obtained by CT scanner (GE) were used for radiomics analysis. 1610 radiomic features describing tumor intensity, texture, shape and size, were employed in this study. Clinical target volume defined by radiation oncologist was used for feature extraction. To clarify the prognostic power of radiomics, the relationship between radiomic features and overall survival was evaluated by Kaplan-Meier method.
Results: For 38 radiomic features based on stability and variance, Kaplan-Meier curves were significantly different ($p<0.05$) between groups with high and low radiomic feature values. For example, Cluster Prominence and Gray level nonuniformity was significantly prognostic for overall survival (Cluster Prominence: $p < 0.01$, Gray level nonuniformity: $p=0.042$).
Conclusion: Our result showed that a significant difference occurred in the survival curves of 38 radiomic features. This study highlights the potential of incorporating radiomic features into prediction model for cancer prognosis. Further investigation with larger sample size is needed to determine the more accurate prediction model with radiomic features.

Contribution ID: 1453
2. Image Processing
02.11. Radiomics

Robust predictive radiomic models for data from independent institutions

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The distribution of a radiomic feature can vary between two institutions due to, for example, different image acquisition parameters, imaging systems, and contouring (i.e., tumor delineation) variations between clinicians. Our aim was to develop effective statistical methods to successfully apply a radiomics-based predictive model to an external dataset.
Monte Carlo (MC) models were used to demonstrate the effect of feature distribution variations on the predictive ability of the feature. Two common feature normalization methods, re-scaling and standardization, were evaluated in terms of their efficacy when applied to datasets containing statistical outliers. Standardization was chosen as the preferred approach. Another MC model was used to demonstrate why a dataset needs to be balanced between positive and negative outcomes before standardization is applied to it.

The clinical effectiveness of the statistical methods was shown using magnetic resonance images of primary uterine adenocarcinoma. Feature selection was done using 94 samples (Institution X), and feature testing was done using 63 samples (Institution Y). The outcomes studied were lymphovascular space invasion and cancer staging. Logistic regression was used to obtain the prediction accuracy of a feature. When comparing the prediction accuracy, sensitivity, specificity, and F-score of promising radiomic features in the testing set with and without standardization, there was an improvement due to standardization in the majority of cases for both of the studied outcomes.
Thus, an elegant statistical approach of feature standardization using balanced datasets was shown to improve the predictive ability of radiomic features when applied to an independent testing set.

Contribution ID: 1596
2. Image Processing
02.11. Radiomics

Radiomic study predicts radiation induced toxicity in prostate cancer patients

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Background and aim: Radiation induced toxicity is one of the main limiting factors in prostate cancer patients undergoing radiotherapy. Predicting such effects is of particularly interest among clinicians and researchers. The purpose of this study was to predict urinary and rectal toxicities using MRI radiomic features.
Material and methods: Prostate cancer patients with urinary and rectal toxicities were included into the study. More than 30 robust image features from co-occurrence and run length matrix families were extracted from rectal and bladder wall MR images. Different machine learning algorithms were used for feature selection and classification to build predictive radiomic models. Area under the curve (AUC) of receiver operating characteristic were used of model performance assessment.
Results: Our results showed that radiomic machine learning models have the high prediction powers. AUC were 0.81 and 0.78 for urinary and rectal toxicities respectively. Based on our results, radiomic features including angular second moment and 45degree_Fraction were found as imaging biomarkers for prediction of urinary toxicity. For rectal toxicity prediction, radiomic features including inverse different momentum and angular second moment were introduced as predictive biomarkers.
Conclusion: Our study identified that radiomic features extracted from bladder and rectal wall MRI may be used as predicting biomarkers for radiotherapy induced toxicities.

Contribution ID: 1624
2. Image Processing
02.11. Radiomics

Textural feature robustness against radiological parameters

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Objective: The aim of this study was to assess how radiological parameters including kV, mAs, filtration and tube angles may changes the radiomic feature values.

Methods: Radiological parameters including kV, mAs, filtration and tube angles were studied to obtain different radiographic images of a tibia bone phantom. Different radiomic texture were extracted from a known region of interest. Textures from features sets including histogram, gradient, run-length matrix, co-occurrence matrix, autoregressive model and wavelet. Robustness were evaluated based on coefficient of variation (COV).
Results: 34 % and 22 of features were most robust (COV≤5%) against mAs and kV respectively and there was no robust features against tube angle and filtration. 100 and 76% of features showed large variations (COV>20%) against filtrations and tube angle respectively. Gradient and autoregressive model feature sets have no robust features against all radiologic parameters. Features including sum-average, sum-entropy, correlation, mean and percentile (50, 90 and 99) belong to co-occurrence matrix and histogram feature sets were found as most robust features.
Conclusions: The results presented here indicated that radiologic parameters have great impacts on radiomic feature values and caution should be taken into account when work with these features. In quantitative bone studies, robust features with low COV can be selected for clinical or research applications.

Contribution ID: 745
3. Information Technology in Healthcare
03.15. Keynote lecture

KEYNOTE LECTURE: Medical informatics; where's the data and how can it be used

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Getting access and analyzing data is the driving force behind all progress in business today. This is also true in healthcare. Patient records hold the information for their current care and there is now intercommunication between heath systems to link data and create a complete patient electronic medical record (EMR). This requires robust security measures to ensure records are only accessible by people that should be accessing them. It also requires a dependable methodology to ensure the correct patient data is linked together.
Once you have the compete patient's EMR it can still be difficult to find the needed data because there is often a lot of extraneous information that may hide what a clinician needs. So how do you find the relevant data? In addition, the data is often unstructured or there are structured and unstructured data combined. Consequently, an intelligent method to search and combine this data is needed. The EMR also needs to have a reliable method for updating personnel when critical findings are added to the EMR. But who should get this notification and how do you minimize notification overload? Also, how do you link a clinical recommendation to a result? This can make sure a patient's care is done in a timely manner, but also provides data on outcomes that can increase the ability to determine the best treatment courses. In addition, there is much more data that needs to be accessible by clinicians to make the right decisions on care. Clinicians need to know all the latest advances and what experts in each area recommend.
This is just a small portion of things that are being done or are needed in medical informatics. A review of some of the methods that are being used to gather and analyze medical data will be presented.

Contribution ID: 1910
3. Information Technology in Healthcare
03.15. Keynote lecture

KEYNOTE LECTURE: Public Health in the Era of Big Data: From Online Evidence to Serious Games

Patty Kostkova
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Recently, the massive explosion of medical evidence on the Internet and mobile devices and increased citizens' involvement in management of their health changed the delivery of healthcare. This rapid process changed healthcare delivery at developed world and increasingly improves community health in the low and middle income countries (LMIC).
In this presentation we will outline the issues surrounding the dissemination of medical evidence and understanding public information needs from Internet search weblogs analytics. Educational effectiveness of serious games highlights the opportunity mobile technology brought to training, community engagement and behaviour change. Social networking with increasing amount of user-generated content from social media and participatory surveillance systems provide readily available source of real-time monitoring and epidemic intelligence.
In this talk, we will draw from several mobile technology projects aimed at citizens in low and middle income countries. In particular, mobile training and crowdsourcing for community engagement to combat the zika virus in Brazil, social media use for vaccination campaigns, early warning epidemics dashboard, and serious mobile games for increasing resilience and disaster preparedness in perinatal women in Nepal.

Contribution ID: 734
3. Information Technology in Healthcare
03.02. Data and information models and representations, standards, interoperability

An engineering module to identify potential diabetes patients and preventive measures for diabetes in developing countries like Bangladesh

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Diabetes has demonstrated as the main chronic disease and crucial problem in Bangladesh. According to a data of International Diabetes Federation (IDF) Bangladesh is the 10th in terms of diabetes patients in the world and diabetes prevalence in Bangladesh would reach from present 7 million to 12 million by 2035 posing a colossal challenge to the health care system. People of all ages are being affected with diabetes, which has become a silent killer. Objective of this study is to develop a module with assistance of doctors and CE/BME which will be used to identify the actual number of diabetes patients and measure the potential risk on health index. The goal of this study is to bring as much people as possible within survey and find the potential diabetic patients together with the peoples who might not have diabetes now but possess the credible risk factors. We will be able to provide preventive information to these populations and motivate and suggest for more care on individual health to avoid diabetes. An optimized software and database is designed for performing several tasks to analyze the patients data collected from various hospitals' of Bangladesh. The numerical statistic will represent the overall patients health index for diseases and assessment will allow us to determine the actual patients number with appropriate threat in categories of diabetes diseases. Findings can confirm both individuals with diabetes and the control group with possible diabetes threat. Proper Diagnosis and treatment then can be assured for these individuals and national precautionary action will accomplish through regulatory control . Future assessment and intervention can be further explored from the perspectives of patients and diabetes information processing which can improve the patients' indexing, safety and health care management in many developing countries.
Index Terms: Diabetes, Health Index, Patients risk, Social challenges,

Contribution ID: 151

3. Information Technology in Healthcare
03.04. Artificial intelligence

Using artificial neural network to predict functional recovery of patients treated by intravenous thrombolysis in acute ischemic stroke

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In general, cerebrovascular diseases are composed of approximately 80% ischemic strokes. They are both expensive and time consuming while physicians take care of the acute ischemic stroke (AIS) patients. It is well-known that thrombolysis treatment in AIS patients can reduce disability and increase survival rate, however only one-half of patients have good outcomes. Therefore, we designed a functional recovery prediction model by artificial neural network (ANN) for AIS patients after intravenous thrombolysis to help make better clinical decisions. In this study, we retrospectively collected 157 AIS patients who received intravenous thrombolysis at a medical center in north Taiwan. The outcome defined Modified Rankin Scale ≤2 after three months follow-up as favorable recovery. 80% data were selected for training this predictive ANN model and 20% data were used for validation. The performance of models is evaluated by Receiver Operating Characteristic (ROC) Curve Analysis. An ANN with 5 inputs and 6 neurons in hidden layer was obtained. The performance of this model was with accuracy 83.87% and the area under ROC curve 0.87. This results showed that this ANN model could achieve a high prediction accuracy for functional recovery evaluation. It is an important issue to predict prognosis of treatment for personalized medicine. Risk and benefit should always be balanced before any treatment is to be applied. The developed prediction models may help physicians to individually discuss and explain the likely recovery probability to patients and their families within short therapeutic time before thrombolysis treatment in the emergency room.

Contribution ID: 271
3. Information Technology in Healthcare
03.04. Artificial intelligence

Data analytics for Metabolic syndrome diagnostics

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Metabolic syndrome (MS) represents an important risk factor for the development of cardiovascular disease as well as type 2 diabetes mellitus, which as one of few clinical syndromes accounts for more than 25% of the world population. There are several definitions of factors describing MS, but among the most commonly used are the NCEP (National Cholesterol Education Program) and WHO (World Health Organization), according to which prevalence of MS results from the presence of at least three of the following factors: insulin resistance, abdominal obesity, atherogenic dyslipidemia, triacylglycerol, lowering cholesterol and raised blood pressure. The diagnosis is often associated with various negative activities, such as little exercise, poor diet, stress, genetics, and excessive alcohol consumption. In this case, it is important to consider all relevant factors and potential associations between them. The aim of this paper is to review existing articles devoted to the topic of MS diagnosis within suitable data mining methods. Our motivation is to identify the best and worst practices in all six phases of CRISP-DM methodology typically used to organize the analytical process. Typically, the researchers used a binary classification with decision trees, neural networks or logistic regression; or suitable statistical methods like Welch's t-test, Pearson's chi-squared test, etc. Mostly, the size of processed data samples is more than one thousand patients, but we would like to stress out some approaches suitable just for the smaller ones. Also, the results depend on patients characteristics, since each study or experiment is devoted to some target group coming from USA, Africa or Asia. Ideally, extracted knowledge can be used for Clinical Decision Support System (CDSS).

Contribution ID: 274
3. Information Technology in Healthcare
03.04. Artificial intelligence

Advancing medical practice through computer expert systems

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All over the world, clinicians represented by the medical doctors, use several sources of data through a series of algorithms to arrive at a diagnostic impression. This is aimed at arriving at an appropriate treatment decision. This research sets out to review the advancements of medical prac- tice through the expert systems. Expert Systems used in Medicine, especially in Medical Diagnosis is usually designed to enable the clinicians to identify diseases and describe methods of treatment to be carried out taking into account the user capability. The formats used here is the C Lan- guage Integrated Production System (CLIPS) as the tool for design. In the system, a number of patient cases is selected as prototypes and stored in a separate database. The knowledge is acquired from literature review and human experts of the specific domain and is used as a base for analysis, diagnosis and recommendations.

Contribution ID: 633
3. Information Technology in Healthcare
03.04. Artificial intelligence

Baby cry recognition using deep neural networks

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Baby cry recognition is a challenging task as it is hard to determine the speech features that can allow researchers to clearly separate between different types of cries. However baby cry is treated as a different way of communication of speech. The types of baby cry can be differentiated using Mel-Frequency Cepstral Coefficient (MFCC) with appropriate artificial intelligence model. Stacked restricted Boltzmann machine (RBN) is popular in providing few layers of neural networks to convert the high dimensional data to lower dimensional data to fine tune the input data to a better initialized weight for the neural networks. Usually RBN is used with another deep neural network to form the deep belief networks (DBN), and the studies in this direction is heading towards the convolutional-RBN variant. The study on RBN to pre-train Convolutional neural networks (CNN) without convolution function in the RBN meanwhile is scarce due to the Back propagation and principle component analysis can be applied directly to the CNN. In this paper, we describe the hybrid system between RBN and CNN for learning class specific features for baby cry recognition using the feature of Mel-Frequency Cepstral Coefficient. We archived an 78.6% of accuracy on 5 types of baby cries by validating the proposed model on baby cry recognition.

Contribution ID: 723
3. Information Technology in Healthcare
03.04. Artificial intelligence

Application of artificial neural network for prediction of incidence of the lung disease due to the air pollution levels

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The aim of this experiment is to correlate air pollution and its effect on lung disease via an Artificial Neural Network (ANN). ANN was created to predict the possibility of lung diseases arising due to air pollution during the upcoming 5 years.
The World Health Organization (WHO) estimates and confirms that air pollution is the largest environmental health risk in the world and the latest studies revealed that approximately 6.5 million deaths were due to air pollutants. The International Agency of Research on Cancer (IARC) indicates that 223,000 deaths due to lung issue worldwide resulted from air pollution. The highest European mortality rates because of air pollution manifests in Bosnia and Herzegovina (B&H), Bulgaria, Albania and the Ukraine and by the new WHO statistics B&H is recorded as the worst European performer. Specifically in B&H, in 2016, approximately 1,105 people have died from lung related diseases. This is a significant increase from 2005 where recorded number of deaths was 931.
The model represents a feedforward neural network for the prediction of incidence of lung disease due to the air pollution, using Levenberg-Marquardt training algorithm. Input parameters for the network are different air particles including sulfur dioxide, nitrogen oxide, carbon monoxide, ozone and atmospheric aerosol particles which were measured by the Federal Hydrometeorological Institute of B&H as well as a number of reported lung disease cases to the Institute for Public Healts FB&H. This approach depicts how the ANN modeling technique is used to predict the incidence of lung disease by the key metrological variables required to adequately predict air pollution concentrations.

Contribution ID: 898
3. Information Technology in Healthcare
03.04. Artificial intelligence

Advancing medical practice through computer expert systems

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All over the world, clinicians represented by the medical doctors, use several sources of data through a series of algorithms to arrive at a diagnostic impression. This is aimed at arriving at an appropriate treatment decision. This research sets out to review the advancements of medical prac- tice through the expert systems. Expert Systems used in Medicine, especially in Medical Diagnosis is usually designed to enable the clinicians to identify diseases and describe methods of treatment to be carried out taking into account the user capability. The formats used here is the C Lan- guage Integrated Production System (CLIPS) as the tool for design. In the system, a number of patient cases is selected as prototypes and stored in a separate database. The knowledge is acquired from literature review and human experts of the specific domain and is used as a base for analysis, diagnosis and recommendations.

Contribution ID: 901
3. Information Technology in Healthcare
03.04. Artificial intelligence

Medical expert system with the properties of artificial intelligence

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Elaboration of synergetic-sinarchic concepts of structural harmonization of systems. Creation of the ideological and methodological instrument of structural research and design based on the theory of structures-attractors. Introduction of objective invariants of evolution and self-organizing into the basics of the theory of complex system design outside of balance. Finding of the latent order in systems and definition of laws-configurators of their substratum, make a harmonization basis - correct formation of «mixed» components in maintenance of due functional quality of complex systems in the processes of their system-genesis.
Efficiency, developed based on the discussed principles, the expert system determined by the fact that it can be "embedded" into the environment of potential users, adapting to their requests. Due to this, the expert system provides a new information technology that approaches intellectual activity in those areas where there is accumulated experience of experts based on understanding the structure and purpose of specific knowledge.
Support for the intellectual activity of the user of the expert system with a synarchy algorithm in generating new knowledge is the rapid implementation of the cycle of building models, their analysis and evaluation. At the same time, the processing of partial, fragmentary knowledge accompanied by an increase in the level of its systematic and integrated.
Real differences in the ways of thinking people of different professions not found. The interactive participation of the expert system using various interfaces in a real thought process will lead to leveling out the difference between the system and the user and may be evidence of the emergence of hybrid intelligence.

Contribution ID: 1166
3. Information Technology in Healthcare
03.04. Artificial intelligence

Personalization of insulin dosing in type 1 diabetes therapy: assessment of a neural network based approach in a simulation study

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Introduction: The recent approval, by U.S. Food and Drug Administration, of the use of continuous glucose monitoring (CGM) sensors for insulin dosing in type 1 diabetes therapy stimulates research on how to improve the standard formula (SF) for insulin bolus calculation, which is normally fed by “static” glucose measurements obtained by fingerprick devices. The aim of this work is to develop a neural network based approach to improve the SF by taking advantage of glucose rate of change (ROC), obtainable by CGM, and some easily accessible patient’s characteristics.
Methods: By using a popular state-of-art diabetes simulator, synthetic data of 100 subjects were created in a noise-free, single meal scenario, with different preprandial conditions in term of blood glucose (BG) level and ROC value. For each subject, insulin bolus has been calculated with 4 different methods: SF, two literature methods accounting for ROC values, and a NN-corrected (NNC) version of the SF, fed also by 10 patient’s characteristics (including, e.g., carbohydrate-to-insulin ratio, body weight and meal carbohydrate intake). Performance of the 4 methods has been compared by calculating the literature blood glucose risk index (BGRI).
Results: When NNC is used in adjunction to SF, a small but statistical significant improvement ($p < 0.001$) of the BGRI value equal to 0.37, 0.23 and 0.20 vs SF and the two ROC-accounting

literature methods, respectively can be observed. Moreover, compared to SF, NNC worsens BGRI only in a small portion of subjects.
Conclusion: This preliminary work suggests that, when CGM is used, the proposed NNC method can improve the SF for insulin dosing. Future work will involve investigations on NNC architecture to improve its safety and effectiveness and to assess its capabilities on more challenging scenarios designed to incorporate all of the sources of error and perturbations that occur in a real-life setting.

Contribution ID: 1251
3. Information Technology in Healthcare
03.04. Artificial intelligence

Dealing with temporal dependencies in computer assisted sleep stagings

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Although there are strong temporal dependencies in data from sleep polysomnography, many pattern classification approaches incorrectly ignore them and classify each signal segment regardless to the context of the previous or future behavior. This paper proposes and compares three approaches to classify data segments that consider the temporal context by taking into account the classification of their adjacent segments.
The first approach is based on the contextual expansion, where labels of previously classified segments are added to model inputs. The other two algorithms are based on transition probabilities – probabilities of transitions between sleep stages that can be estimated from training data or given by physicians. The second approach injects the temporal context through context dependent class priors that are computed from probabilities of transitions between different sleep stages. The third approach is based on iterative repair of the predicted hypnogram using simple local operations that maximize consistence of the hypnogram behavior with predefined transition probabilities.
This paper discusses three mentioned approaches in order to determine which one is more suitable for this type of task and how the performance of the classifier is improved when the adjacence od segments is taken into consideration. By the comparison with standard methods which do not consider the temporal context, the correct classification, when these approaches are utilized, is increased by 15 %.

Contribution ID: 1289
3. Information Technology in Healthcare
03.04. Artificial intelligence

Medical reasoning oriented orthesis to ease clinical practice and record keeping

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Praxis is a one of a kind Electronic Medical Records (EMR) software with no “a priori” variables templates that follows the physician´s reasoning when following the Subjective-Objective-Assessment-Plan (SOAP) paradigm. Behaving like a perfect and memorious assistant Praxis suggests “thought-units“ and “conceptual elements” once the physician either adopts or creates a new “case type” for the patient under examination. The feedback provided by Praxis is the result of the physician´s own experience, recorded as previous “case types”, “conceptual elements” and “thought unit”, organized in an arborescent knowledge structure.

By using previous experience as an implicit context sensitive check list, solving patients becomes a lot quicker, safer and to the point, avoiding lengthy questionnaires, typical of classical Medical Informatics EMR templates.
This artificial intelligence behavior mimics the individual physician´s practice who is faced daily with statistical distributions of rare-to-common cases. When uncommon cases are treated, ruling out normal values smoothly leads to such cases, while confirmation of common symptoms gives quick confidence to diagnostic and treatment decisions naturally suggested.
By accepting or refusing suggested text fragments shown by Praxis, and entering values also suggested by the texts, the physician quickly and effortless creates a clinical note. This is the EMR fragment. But it also creates structured data for interoperable access by other applications.
As the usual medical informatics systems grow in complexity and overlapping modules, the simple, specific approach of Praxis, based on artificial intelligence to compile knowledge is bound to have an ever increasing share of the clinicians´preference.
Future work consists in adapting the too to a variety of Health Systems, languages and reimbursing modalities and to interface Praxis with existing EMR environments complying with international standards.

Contribution ID: 1895
3. Information Technology in Healthcare
03.06. Big data challenges and applications in healthcare

The Repertoire of Mutational Signatures in Human Cancer

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Cancer is the most common human genetic disease. All cancers are caused by somatic mutations. These mutations may be the consequence of the intrinsic slight infidelity of the DNA replication machinery, exogenous or endogenous mutagen exposures, enzymatic modification of DNA, or defective DNA repair. In some cancer types, a substantial proportion of somatic mutations are known to be generated by exogenous carcinogens, for example, tobacco smoking in lung cancers and ultraviolet light in skin cancers, or by abnormalities of DNA maintenance, for example, defective DNA mismatch repair in some colorectal cancers.
Each biological process causing mutations leaves a characteristic imprint on the genome of a cancer cell, termed, mutational signature. In this talk, I will present mutational signatures analyses encompassing 23,517 cancer genomes across 40 distinct types of human cancer revealing more than 60 different signatures of mutational processes. Some signatures are present in many cancer types, notably a signature attributed to the APOBEC family of cytidine deaminases, whereas others are confined to a single cancer class. Certain signatures are associated with age of the patient at cancer diagnosis, known mutagenic exposures or defects in DNA maintenance, but many are of cryptic origin. The results reveal the diversity of mutational processes underlying the development of cancer, with potential implications for understanding of cancer etiology, prevention and therapy.

Contribution ID: 33
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

¬Developing an Automated Clinical Trending Tool for the Neonatal Intensive Care Unit (NICU)

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The primary objective of this work was to develop algorithms to display heart rate (HR) and oxygen saturation (SpO2) data in a useful manner for clinicians; additionally, the tool issues alerts for major changes according to ranges set by our physician partners. Current monitors can display physiologic parameters such as: heart rate, blood pressure, oxygen saturation, and respiratory rate. But nurses and physicians have to integrate several rapidly changing physiologic parameters with clinical signs to understand a patient's current condition. In the case of an unexpected and potentially life-threatening deterioration, the clinician needs to interpret the changes in patient data to intervene quickly. By providing the clinical team with vital sign trending information and alerts for pre-defined deviations, in an efficient and easy to interpret manner, a reduction in the time needed to detect changes in clinical status may be achieved. Currently, monitors are not designed as cognitive aids for the rapid detection of changes in patient status.
This work analyzed four types of patients: a stable patient, a patient who left the Neonatal Intensive Care Unit for a surgical intervention, and two patients who experienced a clinical deterioration. By displaying visual tools which are more intuitive and user friendly for physicians and alerting for short term vital sign deviations of these different patients, we aimed to identify trends which precede clinical deterioration in patients. The visualization of the parameters selected for trending was very well appreciated by the clinical personnel. A future development includes integration with the Physician-PArent Decision Support Tool (PPADS) developed by the authors, which contains a module for physicians and another for parents of infants in the NICU, to help in decision-making when difficult decisions need to be taken. Other physiologic parameters will be added to this trending tool, such as blood pressure and temperature.

Contribution ID: 200
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

Scoring system for the one-year mortality prediction of sepsis patients in intensive care units

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Sepsis is a life-threatening organ dysfunction induced by a dysregulated host response to infection and carries a high mortality and morbidity, therefore, after patients are admitted in an ICU it is necessary to synthesize the large volume of information that is collected in a value that represents their condition. Traditional severity of illness scores seeks to be applicable to all patient populations, and usually assess in-hospital mortality. However, people who survive sepsis may have permanent organ damage and eventually suffer from a sepsis-related death. This study presents the development of a score for the one-year mortality prediction of the patients that are admitted in an ICU with a sepsis diagnosis. 5650 ICU admissions extracted from MIMICIII database were evaluated and divided into two groups (70% development, 30% validation). LASSO and SGB variable importance methodologies were used to select the set of predictors that make up the score. Cut-off points that divided the cohort into two groups with different risks were found for each of these variables, and the numeric data were converted into binary. These predictors were used in a LR model, and its coefficients were rounded to the nearest integer, resulting in the point values that make up the score when multiplied with each binary variable and summed. Then, the one-year mortality probability was estimated using the score as the only variable in a LR model. The score, was evaluated using the validation subset, obtaining an AUROC of 0.753, which outperforms the results obtained with three commonly used severity of illness scores on the same subset. Observed and predicted mortality rates within estimated probabilities deciles were

compared graphically and found to be similar, exhibit that the number of deaths is indeed increasing as the outcome go from the decile with the lowest probabilities to the decile with the highest.

Contribution ID: 270
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

Towards computer supported search for semiological features in epilepsy seizure classification

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Current semiological seizure classification of epilepsies is one of the key parts in the patient pre-surgical evaluation. It combines patient´s ictal signs with seizure semiology. The value of many ictal signs for localization and lateralization of a seizure focus, as well as their sensitivity and specificity for certain focal epilepsies, is well known. All over it, there still remain many signs (and their sequencies) and poorly described patient behaviours during a seizure whose relation to a seizure focus have yet to be specified and confirmed. There have appeared some attempts to point to new signs recently but all of them have been based on data provided from relatively small cohorts (no more than few dozens of patients). This is no surprise since checking for presence of a specific ictal sign in a patient requires to review manually video records documenting his/her seizures.
Our contribution suggests a novel approach to the identification/verification of new ictal signs which is based on computer supported systematic review of unique extensive dataset collected by comprehensive tertiary epilepsy centre of Na Homolce Hospital of approximately 1.000 seizures (representing data of about 400 patients with up to 5 seizures annotated). The first step towards this goal requires transforming the original set of patient records into a database consisting of annotated ictal video-EEG recordings into a structured form that is suitable for statistical analysis as well as for analysis of sequence patterns. The contribution will describe the SW tool ASTEP we have designed and developed for this purpose. Some properties of the resulting database will be demonstrated, namely how a seizure is described as a sequence of considered ictal signs complemented by detailed information on timing, duration, repetition and mode of appearance of these signs. Finally, some preliminary results will be reported.

Contribution ID: 293
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

Development of a cardiopulmonary function monitoring system in patient with spinal cord injury using non-intrusive measurements in bed and bathtub

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The daily cardiopulmonary function monitoring would be helpful for the early recognition of abnormal cardiac beats and respiratory disorder. However, the continuous use of commercially available devices becomes cumbersome for patient with spinal cord injury, because of the need to attach biological sensors to his/her body as well as to operate the devices. This study is concerned with the initial attempt to evaluate the cardiac beat and the respiration in bed, and an electrocardiogram (ECG) in bathtub using a non-intrusive monitoring system. The capacitance-sensitive pressure sensor (Custom-order) could be located under the mattress preventing bedsore. The pressure is changed in accordance with the respiration (0.1~0.5 Hz) and the cardiac beating (5~20 Hz) and thus such information could be detected by an appropriate digital filter. Two electrodes were also fixed to the bathtub wall, near the bather's right and left blade bone. The potential difference between these two electrodes, similar to the bipolar lead-II ECG, was amplified to obtain raw signal inclusive of ECG/QRS components (K. Motoi, et al, Biomed. Eng. Online, 2017). Using these cardiopulmonary data, the increase of cardiac beating and respiratory instabilities through the analysis of spectral ranges of each raw signal. The pulse and respiratory rates obtained by the bed and bathtub system and by the conventional direct method were agreed well with each other. As the medical assessment, the central apnea and the effectiveness of phlegm expulsion care were successfully evaluated in patients (55 and 74 yrs.) with spinal cord injury using the bed-installed system. In another patient (24 yrs.), the fluctuations of the R-R intervals due to the thermal effect and water pressure on his body was also observed in bathtub system. Future investigation will be needed such as the availability in more participants and the development of the alert system for the health condition.

Contribution ID: 522
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

Modeling biological data using dynamic bayesian networks for oral squamous cell carcinoma classification

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We propose a computational approach for modeling the progression of Oral Squamous Cell Carcinoma (OSCC) through Dynamic Bayesian Network (DBN) models [1]. RNA-Seq transcriptomics data, available from public functional genomics data repositories, are exploited to find genes related to disease progression (i.e. recurrence or no recurrence). Our primary aim is to perform a complete upstream analysis based on the differentially expressed genes identified. More specifically, a search for putative transcription factor binding sites (TFBSs), in the promoters of the input gene set, as well as an analysis of the pathways of the suggested transcription factors is conducted. Activities of transcription factors which are regulated by upstream signaling cascades are further discovered. These converge in certain nodes, representing molecules which are potential master regulators of OSCC progression. The resulting gene list is further exploited for the inference of their causal relationships and for disease classification in terms of DBN models. The structure and the parameters of the models are defined subsequently, revealing the patient status during the follow-up period after surgery.
The objectives of the proposed methodology are to: (i) accurately estimate OSCC progression, and (ii) provide better insights into the regulatory mechanisms of the disease. Moreover, we can conjecture about the interactions among genes based on the inferred network models. The

proposed approach implies that the resulting master regulatory molecules along with the differentially expressed genes extracted, can be considered as new targets, and are candidates for further experimental and in silico validations.

References

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Contribution ID: 538

3. Information Technology in Healthcare

03.07. Decision support systems, and tools in healthcare

A novel concept of the management of coronary artery disease patients based on machine learning risk stratification and computational biomechanics

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Coronary artery disease (CAD) is one of the most common causes of death in western societies. SMARTool project proposes a new concept for the risk stratification, diagnosis, prediction and treatment of CAD. Retrospective and prospective data (clinical, biohumoral, computed tomography coronary angiography (CTCA) imaging, omics, lipidomics, inflammatory and exposome) have been collected from ~250 patients. The proposed patient risk stratification, relying on machine learning analysis of non-imaging data, discriminates low (Class I) and medium-to-high risk (Class II) patients, with the latter category indicating the need for CTCA imaging. The CAD diagnosis module is based on the 3D reconstruction and automatic blood flow dynamics of the coronary arteries, and the non-invasive estimation of smartFFR, an index correlated with invasively measured fractional flow reserve (FFR). CAD prediction is based on complex computational models of plaque growth considering the blood rheology, the lipoproteins transport and the major mechanisms of plaque growth, such as the inflammation and the foam cells formation. Finally, the treatment module is based on the simulation of virtual stent deployment. Preliminary analysis of 101 patients yielded an overall accuracy of 85.2% with the sensitivity of Class II reaching 98%. The reconstruction methodology is validated against intravascular ultrasound data and the correlation of the geometry derived metrics such as the degree of stenosis, minimal lumen area, minimal lumen diameter, plaque burden are 0.79, 0.85, 0.81 and 0.75, respectively. SmartFFR has been validated compared to invasively measured FFR with a correlation coefficient of 0.90. Plaque growth modelling demonstrates that the inclusion of variables such as the macrophages and foam cells concentrations can increase to 75% the prediction accuracy of regions prone to plaque formation.

Contribution ID: 618

3. Information Technology in Healthcare

03.07. Decision support systems, and tools in healthcare

TERMOPLANTE-IR Intraoperative DICOM Video Documentation

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TERMOPLANTE is an original instrument designed to record thermal and visual images during surgical procedures. The interactive features allow to create both paper headed (PDF) or Electronic Clinical Record documents in CDA format compatible with HL7. TERMOPLANTE-IR is able to determine an approximation of the temperature of parts of the images, as evidence of re vascularization in case of organ transplant, inflammation during critical moments of the procedure, and in all case as an additional document for the record.
Infrared cameras are mounted in the head lamp handle (cialytic illumination).
The images are captured and stored in DICOM format. The CDA files and the identification of patients follow the national recommendation of the SALUD.UY program, to allow national semantic interoperability of medical information systems

Contribution ID: 663
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

An interpretable data-driven approach with application to non-exercise based cardiorespiratory fitness stratification

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Objectives: The continued exploration of clinically relevant predictive models continues to be an important pursuit. The aim of the current study was to develop a data-driven model, based on computational intelligence techniques, to predict the maximum oxygen consumption as a measure to be used in cardiorespiratory fitness stratification. While the maximum oxygen consumption is a direct mark of the cardiorespiratory fitness, several studies have also confirmed it as a powerful predictor of risk for adverse outcomes, such as hypertension, obesity, and diabetes. Therefore, the existence of simple and accurate models, establishing an alternative to standard cardiopulmonary exercise tests, with the potential to be employed in the stratification of the general population in daily clinical practice, would be of major importance.
Methods: The primary hypothesis to be explored in this work is that individuals with similar characteristics present similar cardiorespiratory fitness levels. Therefore, this work addresses the development of data-driven stratification models able to learn distinct groups (classes) of subjects assessing the similarity between characterizing variables. Moreover, the stratification scheme should permit the definition of interpretable models that characterize the distinct subjects, aligned

with the clinical evidence. While increasing clinician confidence, the extracted information can be used to complement clinical evidence.
Results and conclusions: The models' performance was evaluated using the "FRIEND - Fitness Registry and the Importance of Exercise: The National Data Base". A subset of N=10887 healthy individuals was employed being the proposed cluster approach compared with the traditional Wasserman/Hansen equations. Accuracy (geometric mean) results show the superiority of the proposed approach in the prediction of maximum oxygen consumption. While presenting higher accuracy results, clustering approach can be seen as a valid alternative to traditional models mainly due to their modularity, robustness, capacity do deal with non-balance data and to extract meaningful information from available clinical datasets.

Contribution ID: 691
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

MULTISAB: A web platform for analysis of multivariate heterogeneous biomedical time-series

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There is a growing need for efficient and accurate biomedical software in healthcare community. In this paper, we present MULTISAB, a web platform whose goal is to provide users with detailed analysis capabilities for heterogeneous biomedical time series. We describe the system architecture, including its subprojects: frontend, backend and processing. Emphasis is placed on the processing subproject, implemented in Java, which incorporates data analysis methods. The subproject is divided into several frameworks: record input handling, preprocessing, signal visualization, general time series features extraction, specific (domain) time series features extraction, expert system recommendations, data mining, and reporting. Common signal features extraction framework includes a great number of features in time (both linear and nonlinear), frequency and time-frequency domain. Currently, domain specific frameworks for heart rate variability, ECG and EEG feature extraction are supported, which also include preprocessing techniques for noise reduction and detection methods for characteristic waveforms (like QRS complexes, P and T waves in ECG). Parallelization is implemented for feature extraction to increase performance. It is realized using multithreading on several levels: for multiple records, traces, and segments. Expert system is implemented, which provides automatic recommendation of the set of significant expert features that should be extracted from the analyzed signals, depending on the analysis scenario. The expert system, apart from the role in recommending features, can also participate in automatic diagnosis, after the features are extracted. Current expert system prototype contains diagnostic rules for acute myocardial ischemia, based on medical guidelines. Data mining framework contains dimensionality reduction methods and machine learning classifiers used to construct accurate and interpretable disorder models. A report is produced at the end of the process using openly available libraries. The platform includes best practices from medicine, biomedical engineering, and computer science in order to deliver detailed biomedical time series analysis services to its users.

Contribution ID: 819
3. Information Technology in Healthcare

03.07. Decision support systems, and tools in healthcare

t-SNE applied to discriminate healthy individuals from those with Parkinson's disease executing motor tasks detected by non-contact capacitive sensors

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The diagnosis and evaluation of Parkinson's disease (PD) is a task that has been performed through clinical evaluation and subjective scales. Over the years several studies have reported results and technologies with the purpose of making the follow-up of PD more objective. Usually, in the objective evaluation, inertial and electromyographic sensors are employed for recording movement and muscular activation. A major challenge that exists in the area is related to the monitoring of the technological horizon, in order to identify and incorporate new technologies and methods that can be used for the evaluation of PD. In this perspective, it was proposed in this research the use of non-contact capacitive sensors to record six motor activities of the hand and wrist (i.e., rest, pose against gravity, radial deviation, ulnar deviation, flexion and extension). Another identified challenge is related to the correct classification of individuals with PD. To accomplish this, it makes necessary the use of tools for signal processing and machine learning. In this study, features related to amplitude, frequency and variability of the signal were estimated and then combined by means of t-Distributed Stochastic Neighbor Embedding (t-SNE), which is an innovative tool for dimensionality reduction and visualization of information. Experimental data were collected from groups of neurologically healthy individuals and those with PD. The use of t-SNE allowed for the visualization of data on a two-dimensional space and improved the performance of classifiers responsible for the discrimination between groups. When compared to Sammon's mapping and PCA, classification success rate based on t-SNE was 17% higher. The use of non-contact capacitive sensors introduces an innovative way to measure voluntary and involuntary movements. Furthermore, the application of t-SNE showed to be a successful alternative tool to traditional methods employed in the discrimination of healthy individuals from those with PD.

Contribution ID: 987
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

A gait character analyzing system for osteoarthritis pre-diagnosis using RGB-D camera and supervised classifier

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The gait-related disease, such as osteoarthritis (OA) is a crippling disease which is the most prevalent form of arthritis in the elderly with an incidence rate of more than 50%. In today's clinical diagnosing, the physicians always judge and record the gait of a patient qualitatively. Therefore, a cheap, easy-to-use gait analyzing system is important to achieve a quantified description and recording for both newly diagnosed patients and the follow-up patients. This study proposed an accurate gait analysis method by using RGB-D camera and supervised classifier. Firstly, we set up a gait assessment framework for OA patients using the RGB-D camera; design a joint data acquisition software to build a clinical setting. Secondly, the joint data of both patients and healthy

controls from the sensor are analyzed to acquire the quantitative gait parameters. Finally, a supervised classifier is trained on the gait parameters of OA patients to help automatically diagnosis the gait anomalies. Experimental results demonstrated that significant differences existed in the gait parameters such as knee angle changes between OA patient and healthy controls, and the automatic diagnosis based on gait parameters was accurate. Therefore, our study offers a scientific approach for quantitative, non-interactive and low-cost analysis of the gait, which can facilitate the diagnosis and treatment of the gait-related disease.

Contribution ID: 1104
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

A multicriteria decision making system for setting priorities

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The demand for improvement on the quality and cost control in health care stimulate the utilisation of the Multiple Criteria Decision Making (MCDM) approach, which is a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision making .
The aim of this paper was to develop a user-friendly multiple criteria decision making support system in order to facilitate the application of a MCDM method by decision makers.
The system was developed in Java and compares alternatives (i.e., technologies or projects) by a single or a group of individuals with a set of criteria evaluated by means of an ordinal or numeric scale. An ordinal scale is used to set the weights for each criterion. Then a MCDM method, known as TODIM (Tomada de Decisão Interativa Multicritério, in Portuguese), aggregates the values attributed to each alternative for each criterion in order to obtain a ranking of the alternatives for each individual. Finally, some fuzzy aggregation methods are applied in order to reach a group decision. The system was applied to set priority to emerging medicines for Horizon Scanning in the Brazilian National Health System. The preferences of eight stakeholders, members of a National Committee for Health Technology Incorporation, based on seven criteria, were obtained for three oncological medicine alternatives.
Besides allowing the decision makers to set the scenario of the priority setting process (specification of alternatives, criteria, evaluators and criteria scales), the system shows all the intermediate steps of the decision process, and how each individual preferences are formed. Through its output, it is possible, for instance, to identify patterns in the individual preferences, the most influential criteria, and perform sensitivity analysis in order to show how the outcome is sensitive to changes in the alternatives' evaluations. This way the system brings transparency to the decision making process.

Contribution ID: 1129
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

A multiple-predictor approach to blood glucose level prediction for type 1 diabetes

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Blood glucose prediction plays a vital role in preventing complications related to diabetes mellitus type 1, supporting physicians in their clinical decisions and motivating diabetics to improve their everyday life. Several algorithms, such as mathematical models or neural networks, have been proposed for blood glucose prediction. It is a fact that every algorithm has its own subject range (i.e. one algorithm might work well for one patient but poorly for another or one might be able to work with a small sample of data while another needs a bigger sample).
An approach of combining several blood glucose prediction models is proposed. The main idea of this framework is that an adaptive weight is given to each algorithm depending on the measured prediction error. This approach can be applied to combine any blood glucose level prediction algorithms. As an example, the proposed method was used to combine an autoregressive model with exogenous inputs (ARX), a robust ARX model using Huber weight function (ROBUST/ARX) and a support vector regression (SVR).
The multiple-predictor was compared with these three prediction algorithms on the continuous glucose monitoring system (CGMS) and insulin pump readings of one type 1 diabetic patient for one month; the CGMS readings included blood glucose levels and insulin pump readings provided information about the long-lasting and short-lasting insulin dosages. The algorithms were evaluated in terms of root-mean-square error (RMSE) and Clarke error-grid analysis (CEG).
For one hour ahead, the RMSE for the multiple-predictor is equal to 33.87 mg/dl while for ARX, ROBUST/ARX, SVR is 40.90, 38.55, 38.19 mg/dl respectively. Thus, we conclude that the proposed multiple-predictor can give more reliable results and should be used in blood glucose prediction. Future work could be focused on trying this combined predictor with different models and neural networks in order to improve the results.

Contribution ID: 1233
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

Technology solution for treatment and planning of teeth included orthodontic treatment

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The Additive Manufacture (MA), actually is used aiming the production of small prototypes, until a recent application in the field of Dentistry, intended for the planning, simulation, testing and surgery planning and other dental procedures. Some orthodontic treatments are endowed with levels of difficulty and require dexterity of the highest quality, due mainly to the lack of predictability in the treatment, not allowing a precise and direct plan for the case addressed. Among the most recurrent surgical procedures in this scenario, it is the canine tooth traction surgery included. A situation that occurs frequently during adolescence, requiring a great deal of inference from the responsible professional, that if isn't treated in time, may compromise the reorganization of other teeth and bring irremediable sequelae in long term. In this context, this research aimed to develop a technology solution for orthodontic planning and treatment of included teeth, where clinical cases were used in which it was indicated the surgery of traction and subsequent alignment of canine teeth included. Free and recent software were analyzed that offered the potential to improve the planning process and subsequent treatment through the creation of a biomodel to serve as the basis of the decisions of the surgeon and orthodontists acting in the correction of the problem. In this way the present paper presents a process of software use, which allows the end user to have a free manipulation on the images in the pre-prototyping phase, thus generating a biomodel that carries beyond the visual load obtained through the treatment of DICOM images, the trajectory traversed by the tooth during the surgery, allowing also a virtual simulation of the surgery.

Contribution ID: 1262
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

Design of a smart multimodal earthquake response mobile application

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Indonesia is located in the Pacific Ring of fire, putting it under constant risk of natural disasters such as volcanic eruptions, earthquakes, and tsunamis. Earthquakes are one of the biggest threat of natural disasters in Indonesia and can strike anytime in any area. A key example is the 2004 Aceh earthquake, which caused a large tsunami, killing more than 160,000 people and destroyed more than 200 shops and homes. While Indonesia has significantly improved its disaster mitigation systems in the past decade, problems remain. Seismological stations are still relatively few and in between, community readiness and resilience for earthquakes remains low, and response activities are often hampered by lack of equipment, such as for finding potential survivors trapped in rubble. In order to help alleviate these issues, this paper describes the design of a smart multimodal earthquake response mobile application. The proposed system has four main functionalities, namely (1) broadcast of earthquake alert to mobile phones from the local earthquake measurement centre, (2) smart voice activated interactive guide to guide community members on how to react to an earthquake event and arrive to a safe place based on their current situation, (3) A system to search for trapped survivors based on Bluetooth and wifi hotspot emitted by survivors, and (4) recording of earthquake waves based on mobile phone accelerators to be used to build a more granular geospatial database on earthquake features. The system implements machine learning algorithm, utilizes voice, picture and text activated interface to match any situation's need, and basic augmented reality to help guide users to a safe place.

Contribution ID: 1348
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

Design of a noninvasive continuous blood pressure monitoring device

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The aim of this paper presents a design of a noninvasive continuous blood pressure monitoring device. It is made of a small air-trapped cylindrical container, and a pressure sensor is installed inside. The acquired analog signal is sampled at 200 Hz and 10 bits resolution by Simblee that small microcontroller and using wireless communication. The waveform is calibrated with the known values from the commercial cuff blood pressure monitor equipment and real-time displayed on the computer.

Contribution ID: 1464
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

Internet of Things and eHealth towards early detection of cardiometabolic diseases

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Internet of Things (IoT) and eHealth is a conglomerate of technologies that provides the platform to redefine the traditional healthcare paradigms. Especially in the field of cardiometabolic diseases, early detection followed by efficient treatment is a key strategy to deal with such diseases. Considering lifestyle data has a significant role IoT and eHealth clubbed with data analytics holds the potential to improve the efficiency in predicting cardiometabolic diseases, thereby facilitating early detection and treatment. Taking the perspective to the next level, the prevention could be even more comprehensive thanks to the IoT-based systems, considering the aspects of diet and medication within the same treatment chain. On the other hand, the IoT-eHealth approach extends the reach of healthcare from medical institutions to right into people's home. Physiological data captured using IoT devices and remotely sent to the medical personnel could be analyzed for better visualization and remote treatment of cardiometabolic diseases. Also, this leads to the possibility of determining newer patterns in the physiological conditions of people. By identifying the most impactful parameters, this approach performs the clustering of people into specific risk groups which helps the medical personnel by provising a clicnical decision support system to assess the big picture of the risks in a particular population. On a whole, IoT-based treatment for cardiometabolic disease stands out as a major breakthrough in revolutionizing the healthcare and progressing towards the goal of dealing cardiovascular diseases as highest cause of deaths in the world.

Contribution ID: 1749
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

SIRA-HIV: a tool to analyze next-generation sequencing data for HIV-1 drug resistance

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New DNA sequencing techniques, such as next-generation sequencing (NGS), have been used in HIV genotypic resistance assays to identify HIV-1 drug resistance mutations present at low frequencies not detectable by current HIV-1 genotyping. However, evaluating this data requires an extensive knowledge of bioinformatics and programming commands, which limits the number of studies. Here we propose a user-friendly system to analyze raw NGS data from HIV+ patient samples to identify amino acid variants and HIV susceptibility to antiretrovirals (ARV). We used the package Shiny from R software to implement the interface and the Segminator II for mapping and alignment of viral data. Four genotypic resistance interpretation algorithms were implemented in R: the French National Agency for AIDS Research (ANRS), Stanford HIV Reverse Transcriptase and Protease Sequence Database (HIVdb), Rega Institute (Rega) and the Brazilian Network for HIV-1 Genotyping (Brazilian Algorithm). They were incorporated into the system to classify the HIV susceptibility. The environment, called SIRA-HIV, performs an extensive evaluation of the NGS data to three regions of HIV-1 genome: protease, reverse transcriptase, and integrase. As output, SIRA-HIV provides a list of amino acids and their frequencies found in the regions analyzed, and the HIV-1 resistance classification to ARVs according to two levels of amino acid frequency (>1%

and >20%). When all variants with a frequency greater than 1% are considered, the impact of minority resistant mutations is taken into account. SIRA-HIV can be a promising aid system focused on NGS data analysis, allowing clinicians and laboratories to characterize HIV-1 population and have access to levels of HIV-1 susceptibility to ARVs. The program can help in better decision making regarding the medicines to be administered to each patient, providing benefits to people living with HIV.

Contribution ID: 1802
3. Information Technology in Healthcare
03.07. Decision support systems, and tools in healthcare

An individual patient outcome tool for joint replacement patients

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Patient specific forecasting tools are seen as an essential tool for future improvement of healthcare. Recently there has been a move to utilize information contained within national arthroplasty registries to forecast outcome of individual patients. However, the data they currently contain is insufficient. This has lead to an effort to combine data with other quality registries or genomic data. Surprisingly, the use of fine grained data available preoperatively or at routine follow-up has not been fully exploited. This includes clinical assessments, x-rays and biochemical markers. The major reason for this is access to information. This study outlines a method to integrate existing data sources to allow predictive models.
The Bergen Implant Retrieval Centre collects fine grained data on hip and knee arthroplasty in Norway. Typically collection is limited to failed implants. However there is a lack of data on well-functioning implants to act as controls in development of prediction models. Existing randomized clinical trials act as a source of high quality information on well-functioning implants. Combining these sources allows case-control studies to be initiated.
To test the proposed architecture a pilot system was implemented based on a logistic regression model previously reported. This combined data from 32 failed cases and 43 controls. Regression coefficients for gender, BMI, implant position, and bone cement thickness were computed. A patient specific survival estimate was computed by adjusting the survival estimate for overall population, which has been previously published by the Norwegian arthroplasty registry.
This study has explored the possibility of using web technologies to define a platform that would integrate existing data sources with minimal extra burden on the patient and the healthcare system. This provides a promising method to implement prediction of pre-operative and post-operative follow-up. Future steps will include full implementation and testing of the system to predict individualized patient outcomes.

Contribution ID: 412
3. Information Technology in Healthcare
03.08. Electronic patient/medical/health records

Task-based approach guidelines to enhance data visualization in the Kenya national health data warehouse

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Simple charts are a popular way to representing data in various sectors of the economy. Despite the health sector following suit, it still lags behind in development of health data visualization tools due to the complex nature of health data. Furthermore, due to the volume, velocity and veracity of health data consolidated from various sources, representing it in a way that promotes various aspects of human interaction becomes even more challenging. With the plethora of research on improving visualization of integrated health data, focus is shifting from simple charts to more innovative ways of data representation. In addition, over reliance of simple charts while ignoring cognitive aspects may deny users the opportunity to gain numerous insights, pattern trends and exploration of various facets of data. Despite numerous publications on optimal approaches to improving health data visualization, there is need for an in depth exploration on aligning visualizations to tasks, context, and appropriate cognition aspects. This paper thus adopts a task-based approach, guided by proposed frameworks that explore novel design approaches and human cognition, in order to formulate guidelines. Hence, we identify two salient tasks performed, Kenya National Health Data Warehouse (KNHDW) and propose guidelines on use of cost effective, sophisticated data visualizations that leverage cognitive aspects and promote efficacy of tasks.

Contribution ID: 421
3. Information Technology in Healthcare
03.08. Electronic patient/medical/health records

Digitalisation of pacemaker follow-ups with the use of a generic interface

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The presentation of clinical use of a digitalisation system that collects, stores and sorts relevant clinical data from various device manufacturers - the open source aproach, and the desirability as well as practicality of creating new standards for as highly specialized fields as cardiological implant followups.
The presented service associated and provided by the device represents a model aproach of an open and evolving telescoping approach to development, with incremental improvements from user feedback that allow for optimisation of the digital storage and retrieval of time critical information in an organized fashion, as well as continual monitoring of patients who have undergone device replacement. This permanent storage of data that would otherwise be difficult to archive in a comprehensive database allows the use of powerful search tools for data mining of patients involved in clinical studies, as well as significant progress in digitalisation of the entire patient record into a HIS.

Contribution ID: 576
3. Information Technology in Healthcare
03.08. Electronic patient/medical/health records

Architecture and organization of a computational system for the management of data from individuals with Parkinson's disease

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The volume of data related to the monitoring of wellbeing and health of individuals, and the number of devices used to perform tests in patients remotely, have grown substantially. Following this trend, over the past years we have seen an increase in the number of studies reporting the monitoring of the cardinal signs (e.g., tremor, stiffness and bradykinesia) of Parkinson's disease (PD) during prolonged activities for hours or days. The characterization of the individual with PD is made by patient history, exams and response to medication. A major challenge in the area is to objectively monitor the progress of the disorder so that treatments can be customized. In addition, patients suffer from the lack of predictive information regarding their health condition. In this context, customized systems, i.e., database, that can group information from the motor symptoms of PD are of paramount relevance. By using such systems, one can track the progress of the disorder and more importantly can use data mining for seeking hidden patterns in the data. In order to contribute to the organization and management of information obtained from patients with PD this research proposed the architecture and organization of a system so-called SIDABI (Integrated Biomedical Data System). SIDABI is a multiplatform system with customized user control, modules and permissions to manipulate information on each screen. This system has three modules, being the first for storing and organizing information from data collection with distinct types of data; the second for the management of information from the application of the Unified Parkinson’s Disease Rating Scale; and the third for promoting technological innovation in the area. The union of these three modules in a single system can be part of the clinical routine of hospitals and research centers dedicated to the understanding, treatment and research in PD.

Contribution ID: 961
3. Information Technology in Healthcare
03.08. Electronic patient/medical/health records

Propose a model of multimedia electronic patient record system for Sri Lankan public health sector

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Multimedia electronic patient record systems are not a new idea in the world, but in Sri Lankan health sector it is a new idea. Multimedia electronic patient record systems is complete online patient data, including traditional medical chart information and clinical images, are essential to providing good health care. A complete multimedia electronic patient record system can improve patient care, promote safe practice, and enhance communication between patients and multiple providers, reducing the risk of error. Currently there is no available any multimedia electronic patient record system in Sri Lankan health sector. It is possible to analyze current requirement of Sri Lankan health sector and propose a model of multimedia electronic patient record system for Sri Lankan health sector. A questionnaire survey, mathematical and statistical analysis method is used in this investigation to analyze an appropriate model of multimedia electronic patient record system. 30 hospitals were responded for this survey and out of 30 hospitals 21 were government and 9 were private hospitals. Using a statistical method it is possible to propose a model of multimedia electronic patient record system for health sector of Sri Lanka and this survey reveals major barriers and suggestions which have to be implemented in order to achieve an efficient electronic patient record system for Sri Lankan health sector.

Contribution ID: 1155
3. Information Technology in Healthcare
03.08. Electronic patient/medical/health records

Electronic delivery book: structured database enables analysis of perinatal risk factors

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The Electronic Delivery Book (EDB), an electronic information system, was developed in cooperation with obstetricians, midwives, and neonatologists from the University Hospital in Brno. The main aim was to create structured electronic documentation of selected delivery-related parameters based on the existing paper-based documentation. The system contains information from the different stages of delivery: parameters of the pregnancy, medications/interventions during the birth, outcome measures for the newborn(s), and primary attributes from neonatology. The EDB also allows to create overviews and basic statistics for everyday clinical needs and offers structured data for retrospective as well as prospective studies.
One of the first results based on data collected using the EDB was the analysis aimed at identification of potential risk factors for low umbilical cord artery pH in term, singleton pregnancies. The data selected from EDB represents a basis for the retrospective case-control study. Cases were deliveries characterized by umbilical cord artery pH ≤ 7.05. Controls were with no sign of hypoxia. In the database of 10637 deliveries, collected between 2014 and 2015 at the University Hospital in Brno, we identified 99 cases. Univariate analysis of clinical features was performed. The following risk factors were associated with low pH: the length of the first stage (odds ratio (OR) 1.40; 95% CI 1.04 - 1.89) and the length of the second stage of labor (OR 2.86; 1.70 - 4.81), primipara (OR 2.99; 1.90 - 4.71) and meconium stained fluid (OR 1.60; 1.07 - 2.38).
Clinical conclusion: among the risk factors increase the chance of low umbilical cord artery pH at term, excessive length of the first and second stage of labor, parity, and meconium stained fluid was identified.
Technical conclusion: EDB substantially improves delivery of clinical data-analysis based on structured data which would be almost impossible with the HIS database.

Contribution ID: 1336
3. Information Technology in Healthcare
03.08. Electronic patient/medical/health records

Vital sign monitoring using an ultra-wideband microwave system

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Vital signs, such as heartbeat rate and respiration rate, are the important indicators of a person's health. Regularly checking of these functions is very important for preventing or monitoring medical problems.
The devices available on the market for vital signs detection generally have the drawbacks of being costly and uncomfortable, which has led to the research of new monitoring solutions. In the last few years, many different types of sensors have been proposed and investigated for vital sign monitoring, and depending on the manner of operation, these sensors could be classified as contact and non-contact types. In contrast with a contact sensor which needs to be attached to the skin during measurement, a contactless sensor is more suitable for long-term monitoring. One of the potential technologies for non-contact vital signs monitoring is using microwaves.
Microwave method is safe, comfortable and cost effective, and it is therefore very suitable for long-term monitoring. Both continuous wave (CW) and impulse radar ultra-wideband (IR-UWB)

approaches have been investigated. In this work, we investigate on using a different type of UWB microwave system for vital sign monitoring. In comparison with a conventional IR-UWB system, which sends out an ultra-short pulse, this system uses a pseudo random binary sequence (PRBS) as the transmitted signal in order to achieve higher measurement sensitivity.
The investigation were done for both a robot which imitates the chest movement due to respiration and heartbeat and human body. The results show that both the respiration rate and heartbeat rate are detectable using the developed system.

Contribution ID: 1381
3. Information Technology in Healthcare
03.08. Electronic patient/medical/health records

Usability of electronic patient records for assessment and care planning in nursing homes

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Background: Nursing homes are more frequently turning to the electronic patient record (EPR) to manage documentation. Potential benefits associated with EPR include the storage of longitudinal information, interoperability, and improved documentation quality. However, the uptake of EPR in nursing homes has varied considerably across countries, which has been associated with the incompatibility of some EPR systems with this environment. Furthermore, the suitability of EPR for planning dementia care is largely unknown.
Objective: This study aims to produce recommendations for the future development of EPR systems for use in the assessment and care planning for people with dementia in nursing homes.
Methods: Case studies of four nursing homes using EPR in Belgium, Czech Republic, Spain and the UK will be conducted. There are two elements to the study: (i) the contextual inquiry method will be employed to explore usability issues with different types of end users. Data will be analysed using qualitative content analysis; (ii) the electronic care plans used in each of the homes will be compared with best practice guidelines for dementia care planning in order to explore the extent to which they include aspects of care that are relevant for people with dementia.
Results: Primary data collection will be ongoing throughout 2018, and results will form the basis of recommendations for future EPR development.
Conclusion: It is expected that results will lead to improved design of EPR for use in nursing homes, specifically in the assessment and care planning for people with dementia.

Contribution ID: 1479
3. Information Technology in Healthcare
03.09. Information quality, privacy, security, and ethics

Raw data access and data security of contemporary mobile sensor devices

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Mobile sensor devices have made a great leap in terms of popularity and proliferation amongst the public in recent years, being used for a wide variety of lifestyle, fitness and health applications. This makes them very attractive for scientists and users who are interested in the actual bio and environmental data these devices measure, what they are capable of and their limitations.

However manufacturers like to limit access to such data, storing it on their own private servers, only giving customers access to the results of their often very specific and limited analyses. The underlying filtering methods, algorithms and training sets are virtually never disclosed.
Mobile sensor devices use various Bluetooth-protocols like RFCOMM and GATT to transfer data onto a smartphone or tablet. And there is the crux of the matter: Hardly any of the manufacturers encrypt their connection, because that would take precious processing and battery power as well as more resources in development.
This paper describes how to access raw bio-data on a selection of wearable and stationary sensor devices using nothing but a contemporary Android-smartphone and a PC.
A detailed example of how to access such a device is given. From the combined experience of accessing several mobile sensor devices a generalized approach was formulated. Finally a shortlist of simple methods that should prevent abusive exploits is given in the hope that future devices will show improved data security in particular for health-relevant applications that deal with sensitive information.

Contribution ID: 1496
3. Information Technology in Healthcare
03.09. Information quality, privacy, security, and ethics

It Takes A Team - Building A Collaborative Culture To Manage Risk

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The news media is filled with stories of attacks against healthcare organizations and the security of medical devices. This session will cover the threat landscape for healthcare, particularly in the pharmaceutical and medical device space. The speakers will discuss enterprise risk management and offer case studies and examples to illustrate why creating a collaborative culture is vital to ensure organizations can remain resilient when facing cyber threats.

Contribution ID: 1898
3. Information Technology in Healthcare
03.09. Information quality, privacy, security, and ethics

The KONFIDO ethical framework for eHealth cross-border applications

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The last political goals are centred on solutions to implement a cross-border healthcare in the European Union (EU). In this framework there is a need for secure interoperable eHealth technologies and solutions, including electronic health records (EHRs), electronic prescribing (ePrescription), mobile health (mHealth) devices and applications.
In this context there is a growing demand for tools to assess the ethical impact of personal and medical data exchange. This paper presents the ethical challenges defined during KONFIDO, an EU-funded project (grant agreement no 727528). KONFIDO aims to develop tools and procedures to create a paradigm for secure inner and cross-border exchange of healthcare data in a legal and ethical way at both national and European level. In this project, an ethical framework has been defined considering a set of ethical principles derived from the review of literature and recent EU documents.

After a methodological definition of the KONFIDO ethical framework, a review checklist and an operative flowchart have been produced. The first has been used to assess the architecture design and the latter to detail the patient's informed consent.
The tools were presented to KONFIDO partners involved in the design of the informatics architecture. A list of suggested actions was derived to guarantee that KONFIDO design is ethically compliant.
The final aim of this work is to provide a concrete and practical ethical guidance for developers and healthcare professionals in the broad field of eHealth data exchange.

Contribution ID: 473
3. Information Technology in Healthcare
03.10. Integrated healthcare workflow, systems, applications

Restricted Interest-based adaptation of avatar for interaction with children with Autism Spectrum Disorder

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This article presents a systematic process to develop technological supports for children with Autism Spectrum Disorder (ASD), based on restricted interests. With the information generated from the diagnostic evaluations applied to a group of children with this disorder, were selected avatars that match their preferences. To do this, through software Blender, mobility was added with the aim of being used as a base in the development of therapies that promote the interaction and learning processes of children with ASD. The advantage of basing this adaptation on the analysis of restricted interests consists in the safety of acceptance by children towards their respective avatars, unlike other empirical processes that require an intermediate stage of acceptance. At the end of the article we present an avatar example ready to be animated.

Contribution ID: 1110
3. Information Technology in Healthcare
03.10. Integrated healthcare workflow, systems, applications

Model-based evaluation of integrated care solutions in heart failure treatment

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Demographic developments over the last decades, in particular increased life expectancy and associated rise in chronic diseases, pose growing challenges for public health care systems. New, holistic and personalised methods of care are potential solutions to overcome increasing financial burdens and improve overall treatment outcomes. To evaluate progressions towards new directions in health care, models represent feasible tools to discuss potential advantages, estimate prospective implications and lastly serve a potential basis for decision-making.
This work focuses on a hybrid heart failure model, combining agent based and discrete event methods to simulate and compare conventional, telemonitoring as well as disease management concepts for both inpatient and outpatient care. To form a basis for the low degree of abstraction of the chosen modelling technique, a significant depth of underlying data is essential. Cooperation with Austrian health care and health insurance providers allowed realising the model structure

based on clinical data of roughly 18.000 patients. Each of them is represented as an individual agent that can be traced throughout the simulation runs, logging key events and statistics during the course of treatment. NYHA class, age, gender, ATC-based medication, admissions to standard and intensive care, individual medical procedures, comorbidities and different support systems are integrated to assess state of health and treatment outcomes along the clinical pathway. Based on the patients' profile, probability density functions are derived to express transition states within the model.
Results show that benefits and limitations of mentioned concepts of care strongly correlate with the patient collective simulated, thus underlining the importance of distinct selection criteria for personalised methods. The established model represents a comprehensive tool to evaluate integrated care solutions in heart failure treatment and thus contributes to the formulation of holistic approaches in health care.

Contribution ID: 1245
3. Information Technology in Healthcare
03.10. Integrated healthcare workflow, systems, applications

A Process Modelling and Analytic Hierarchy Process Approach to Investigate the Potential of the IoT in Health Services

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Over the last 20 years, patients are concerned more often with their personal well-being decisions, which indicate a shift from curing medical problems to preventing health problems. Therefore, e-health should not focus merely on building cost-effective, convenient, accessible and quality healthcare solutions. E-health's ultimate vision is to empower stakeholders, such as patients, families and societies to engage in the decision-making and management of their own health status. The proliferation of the Internet of Things (IoT) is expected to change the way that health services are designed, implemented and delivered. However, little research has been done to investigate the IoT potential in the health sector. The IoT represents a significant technological field with enormous implications for both patients and health organisations. This paper combines process modelling and the Analytic Hierarchy Process (AHP) multicriteria analysis method in order to investigate and assess the potential of the IoT in health services quality. First, this paper, utilises process modelling in order to capture the workflow of delivering health services to patients. It suggests that workflow modelling provides the conceptual foundation for the systematic consideration of the opportunities stemming from the IoT deployment. Further, this paper utilises the (AHP), in order to measure the potential of the IoT opportunities that can be identified along the workflow, in terms of its contribution to health services quality. An AHP questionnaire was structured and data was collected and analysed from a group health care experts. The results advocate the wide use of IoT in health services and argue for the applicability of the suggested approach as a means for medical organisations to design and deliver quality health services.

Contribution ID: 95
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

The influence of the voice acquisition method to the mental health state estimation using voice

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Mental health disorder has become a social problem, and its countermeasures are required. The previous work of the authors, developed the MIMOSYS(Mind monitoring system) algorithm to evaluate the mental health state using voice. The mental health state is presumed from the aspect of the emotions contained in the voice, but since the emotions changeable delicately, influence to emotions will be concerned due to voice acquisition methods such as natural conversation with the opponent or reading of fixed phrase without the opponent.
In this research, we aim to evaluate the influence of the voice acquisition method to the emotion and mental health state estimation by MIMOSYS using voice.
In the experiments, we collected emotions and MIMOSYS analysis results estimated from call voice and reading of fixed phrases from the application for over 2 weeks. In addition, BDI test was carried out to evaluate subjective depression level at the beginning of the experiment period. This research was approved by the Research Ethics Review Committee. Then it was carried out with the agreement of the subject.
In the evaluation, we analyzed call voice and reading of fixed phrases, for the subjects in the normal range (0 to 9) as the result of the BDI test.
As a result, compared to call voice, expression of emotions was suppressed in the reading of fixed phrase, and the analysis result by MIMOSYS tended to be lower. Consequently, when measuring the state of mental health from voice, it was suggested that it was necessary to take measures such as matching voice acquisition methods or correcting estimated result by recording method.

Contribution ID: 389
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

Designing a multiple sclerosis application to support patient self-management

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This paper presents a high-fidelity prototype of a mobile application for patient self-management within the field of Multiple Sclerosis (MS). Its development included low and middle fidelity prototypes which were based on the information needs inquired form the potential user groups and their reflection on publicly available applications. The aim has been to design an application to suit Norwegian user groups. msHealth application has four selected modules: Diary module, Physical activity module, Visualisation module, and To-do list.
Two medical experts were interviewed at the Haukeland University hospital in Bergen, Norway. The semi-structured interview consisted of two parts; one with questions on which the experts could elaborate, and one with evaluation of the prototype msHealth using System Usability Scale (SUS). The results have suggested that healthcare personal would be interested in patient data from a mobile diary, and how a patient should plan a day if suffering from symptoms; to name the two most prominent functionalities.
Feedback from medical staff using SUS was promising, as well. The evaluation provided feedback as how to modify the prototype to have a personal tone by encouraging the user to plan desired activities, and learn how to live with the disease.

All these new functionalities are being implemented to reduce stress, and include the prototype application as a decision support during a patient – physician consultation. This is something that is not being currently practiced in Norway, so the research will attempt to address the potential of the application in patient routine care.

Contribution ID: 818
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

Security mechanism for medical record exchange using hippocratic protocol

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The use of new technologies in healthcare sector is growing and, as a consequence, the security problems using these technologies are increasing. This work began with the study of RFID, NFC and sensor technologies with their applications in the health sector, and it showed that these new technologies have similar hardware characteristics, e.g. low power consumption and low processing power, so a communication protocol based on Hippocratic principles and its standardization was proposed to increase data security when these technologies were used. To evaluate this proposal from a practical point of view, a system based on an application for smartphones with the Android operating system and Wi-Fi as the connection platform to exchange medical records between health personnel and information database of a medical center was developed. For this system it was assumed that the user that controls the relationship between doctors and patient is the patient and that this relationship needs to be established personally, using a smartphone with NFC technology, but may be dissolved by the patient remotely, without interaction with the doctor. Some operative problems were found but the conclusion is that this is a viable solution and that applying the Hippocratic principles is possible to have two levels of security, being the more secure the use of the Hippocratic protocol.

Contribution ID: 1046
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

Computerized Cognitive Assessment System for Dementia Screening Application

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The occurrence of dementia is increasing in an aging, even aged society. According to the previous research reports, early diagnosis and treatment of dementia, the progression of illness for the patient may be slowed down and the cost of care-giving may be also reduced. There are several assessment measures currently applied in clinics, such as MMSE, CDR, CASI, MoCA, etc. However, their common feature is the need of instructors to guide one patient at a time. In addition, most of the tests are based on western culture. In Taiwan area, the hospital visiting rate of dementia patients is very low. This points out the problem that the clinical assessments are not often used for screening. In this study, a game based computerized measure for assisting the assessment of the suspected subjects is developed and its efficacy is discussed. The proposed system is developed and embedded in an interactive game based on Taiwanese culture theme. This system can work on Android and Windows platform, and it includes obtaining the user

background and testing different cognitive domains, including attention, language, memory, visuospatial abilities, executive function and orientation. After implementation, the clinical trial for evaluating its efficacy is performed with informed consent. 50 normal subjects and 50 dementia patients are recruited with IRB approval. From the experimental results, it is demonstrated to be feasible for cognitive assessment with good correlation.

Contribution ID: 1056
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

Evaluating usefulness of new accessible electronic musical instrument for the disabled persons

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We have been developing an accessible electronic musical instrument Cymis (Cyber Musical Instrument with Score) for disabled persons with neural or motor impairments such as cerebral palsy. The purpose of this study was to show usefulness and effectiveness of our developed one. Cymis was composed of a personal computer, a touch screen, a MIDI sound source, and speakers. A pre-programmed musical score was displayed on the touch screen. The player touched displayed note heads in turn and then the piece was performed. In order to demonstrate usefulness of Cymis, we have executed field experiments at a nursing home (capacity: 52 clients (average age 58.6) including 32 cerebral palsy clients) and investigated (1) the accessibility of Cymis, (2) progress in clients' performance and (3) psychological effects of playing the instrument on clients. The accessibility of Cymis was investigated by counting the number of clients who were able to use it and maintain the performance during a certain period. It was shown that 34 clients played it in 2016 and playing period averaged 5.6 years. The performance progress in each client was assessed by examining the performance style. Among 31 clients, 13 showed progress, 17 showed no change, and 1 revealed deterioration in condition. The psychological effects were measured by using our suggested Face Scale. It was shown that clients became happier in 208 performances, showed no changes in 139, and became sadder in 48 for a total of 395 performances by 38 clients. It was shown that Cymis was useful and effective for the disabled persons to maintain or improve their quality of life.

Contribution ID: 1085
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

Design of a multisensory room for older people with neurodegenerative diseases

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Multisensory stimulation in older persons is an effective practice that helps to train the mind and motor skills through elements that make work the senses of the people. Some of the spaces where specialists work the sensory stimulation are the so-called multisensory rooms "Snoezelen". Initially, the use of these rooms was mainly intended for children with learning difficulties, the same that had difficulties to explore their environment. However, in recent years there have been realized investigations of the implementation of these rooms in persons who present cognitive deteriorations of moderated to severely and neurodegenerative pathology as Parkinson's, Dementia, Alzheimer's, Huntington's, Bipolar disorder, between others. This project developed and implemented a Multisensory Black Room for older patients with neurodegenerative diseases and cognitive impairment. Different sensory stimuli were used to help the cognitive and functional sphere of older people. The implemented room has some elements: stairs of colors, star curtain, fiber optic shower, panel of smells and bubble tube. The results indicate that it has been possible to reduce the aggressiveness pattern and to evolve in the functional part (fine-gross motor) and focus the attention that was dispersed in patients with neurodegenerative diseases and cognitive impairment in the early and late stages. In addition, patients improve the relationship with their social and personal environment, since the initiative of the room is to provide an atmosphere of wellness and relaxation, for the patient and the specialist.

Contribution ID: 1158
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

Model-based fusion of mobile sensor data

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Continuous monitoring of individuals’ behaviors and health states is a key component of future proactive and distributed care that will transform current healthcare to precision care tailored to individuals. In this framework, frequent or continuous monitoring will enable inferences of subtle changes in health states as well as optimal just-in-time interventions helping individuals to improve their health behaviors. As a result of the rapid advances in wearable and mobile sensing systems, it is now possible to monitor continuously vital physiological variables as well as behaviors and use these to infer individuals’ health states. A significant limitation to our ability to assess health states and behaviors is the variability and unpredictability contextual and environmental effects that may significantly distort measured data. To mitigate these adverse effects, we have been developing a variety of data science approaches leveraging computational models of the targeted variables and their combinations as well as the distorting influences of context-related variables. In this paper, we describe two techniques for combining information from multiple sensor streams. The first approach involves a traditional approach to data fusion that leverages a Bayesian formulation where the resulting estimates maximize the posterior probability given previous observations constrained by a model of the relevant stochastic sequences. The second, more novel, technique uses contextual data to control the processing of the targeted variables. We illustrate this approach on an example where we estimate heart rate variability from photoplethysmographic measurements generated by a wrist-worn sensor. As is well known, assessment of heart rate using photoplethysmographic measurements is significantly affected by any activity involving wrist movements. Our technique controls the degree of smoothing and cleaning using the data from the accelerometer. We illustrate our approach by processing data from the Microsoft Band 2 and compare it to ECG data collected by a FirstBeat system.

Contribution ID: 1162
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

A mobile app for the self-management of type 1 diabetes as tool for preventing of exercise-associated glycemic imbalances

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mHealth is a growing field of research, concerning the great potentialities of mobile technology as a tool for self-management of chronic conditions. Physical activity greatly influences blood glucose levels, therefore for type 1 diabetes patients is important to adapt their diet and therapy in order to avoid exercise-induced hyperglycemia and hypoglycemia. The later represents one of the major barriers to physical activity and it limits volitional exercise in type 1 diabetes patients. However, there is lack of stand-alone mobile tool that provides the support to the patient in order to perform physical activity and exercise under safe glycaemia levels. Recently, Exercise Carbohydrate Requirement Estimating Software (ECRES) algorithm was proposed to calculate patient-exercise tailored glucose supplement required to maintain safe blood glucose levels during physical activity. The objective of this study was to develop a mobile App which implements an individualized predictive system for blood glucose in type 1 diabetes, depending on exercise strength. Its usability and accuracy were compared to original ECRES estimating software in 15 volunteer subjects. The developed application provides relevant feedback to patients on carbohydrate intake needed to carry out a planned physical activity, in a safe manner. Furthermore, application provides other important features, for self-management of this chronicity, reported in recent literature: entry of blood glucose values, display of diabetes-related data, such as blood glucose readings and their analysis, carbohydrate intake, insulin doses, and easy data export. The application also incorporates food atlas in order to facilitate carbohydrates calculation. The results of the test showed that developed application accurately implements ECRES algorithm and the self-management features. In conclusion, proposed App could be a useful support tool to diabetes type 1 patents. The results should be confirmed in larger clinical study.

Contribution ID: 1168
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

Design of an integrated nutritional and financial literacy application for mother and child in Indonesia

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Indonesia, like many other emerging nations, faces a double burden of mother and child malnutrition, with high rates of both under and over nutrition. This issue is driven by a complex combination of outdated feeding practices, rapid socioeconomic changes and other pressures. Meanwhile, healthcare workers and mothers have limited resources and time, which limits the effectiveness of existing interventions. While many interventions focus on solely the health aspect of this issue, the underlying causes for this problem comes from multiple interconnected sectors, including family financial capabilities. Therefore, this paper proposes the design of a set of mobile based applications that integrate basic individual and community based nutritional and financial practices to support better nutrition for mothers and children. The application focuses its implementation in Community Health Centres (Puskesmas) as an existing community driven infrastructure for mother and child health in Indonesia, and will leverage the existing user base and data of a previously developed, currently operating mobile based application for mother and child health. One application will provide mothers with a simple healthy meal-planning and budgeting

tool adjusted to local conditions and ingredients availability. Another application will provide primary healthcare providers with tools to assist in nutritional communication, education and patient management based on existing health guidelines. This individual based approach is complemented by a community based approach, focusing on leveraging traditional community based activities on the Puskesmas. Examples of these activities include digital facilitation of the traditional arisan (rotating savings) or jimpitan (voluntary community contribution), as well as entrepreneurship or other training and community engagement activities. It is hoped that the implementation of this approach can help alleviate the double burden of mother and child malnutrition in Indonesia, and eventually also in other emerging nations.

Contribution ID: 1211
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

Tailored coaching advice based on dynamic user models

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With chronic disease and conditions associated with aging dominating health care and costs, it is more important than ever to focus on scalable cost-effective solutions for delivering health interventions to the home on a routine basis. The rapid advances in sensor and communications technologies have now made it feasible to incorporate state-of-the-art computational algorithms in providing tailored and timely feedback and recommendations to patients. Our novel coaching platform incorporates real-time sensor data from the home to update our dynamic user model and trigger just-in-time tailored messages for home health interventions in physical exercise, stress management, nutrition, socialization and sleep management. Our sensors include passive infrared motion sensors and contact switches for activity detection, Kinect camera and wearable accelerometry data for physical exercise, heart rate variability and electrodermal activity for stress, pressure mat data for sleep, phone and computer data for socialization, and mobile self-assessment for nutrition. These areas of health management are important for all disease management programs, as well as being critical in the care of the elderly at home. Although we have tested and studied the health modules independently, for long-term lifestyle health management, they are designed to be offered together in incremental steps. With our integrated modular coaching platform we use a dynamic user model to track patient activity, adherence and preferences to deliver just-in-time coaching advice and feedback on performance to both inform and motivate patients in improving their health behaviors.

Contribution ID: 1214
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

135/5000 Design and implementation of a videogame system in Android for rehabilitation of the upper extremities in adult patients

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The present paper is focused on the rehabilitation of patients with Parkinson Disease (PD), through the use of video games that respond to the movements of the player. It is important, to begin reviewing the state of the art, in order to delimit the characteristics of the system. Subsequently, the system was designed and implemented for use with software Unity and Arduino. Finally, the validation tests of the system were performed with patients of the PD and healthy patients.

First of all, a review of the theoretical framework of Parkinson's Disease, rehabilitation, and videogames present today is carried out, analyzing advantages and disadvantages of the different systems existing in the market. Then, the characteristics that the game must fulfill are defined, such as the transmission technologies, methodologies to be implemented, equipment and software that will be used for the design.
Next, the videogame design is done using the Unity software, the same one that allows to export it to the Android platform. The system consists in acquiring patient data using a Bluetooth module and an accelerometer, whose data intervene in the game and are sent wirelessly to the mobile device, for the project were used a cell phone and a Tablet. The "Rehabilitation" application contained PlaneGame with three levels and BallGame with two levels of participation.
Finally, the validation of the system and analysis of results were executed, where the tests are carried out at the Adulto Mayor University. In conclusion, the results at the end of the rehabilitation sessions showed that the developed system improves the motor movements of the upper extremities, which favors raising the life quality of patients

Contribution ID: 1244
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

Wearable cardiorespiratory monitoring system for unobtrusive free-living energy expenditure tracking

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The real-time energy expenditure tracking provides valuable information of the metabolic state and physical activity level. This information will help people in the management of their daily life and exercise, and even in prevention and treatment of many health problem such as obesity and diabetes. The heart rate monitor is often used to estimate the free-living energy expenditure. However, the relationship between heart rate and energy expenditure is rather poor in low intensity exercise and sedentary condition, and can be influenced by several other factors that are irrelevant to physical activity. In this work, we want to introduce combined heart rate and respiration monitoring for more accurate energy expenditure tracking on free living subjects. We have developed a wearable cardiorespiratory monitoring system that is compatible for unobtrusive heart rate measurement and ventilation estimation. The system is based on a garment integrated with textile electrodes for electrocardiograph and impedance pneumography measurements. A pilot experiment has been implemented to proof the concept and explore the character of heart rate and ventilation estimated by our system in relation to energy expenditure. The experiment covered a variety of living, sporting and working scenarios, including different postures, activity intensities, and muscle groups to simulate complex free-living environments and the indirect calorimetry is used as the reference. In the experiment, the ventilation shows a better linearity in relation of the energy expenditure at the low intensity region than the heart rate. Based on the characteristics, a model to combine heart rate and ventilation for energy expenditure estimation is purposed. The combined model shows a significantly lower estimation error than the heart rate only model in the pilot experiment.

Contribution ID: 1660
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

Automatic classification method using machine learning with a single inertial measurement unit for trunk posture category of OWAS

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Low back pain is a prevalent occupational disease. Aiming at preventing occupational diseases, the Ovako Working Posture Analyzing System (OWAS) is used for evaluating working loads. OWAS has a posture category for estimating working load by human visual confirmation. If the posture category of OWAS can be confirmed using sensors, it would theoretically be possible to estimate working loads. There are some systems that automatically classify postures. However, these systems require the use of many sensors or cameras, thus limiting the locations or clothes of users.
In this study, we propose an automatic classification method using a single inertial measurement unit (IMU) for the trunk posture category of OWAS. IMU is worn on the trunk. In addition, the postures are classified by machine learning using 3-axis accelerations and 3-axis angular velocities obtained by IMU. The feature quantities are root mean square values calculated from the time series data of accelerations and angular velocities.
We tested the proposed method on the classification of four motion patterns based on the trunk posture category of OWAS in three young and healthy participants. Our method was able to classify the four motion patterns with an accuracy greater than 0.9. Therefore, the proposed method can be applied in automatic classification systems for evaluating working loads, thereby helping prevent occupational diseases.

Contribution ID: 1752
3. Information Technology in Healthcare
03.11. Personal health systems, patient–centered healthcare services and applications

Comparison of menstrual phases with nocturnal temperature of the Oura ring and oral body temperature at wake-up

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Body temperature is a well-known method to track menstrual cycle due to temperature rise in luteal phase. The expected rise of 0.4˚C following ovulation occur simultaneously with rising progesterone levels [1]. Oral body temperature immediately after wake-up is widely used practical alternative for core body temperature measurements at home. Nowadays wearable sensors such as armbands, bracelets, and earbuds measuring nocturnal temperature have entered fertility tracking industry offering more effortless way to track menstrual cycle.
The aim of this study was to evaluate the capability and accuracy of temperature measurement using the Oura ring sensor (Oura Health, Oulu, Finland). Among other metrics, the ring registers skin temperature every minute. We assessed the association of nocturnal skin temperature provided by the ring and the oral temperature taken immediately after wake-up, and tested the capability of each method to differentiate the follicular (pre-ovulation) and luteal (post-ovulation) phases.

Volunteer women (n=23, age 21-49 years, mean 34.8 years) used the Oura ring around the clock and measured oral temperature in the morning over at least one menstrual cycle. Ovulations were detected by ovulation tests. Menstrual cycle was divided into follicular and luteal phases.
The temperature measured by the ring and the oral temperature readings differed between luteal and follicular phases, the difference being 0.30 ˚C (SD 0.12) for ring ($p<0.001$), and 0.23 ˚C (SD 0.09) for oral temperature ($p<0.001$). Oral and the ring temperatures correlated with a correlation coefficient 0.564 (1039 days, $p<0.001$).
The present findings are promising for detecting fertility related time points in women using wearable ring sensors. Accuracy might be further improved when temperature is accompanied by other metrics determined by the Oura ring and user input.
[1] Baker FC et al., Journal of Physiology 530(3): 565-74, 2001

Contribution ID: 141
3. Information Technology in Healthcare
03.12. Usability and user experience issues with health IT

Present state of outpatient pharmacy information systems in the Czech Republic

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Objective – This paper explores the outpatient pharmacy information systems used in the Czech Republic, describes their functions, market share, users' views, and complexity of the systems.
Methods – Data were collected using communication with producers, survey among pharmacists and testing of the systems.
Results – A total of 12 different outpatient pharmacy information systems from eight different providers are currently used in the Czech Republic. Each of these systems is able to provide necessary support for the pharmacist and is connected to current drug and interaction databases. Every system also cooperates with the Czech e-prescription system. The average list price of a pharmacy information system is 7330 EUR, which puts the market value of such systems in the Czech Republic at 22 million EUR. Czech users are generally satisfied with their systems.
Discussion – Although only scarce data are available from other countries, there seem to be a large variety of outpatient pharmacy information systems in the Czech Republic in comparison to other states. The market value of the systems in the Czech Republic corresponds with findings in literature. For better usage of the systems a better e-prescription system should be introduced.
Conclusions – This is the first study to evaluate Czech outpatient pharmacy information systems. More such studies should be done and published to enable comparison of various eHealth systems.

Contribution ID: 159
3. Information Technology in Healthcare
03.12. Usability and user experience issues with health IT

Improving the usability of mobile electronic data capturing forms in rural Uganda

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Mobile Electronic Data Capturing Forms in healthcare enable easier data collection and the possibility for delivering tailored services in a timely manner. However, many of the developers of such forms, especially those in limited resource countries, do not emphasize usability. Much as they have a general understanding of usability, time-constraining deadlines, a lack of standard procedures of measuring usability, software limitations, and unclear user needs often negatively affect the usability. In addition, a typical data collector could be semi- or non-literate, which further presents a challenge when designing the forms, since the data collected must be accurate.
Consequently, we designed four different mid-fidelity prototypes in an attempt to improve the usability of the mobile electronic data capturing forms that are being used to collect data from recently delivered women in rural Uganda. The basic requirements we considered were that the design should be simple, easily understandable by a broad user group, and supported by the Android mobile platform, the most commonly used mobile platform in Africa. All four mid-fidelity prototypes are simple, straightforward, and suitable for low cost mobile devices. The major differences in these designs are found in the overall layout and use of colors. There are also variations in the list pickers, date formatting, progress, fonts, labeling, error messages, data validation, tables, and navigation buttons. The different prototypes are currently being evaluated by end users. Design principles will be derived from the evaluation and will serve as part of the guidelines for designing mobile electronic data capturing forms in rural Uganda. We believe that this will help in improving usability at a minimal cost and save developers' time. Moreover, the guidelines could be reused in similar projects to spare the full development cost.

Contribution ID: 507
3. Information Technology in Healthcare
03.12. Usability and user experience issues with health IT

Design features of a usable Mobile Electronic Data Capturing Form: The form developers' perspective

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Mobile Electronic Data Capturing Forms (MEDCFs) are continuously being adopted to collect health data in rural settings during health surveys, surveillance and patient monitoring using customizable electronic data collection (EDC) tools. These electronic forms are usually a representation of hard copy questionnaires designed by form developers based on the array of functionalities or features provided by the EDC tools. However, the health questionnaires are usually long and with varying data types which occasionally cause usability challenges due to the design limitations in some of the EDC tools. The main objective of this study therefore was to determine the design features that define a usable MEDCF from the form developers' perspective.
An electronic questionnaire was created and distributed by Email to fifteen mobile form developers using Survey Monkey, an online data collection tool. The questions were based on features that are common with mobile forms such as progress, feedback, logic, form navigation, data input format requirements, data validation, language translation and error handling among others.
All form developers indicated that feedback should be given when a user completes filling the form, and that the user should be informed immediately in case of an error, while only 45% agreed to language translation and accessibility at any point in the form. The form developers also suggested that users should not be blocked from submitting forms in case of errors, but that the data can be flagged and corrected later. Mobile forms also needed to be less crowded with enough clickable surface area to accommodate a finger touch.

These findings depict that form developers appreciate usability differently. Furthermore, we can recommend that usability in mobile forms is not a task that should be left to form developers alone, but should be a collaborative effort involving software developers, form developers, project implementers and data collectors.

Contribution ID: 1458
3. Information Technology in Healthcare
03.12. Usability and user experience issues with health IT

Technologies catalog to support the identification of user behavior during usability tests

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Introduction: IEC ISO 60601-1-6: 2015 is the regulatory standard for medical products and directs to ISO IEC 62366: 2015 as a technical standard. However, due to the general nature of this standard, it does not provide details about criteria to guide usability testing of medical products. In this way, the manufacturer deals with the unpredictability of the user according to the subjective convenience that he deems necessary to the type and class of the device.
Objectives: To present a Catalog indicating technologies that can be used to detect the ergonomic or biomechanical behavior of the user. So that the test team has support for the follow-up of the experiment and for assistance in interpreting the test results.
Method: A bibliographical review on technologies used to detect human behavior, and a technical survey of the market for products capable of capturing such behavior, were carried out in 2017 to establish and create the Catalog.
Results: Findings allowed to list technologies that can be used to analyze the behavior of the user, assisting the execution of usability tests of the medical product, being effective to detect the behavior and generate data to support the analysis and generation of reports.
Conclusion: The Catalog classified technologies that can generate information about the usability of the medical product, considering the analysis of the user's behavior. The Catalog contains the association between the technology and the behavioral possibilities that can be identified, serving as support to choose the technology most appropriate to the usability test.

Contribution ID: 1678
3. Information Technology in Healthcare
03.12. Usability and user experience issues with health IT

Design reflection on mobile electronic data capturing forms in African rural settings

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This paper presents a literature overview of the existing tools for data capture in African rural settings. The objective has been to investigate and understand design approaches, usability, user satisfaction, as well as feasibility of capturing data using mobile device forms. Existing open source solutions are most commonly used in a variety of applications such as maternal care, new born child health, and routine health care monitoring. The common design issues involve customizing forms for the intended purpose and for semi- or non-literate user groups. User evaluation is also not often reported, however some of the studies suggest a high satisfaction as compared to the traditional paper based approach. Typical barriers include: cost, user input, user motivation, limited graphical user interface, and availability of technology in rural areas. Some of these barriers could be addressed by practicing User-Centered Design. We suggest including all future user groups in the development of mobile electronic data capturing forms to increase usability, data accuracy, and the user satisfaction.

Contribution ID: 400
3. Information Technology in Healthcare
03.14. Other

Real Challenges Associated with Patient Identification

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Patient identity at the point of care as well as across healthcare systems for the continuum of care is critical to the quality of care and patient safety. If this issue is neglected or unsatisfactorily handled, it results to patients' misidentification which has very severe ramifications such as medical errors, transfusion errors and wrong person procedures among others. In an effort to identify each patient uniquely, various identification methods based on diverse technologies and techniques have emerged. However, patient identification continues to be challenge. In this paper, we present field observations based on semi-structured interviews in a preliminary study in three healthcare facilities as well as from the Web of Knowledge search supplemented by grey literature search. Patient identification challenges revolve around the domains: technology, process, people, and standards.
Keywords: Patient identification, patient misidentification, patient safety, quality care.

Contribution ID: 622
3. Information Technology in Healthcare
03.14. Other

Patient-Specific Three-Dimensional Printing for Pre-Surgical Planning in Hepatocellular Carcinoma Treatment

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Purpose: The aim of this study is to investigate the feasibility of utilising 3D printed liver models as clinical tools in pre-operative planning for resectable hepatocellular carcinoma (HCC) lesions.
Methods: High-resolution contrast-enhanced computed tomography (CT) images were used to generate a patient-specific 3D printed liver model. Hepatic structures were segmented and edited to produce a printable model delineating intrahepatic anatomy and a resectable HCC lesion. Quantitative assessment of 3D model accuracy compared measurements of critical anatomical landmarks acquired from the original CT images, standard tessellation language (STL) files, and the 3D printed liver model. Comparative analysis of surveys completed by two radiologists investigated the clinical value of 3D printed liver models in radiology. The application of utilizing 3D printed liver models as tools in surgical planning for resectable HCC lesions was evaluated through analysis of questionnaires completed by two abdominal surgeons.
Results: A discrepancy was found in the total mean of measurements at each stage of production, with a total mean of 18.28±9.31mm for measurements acquired from the original CT data,

15.63±8.06mm for the STL files, and 14.47±7.71mm for the 3D printed liver model. The 3D liver model did not enhance the radiologists' perception of patient-specific anatomy or pathology. Kappa analysis of the surgeon's responses to survey questions yielded a percentage agreement of 80%, and a κ value of 0.38 (p=0.24) indicating fair agreement.
Conclusion: This study indicates that there is minimal value in utilizing the 3D printed models in diagnostic radiology. The potential usefulness of utilizing patient-specific 3D printed liver models as tools in surgical planning and intraoperative guidance for HCC treatment is verified. However, the feasibility of this application is currently challenged by identified limitations in 3D model production, including the cost and time required for model production, and inaccuracies potentially introduced at each stage of model fabrication.

Contribution ID: 703
3. Information Technology in Healthcare
03.14. Other

Study on Non-contact Heart Beat Measurement Method by Using Depth Sensor

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For the purpose of simple observation of the mechanical phenomenon of the heart, we propose a new noncontact heartbeat measurement using a depth sensor.
The depth sensor is an image sensor applying infrared light projection, and by using this sensor it is possible to calculate the three dimensional shape of the chest. In addition, it is possible to measure minute displacement appearing on the body surface by heartbeat. By visualizing the distribution of shape change using computer graphics, visualization of the heart beat is realized.
Since the method is non-contact measurement, it does not prevent simultaneous measurement with the electrocardiogram. Therefore, it can be expected to be used as a means for simultaneously observing mechanical and electric phenomena of the heart.
Simultaneous measurement using the method and electrocardiogram was performed. As a result of the measurement of 10 subjects (male in their 20s), it was confirmed that the peak interval of the waveforms obtained by the two methods shows high consistency. The difference between the two peak intervals was less than 0.04 seconds.
In the above discussion, subjects stopped respiration, by applying the filtering process, it is also possible to detect the heart beat waveform during breathing. During respiration, fluctuations are included in the measured waveform. In the simultaneous measurement of the two methods, the difference in the peak intervals is less than 0.05 second. This value is slightly larger than when breathing is stopped.
In addition, as a result of the visualization of heart beat, the phase of vibrations by the heart beat appearing on the body surface is different depending on the position. Specifically, a phase lag occurred upward direction from the abdominal, and it was visible by animation. This result suggests that the observation of the mechanical phenomenon of the heart may be realized by the method.

Contribution ID: 1431
3. Information Technology in Healthcare
03.14. Other

Computed tomography (CT) imaging translation process for Additive Manufacturing (3D Print) medical devices

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Computed tomography (CT) and Magnetic Resonance Imaging (MRI) are very import imaging process for Additive Manufacturing (3D Print) implant medical devices, and how to create the relationship between Digital Imaging and Communications in Medicine (DICOM) image and 3D printing is an important topic.
In this paper we provide a one-stop shop service platform, and create an image translation parameter to 3D print for the implantable medical devices.The DICOM image file has been created by 128 CT scan, and converted to printed files based on CT scan parameters. Finally, Medical devices can be printed.

Contribution ID: 1450
3. Information Technology in Healthcare
03.14. Other

A web platform for topics and trends analysis in medical literature

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Topic modeling refers to a suite of probabilistic algorithms for extracting word patterns from a collection of documents aiming for data clustering and detection of research trends. The steps that structured the implementation of those algorithms required knowledge that is not acquired by the medical professionals. We developed a web platform that implements different variations of Latent Dirichlet Allocation (LDA) algorithm, as it presents highest precision results compared to other available topic modeling algorithms. Scientific literature origin from targeted search queries in PubMed, works as input to the platform, while output files are available for every step of the process, giving the researcher the opportunity to select different preprocessing algorithms for the corpora, as well as different implementations and execution parameters of the topic modeling algorithms. We provide a comprehensive platform, built with distinct steps that do not require previous preparation from the user side. Our intention was to present all the available data to the researchers in order taking their decisions regarding topics. They can compare the results of different corpora, preprocessing texts and topic modeling parameters in a quick and organized way. Information regarding topics, such as word proportion and their variation per year listed to help users label topics and group them to categories. Visualization of data is another part of our platform with graphs generated on the fly providing information about the corpora, the topics, groups of topics and categories as well. We rely in modern technologies and follow the principles of agile software development to achieve scalability and discreet design.

Contribution ID: 1886
3. Information Technology in Healthcare
03.14. Other

A simple room localization method to find technology in a big trauma center”

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Trauma Center is a big operating theatre of over 4000 square meters on two floors and 14 operating rooms. In this context, the share of the equipment is fundamental to reduce expedition but may cause an excessive loss of time by medical staff that needs devices for the clinical therapy. Therefore, knowing localization is useful for health monitoring of important electromedical devices. In recent years, a lot of technologies have been developed for the indoor localization, like the Bluetooth wireless standard technology. In particular, Beacon technology is very interesting, which uses the Bluetooth low energy (BLE) technology. However, due to the complexity of internal ambiences, the development of an indoor localization method is always associated with various problems, mainly for the presence of obstacles among the direction of propagation of signals. Application of BLE for the localization of medical equipment could help to save time during an emergency. With this preliminary study, using Beacon devices like tag, three mathematical average methods for reducing variability in indoor localization techniques are performed. Although mathematic aVerage methods can reduce variability, it is very difficult to eliminate the calculation error of the tag-reader distance. Nevertheless, in this preliminary analysis the mathematical method using the average of RSSI measures present a constant error pattern, along distances, ranged between 0 and 8 meters not too big for a room localization method.
Keywords: Indoor localization, Medical Emergency, Bluetooth Low Energy.

Contribution ID: 109
4. Modelling and Simulation
04.18. Keynote lecture

KEYNOTE LECTURE: Monte Carlo simulation of early biological damage induced by ionizing radiation at the DNA scale: overview of the Geant4-DNA project

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Modeling accurately biological damage induced by ionizing radiation at the scale of the DNA molecule remains a major challenge of today’s radiobiology research. In order to provide the community with an easily accessible mechanistic simulation platform, the general purpose and open source “Geant4” Monte Carlo simulation toolkit (http://geant4.org) is being extended in the framework of the “Geant4-DNA” project (http://geant4.org) with a set of functionalities allowing the detailed simulation of particle-matter interactions in biological medium. These functionalities include physical, physico-chemical and chemical processes that can be combined with nanometer size geometries of biological targets in order to predict early DNA damage. We will present an overview of the Geant4-DNA project and discuss on-going developments. User applications based on examples available in Geant4 will be shown.

Contribution ID: 1909
4. Modelling and Simulation
04.18. Keynote lecture

KEYNOTE LECTURE: The IUPS Physiome Project

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Multi-scale computational models of organs and organ systems are being developed under the umbrella of the Physiome Project of the International Union of Physiological Sciences (IUPS) and the Virtual Physiological Human (VPH) project funded by the European Commission. These computational physiology models deal with multiple physical processes (coupled tissue mechanics, electrical activity, fluid flow, etc) and multiple spatial and temporal scales. They are intended both to help understand physiological function and to provide a basis for diagnosing and treating pathologies in a clinical setting. A long term goal of the project is to use computational modeling to analyze integrative biological function in terms of underlying structure and molecular mechanisms. It is also establishing web-accessible physiological databases dealing with model-related data at the cell, tissue, organ and organ system levels. The talk will discuss the current state of the standards, databases and software being developed to support robust and reproducible multiscale systems biology models for the VPH/Physiome project.

Contribution ID: 305
4. Modelling and Simulation
04.01. Biological effects of ionizing radiation

Is Dose The Best Quantifier Of Biological Damage?

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When a monoenergetic proton beam is sent through a medium during proton therapy, each proton will be slowed down by different degree due to the stochastic nature of particle collision, resulting in a spectrum of energy within the medium. Given a distribution of proton's energy in the medium and that each energy has different Relative Biological Effectiveness (RBE), it is questionable if dose remains the best quantifier of biological damage. In this work, we will present our simulation study and shows that dose is not entirely indicative of biological damage in the context of Proton Therapy. The summary of the methodology is as follows: We integrate our in-house radiobiology software which is capable of predicting Double Strand Breaks Yields (DSB) (including direct and indirect effects contributions) for any incident energy proton beam into a Geant4-based particle transport code using realistic and validated Proton Therapy Nozzle design. Then, we calculate the 3D DSB yields in both a simple homogeneous water phantom and a heterogenous Lung DICOM data. A Monte Carlo dose calculation engine is also used to calculate the 3D dose in these two geometries. A comparison between the 3D DSB yields and Dose show the relationship between the two quantities and if they are completely correlated to each other. Our result shows that for both geometries, the spatial location of maximal DSB yields do not coincide with that for dose. There is a small but noticeable difference in distance especially towards the Bragg peak.

Contribution ID: 635
4. Modelling and Simulation
04.01. Biological effects of ionizing radiation

A radium-223 monte-carlo computational model for bone metastatic disease treatment

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Alpha particle emitting radionuclides have recently been shown to deliver significant improvements in the care of cancer patients, exemplified by the bone seeking α-emitter radium-223 (223Ra). In clinical trials it was shown to have not only a palliative effect, but also a survival benefit in metastatic castration resistant prostate cancer patients. This has encouraged the use of 223Ra in novel patient treatment trials, one of which is being held in Belfast (ADRRAD). However, despite this effectiveness of 223RaCl2 among patients with symptomatic bone metastatic disease, its mechanisms of action are still a major subject of discussion. Computational models add a new perspective to the topic as they can quantitatively investigate the interaction of α-particles with a target in an event-by-event particle tracking basis. There is a pressing need to quantify α-particles effects in pre-clinical and clinical models in order to optimize the next generation of trials using 223Ra.

With that in mind, we have designed a computational model that describes the dynamics of a bone metastasis under 223RaCl2 treatment. The model is based on clinical data including injected treatment activity and tissue accumulated doses. We have modelled the radiation effect of 223Ra in a metastatic tumour growth in bone combining Monte-Carlo simulations for dosimetry and Gompertz-based growth models. This model predicts the outcomes of 223Ra treatments at different growth stages of a bone metastasis, allowing the investigation of different assumptions about 223RaCl2 treatment. These predictions can be comparable to the current clinical data to improve our understanding of 223Ra activity, allowing for better treatment optimizations for future patients.

Contribution ID: 884
4. Modelling and Simulation
04.01. Biological effects of ionizing radiation

4D cellular model of tumor growth, radiation track structures and DNA damage induction

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Stochastic radiotherapy models have the potential for greater accuracy and utility than analytic models like the Linear Quadratic model and its variants. A 4D cellular model of tumor growth, irradiation and DNA damage induction was developed for head and neck cancer. In the model, 3D ellipsoidal cells containing nuclei occupy randomized non-overlapping positions. An epithelial cell hierarchy consisting of stem, transit and differentiated cells is simulated. When cells divide they push each other around. A connected, chaotic network of blood vessels grows between the cells. Clinical data from human head and neck cancer dictates the amount of tumor vascularization and blood oxygenation. Each cell's oxygenation (pO2) is derived from its proximity to blood vessels and its cell cycle time is pO2-dependent. To irradiate the tumor, cellular geometry is voxelized into 2 μm voxels and imported into Geant4. Geant4-DNA physics and chemistry are used to simulate the direct and indirect effects. Water radiolysis and chemical tracks are simulated along segments of physical tracks inside nuclei. Photon and particle beams can be simulated. By clustering the direct events and hydroxyl radical interactions in the nucleus of each cell, spatial distributions of single- and double-strand breaks, modified bases and modified sugars are generated in cell nuclei, taking into account cellular pO2. As a proof of concept, a million X-rays from a 6 MV linac were fired at a 0.23 mm diameter cluster containing 1105 cells (over a million voxels) and the DNA damage calculated for different pO2 conditions. Model behavior was validated, including that the DSB yield, number of strand breaks within DSBs and DSB clustering all increased with increasing LET and pO2. The model is currently being extended to predict cell kill based on DNA damage. Tumors will then be irradiated in multiple dose fractions, with tumor shrinkage and regrowth modeled.

Contribution ID: 1101
4. Modelling and Simulation
04.01. Biological effects of ionizing radiation

Stochastic predictions of radiation dose enhancement using gold nanoparticles using an individual cell hypoxic tumour model, HYP-RT

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Introduction:Dose enhancement ratio (DER) effects due to gold nanoparticles (GNP) have been employed in a computerised tumour growth and radiotherapy model for hypoxic head and neck cancer, to predict the total doses required for local control, with and without the presence of nanoparticles.
Method:The HYP-RT model simulated tumours of 100 million cells followed by virtual irradiation in the form of fractionated 6 MV radiotherapy, with various GNP DER uniform factors or probabilistic distributions applied to cell death probability calculations, defined as DwithGNP/DwithoutGNP. The average DER values utilised were 2.56, 1.23, 1.04, which corresponded to effects at/near the nucleus, average nanoparticle effects as well as large (400nm) GNP cluster effects in the cytoplasm, respectively. Death of cancer stem cells, transit, differentiating and hypoxia induced quiescent cells was also dependent on dose, alpha-beta ratio, oxygenation and cell-cycle phase. Well oxygenated as well as moderately hypoxic tumours were compared, with the added effects of gradual reoxygenation of hypoxic tumours and accelerated repopulation (AR) considered.
Results:A DER of 1.04 reduced the total dose required for tumour control by <10%. However, a DER of 1.23 was successful in reducing total dose by 24% in oxic tumours (e.g. 72Gy down to 55Gy) and 15-22% in hypoxic tumours. With AR applied, this dose reduction rose to between 10-20% for DER=1.04 and a substantial 50% for DER=1.23. The extreme DER value of 2.56 killed identical tumours with differing AR start times with the same doses (e.g. 20Gy for oxic and 30-32Gy for hypoxic tumours).
Conclusion:GNP dose enhancement during radiotherapy was simulated on a verified tumour model, with model outcomes predicting biologically plausible and significant beneficial effects (i.e. reduction) on the total doses required to control well-oxygenated and hypoxic tumours, even in the presence of continuous and accelerated tumour re-growth during treatment.

Contribution ID: 1230
4. Modelling and Simulation
04.01. Biological effects of ionizing radiation

Extension of the RADAMOL tool for modeling radiation damage to nucleosome

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Radiobiological studies of the initial effects of ionizing radiation on DNA often use a plasmid DNA as a simpler model system. While drawing conclusions from such model for the situation in a cell is tempting, the difference between the plasmid and low-level DNA organization in the cell nucleus is worth exploring.
RADAMOL was developed to model the pre-chemical and chemical stage of the ionizing radiation action on biomolecules in an aqueous environment. Two inputs are required – event-by-event track data from TRIOL or Geant4-DNA, and a description of the target molecule. Previously, we used an atomic level model of 100 bp oligomer generated using Amber 8 molecular dynamics software.
We have prepared an atomic-level model of the nucleosome and extended the tool to use it. Preliminary results demonstrating the difference between the DNA damage yields calculated for short oligomer and nucleosome for a set of radiation qualities will be presented and discussed.

Contribution ID: 1238
4. Modelling and Simulation
04.01. Biological effects of ionizing radiation

Radiation-induced plasmid DNA damage in relation to DNA length and high level molecular structure

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Ionizing radiation induced DNA damages are specific in their complexity, related to a success of a cell reparation and therefore the cancer risk level. However, precise detection of DNA damage is challenging. Standard methods can lead to underestimation of the real damage yields, particularly for large delivered doses and high linear energy transfer cases. The question is how the possible underestimation relates to DNA length, which defines its high level molecular structure?
Plasmid DNA in water can be considered as a simplified model of cell nucleus without reparation processes and therefore can greatly aid in quantification of primary radiation damage. In our study, we used three plasmids of increasing lengths (2686 bp, 4361 bp, 9107 bp). The plasmid solutions were irradiated with gamma rays and high energy heavy ions and analysed with agarose gel electrophoresis. This enables to calculate yields of single and double strand breaks per base pair and Gy.
The results of the experiments were compared to the DNA damage yields computed for the respective plasmid lengths and radiation sources using the RADAMOL tool. Plasmid models were constructed using the worm-like chain approach, and the Geant4 Monte Carlo toolkit has been used to provide track structure data. The effect of plasmid DNA length on probability of induction of multiple damages on one plasmid by a single primary particle will be discussed.

Contribution ID: 1414
4. Modelling and Simulation
04.01. Biological effects of ionizing radiation

The study of biological effectiveness of proton and ion beam by using Geant4-DNA simulation

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It is well established, according to a number of biological experiments, that the probability of cell damage when radiated with ionising radiation significantly depends on the deposited energy of the beam or Linear Energy Transfer (LET). Many cells are capable of repairing themselves if the radiation dose does not pass the threshold but a very concentrated dose will 'overkill' the cell. Therefore, peak effectiveness lies somewhere in between in a way which depends on the effective target size and the spatial distribution of the LET at the microscopic level.
To improve the understanding of ion beam therapy, an investigation of energy deposition and the pattern of particle tracks, which may cause the consequent damage to the cells, has been performed by using Geant4 simulation. Although the physical attributes of particle therapy clearly hold a benefit over conventional radiotherapy, the biological effects hold uncertainties, and modelling the way particles interact with tissue on a cellular level can reduce these. The study of radiobiology of proton therapy by using a Monte Carlo study should be provided some fundamental link between physics and cell biology.
In this study, the preliminary results have been suggested that particles of different charge and different energy can have the same energy deposition when considering the deposited energy of the particles at the same depth. This result is interesting because it can enable the study of the dependence of effectiveness on the energy deposited in a particular cell. However, it is in the early stage and needs more simulations in order to further investigate the probability of cell killing. The relationship between energy distribution and the probability of DNA cluster breaks will also be evaluated according to the result of the previous simulation.

Contribution ID: 1532
4. Modelling and Simulation
04.01. Biological effects of ionizing radiation

Effecet of regimen dietry on myocardial absorbed dose in patients 18F-FDG PET/CT using Monte Carlo simulation GATE

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18F-FDG PET/CT sac is non-invasive imaging method. The ultimate goal in nuclear medicine imaging is obtaining optimized critical organ absorbed dose with the best image quality.
Normal biodistribution of 18F-FDG impose high level of absorbed dose on myocardial tissue. Based on extensive medical and clinical researches, different dietary regimen can effectively modify the heart tissue's uptake results in better diagnostic approaches. The main aim of this research is to evaluate the LCHF dietary regimen effects on myocardial absorbed dose to reduce myocardial absorbed dose. Our research is inclusive of experimental activity in parallel with Monte Carlo simulation for Patient specific dosimetry to achieve more reliable and accurate results.
Method:
Our study commence with patients referred for oncologic 18F-FDG PET/CT scan. They were divided in two groups. First group with routine regime; however, one day LCHF regimen dietary prescribed for the second group. They were underwent 18F-FDG PET/CT and GATE Monte Carlo code used for simulation and the integration gave us S-values, absorbed dose and cumulated activity consequently.
Results:
Because of the specificity of the research, 20 patients with mean age of 45.48 years were examined. Our subjects consist of 10 female and 10 men. Residence time for the first and second group was 313.90, 93.27 second respectively. The mean cumulated activity, S-value, and absorbed dose are 1.17E+5 MBq, 2.18E-4 mGy/MBq.s, 2.19E+1 mGy respectively for patients with routine regime, even though these values is 3.76E+4 MBq, 1.4E-4 mGy/MBq.s, and 5.93 mGy for patients following LCHF regimen dietary.

Conclusion:
As 18F-FDG is glucose analogue and heart intend to uptake high rate of glucose, this consumption causes myocardial tissue becomes one of the critical organ. Internal dosimetry using dynamic imaging and GATE simulation indicates that using LCHF regimen dietary for patients referring for 18F-FDG PET/CT scan as routine preparation, could decrease myocardial dose.

Contribution ID: 382
4. Modelling and Simulation
04.02. Biological effects of non–ionizing radiation

Physical analysis of low-dynamic pulse magnetic therapy into human tissue

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The using of magnetism for treatment of the various types of diseases has a very long history and the application of the low-frequency pulse magnetic field is a very common medical procedure today, but still is this method considered by some physicians not fully fulfilling the criteria of the “evidence based medicine”. This article makes an effort to explain some physical and energy aspects of practice using magneto therapy in the treatment of the musculoskeletal system (orthopaedic surgery, physiotherapy and the rehabilitation).
We are presenting the principles of electromagnetic induction in muscle tissue as typical example of the parts of human body. The main accent of presenting theory is put on macroscopic physical and energetic behaviour of low-frequency pulse electromagnetic field in lower extremities. The problems are demonstrated with 3D modelling. This theoretical approach uses simplified model of tissue conductivity.
One of the goals is to warn about different distribution of magnetic field in parts of body caused by diverse position, spatial orientation, volume of exposed to part of body. The metal implants in treated part of body during the magnetic therapy have principal influence on distribution of magnetic field. Another analyse introduces physical and energy differences among individual types of power sources of magnetic field and their dynamic behaviour.

Contribution ID: 314
4. Modelling and Simulation
04.03. Modelling in treatment planning

Quantifying the spatial and angular distribution of lethal neutrons for treatment planning

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It is known that high energy protons in proton therapy generate secondary particles. Of which, secondary neutrons are a main concern as they deposit out-of-field doses and can have long-term health effects on cancer patients. Here, the energy, 3-D spatial and angular distribution of the production yield of neutrons will be scored along the proton beam path in different types of tissue medium. The degree of biological damage can then be quantified through factoring in the relative biological effectiveness of neutrons. The systematic study involved simulating 70, 150 and 200 MeV proton beam transport in various tissue compositions and physics models with the GEANT4 code. System specifications of the Hitachi proton therapy system were used in the study, and is the first proton therapy system in Singapore and South-East Asia. Results showed the neutrons are forward facing and are generally emitted at a preferential angle. With considerations on the relative biological effectiveness variation with neutron's energy, the spatial and angular distribution of the production of lethal neutrons were identified along the proton track. Non-trivial relations between biological damage in differing tissue medium were observed. Such comprehensive simulation studies have not been reported and this input information will be useful for treatment planning in reducing out-of-field neutron dose and avoid sensitive organs.

Contribution ID: 363
4. Modelling and Simulation
04.03. Modelling in treatment planning

Evaluation of constitutive models for medical grade silicone used in airway endoprotheses

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The aim of this work was to develop a methodology to obtain and evaluate the constitutive models of medical grade silicone used in the HCPA-1 airway stent. Virtual mechanical simulations in three-dimensional prototypes through the use of the finite element technique allow the development of new stents with different materials and geometries while reducing cost, since it reduces the development time needed to get new samples and more accurate injection matrices. Silicone elastomers usually exhibit a strongly non-linear stress-strain relationship that is characteristic of hyperelastic materials. The ANSYS R15.0 Academic software was used to characterize the material from experimental tests. We chose to perform only the uniaxial tensile mechanical test using medical grade silicone as test sample according to the standard ASTM D412C. All data were acquired using an Instron universal test machine. Results: These experimental data was then used in ANSYS to obtain the hyperelastic constants for the following mathematical models: Neo-Hooken, Mooney-Rivlin, Ogden, Arruda-Boyce, Polinomial and Yeoh. We performed virtual simulations of mechanical deformations in ANSYS on an ASTM D412C test body and a HCPA-1 stent (16x70mm) with its more complex geometry. The stent simulations using the hyperelastic constitutive models obtained from a simple geometry presented a relative error between the experimental and simulated data in the range of [-20%; + 74%]. The Arruda-Boyce model presented the smallest error (+ 10%) and was considered the best option to simulate mechanical deformities in the stent. Conclusion: The simulation showed significant variations in the results. The option for the Arruda-Boyce model presented good results of mechanical deformation for that specific geometry. For new geometries a new experimental evaluation is necessary to find out the best constitutive hyperelastic model.

Contribution ID: 429
4. Modelling and Simulation
04.03. Modelling in treatment planning

Validation of Geant4 nuclear reaction models for hadrontherapy and preliminary results with SMF and Blob

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Reliable nuclear fragmentation models are of utmost importance in hadrontherapy, where Monte Carlo (MC) simulations are used to compute the input parameters of the treatment planning software, to validate the deposited dose calculation, to evaluate the biological effectiveness of the radiation, to correlate the β+ emitters production in the patient body with the delivered dose, and to allow a non-invasive treatment verification.
Despite of its large use, the models implemented in Geant4 have shown severe limitations in reproducing the measured secondaries yields in ions interaction below 100 MeV/A, in term of production rates, angular and energy distributions . We will present a benchmark of the Geant4 models with double-differential cross section and angular distributions of the secondary fragments produced in the 12C fragmentation at 62 MeV/A on thin carbon target, such a benchmark includes the recently implemented model INCL++. Moreover, we will present the preliminary results, obtained in simulating the same interaction, with SMF and BLOB. Both, SMF and BLOB are semiclassical one-body approaches to solve the Boltzmann-Langevin equation. They include an identical treatment of the mean-field propagation, on the basis of the same effective interaction, but they differ in the way fluctuations are included.
In particular, while SMF employs a Uehling-Uhlenbeck collision term and introduces fluctuations as projected on the density space, BLOB introduces fluctuations in full phase space through a modified collision term where nucleon-nucleon correlations are explicitly involved. Both of them, SMF and BLOB, have been developed to simulate the heavy ion interactions in the Fermi-energy regime. We will show their capabilities in describing 12C fragmentation foreseen their implementation in Geant4.

Contribution ID: 457
4. Modelling and Simulation
04.03. Modelling in treatment planning

Proton therapy treatment plan verification in CCB Krakow using Fred Monte Carlo TPS tool

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Monte Carlo (MC) methods account for many details of the interactions of particles with human tissue in proton beam therapy. The accuracy and fast dose calculation time offered by GPU-accelerated MC treatment planning systems (TPS) pushed development of such tools to support experimental treatment plan verification in the clinical routine. The GPU-accelerated MC-TPS

"Fred" (Schiavi et al. 2017; University of Rome) is has been adopted by the Cyclotron Centre Bronowice (CCB) Krakow proton beam therapy centre (Poland) that is in clinical operation from October 2016.
Krakow proton centre physical beam model has been implemented in Fred and was validated against Eclipse TPS calculations and patient Quality Assurance (QA) measurements in a water phantom. We analyzed depth-dose distributions of proton pencil beams, dose cubes of varying range and modulation in water, and verified treatment plans of dozens of patients treated in CCB. We used clinical volumetric indices and the gamma index method as quantitative measure and obtained a good agreement between Fred, measurements, and analytical TPS calculations. We have also found that Fred offered improved accuracy in heterogeneous material with respect to analytical TPS, and superior tracking performance (10^6 primaries/s) with respect to standard full MC codes.
In the future, the proposed fast MC methods can help to reduce the time needed for experimental patient treatment plan verification measurements in water phantoms that are part of clinical routine procedures. With the GPU-accelerated MC-TPS tool, dose computation of patient treatment plans is faster and biological dose recalculation with variable RBE will help to improve patient treatment with protons in the future, once implemented in the clinical protocols.

Contribution ID: 465
4. Modelling and Simulation
04.03. Modelling in treatment planning

A feasibility study of treatment planning using optimization algorithm for improving tumor treating fields therapy efficiency

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Treatment with alternating electric fields at an intermediate frequency(100~300kHz), referred to as tumor treating fields(TTFields) therapy, approved for treatment of glioblastoma. Previous studies show that therapeutic effect increases with field intensity, but effects on the normal organs or cells were little known. It is important to deliver more than prescribed intensity to the tumor site and only minimal intensity to the normal organs. Therefore, in this study, we investigated the optimal treatment planning methods using optimization algorithm for improving the efficiency of TTFields therapy.
To simulate delivery of electric fields to the tumor, we used simple phantoms containing virtual tumor and organs and a realistic human phantom constructed from MRIs data. Electrodes imposing the electric fields to the target placed on two opposite surfaces of the phantom. Optimizations of field intensity were performed to minimize objective function and satisfy boundary conditions by adjusting weighting factors multiplied to individual field intensities generated at selecting the electrode on each side.
When normalizing the electric fields strength of the tumor to 1.5V/cm for the total volume, the maximum field intensity delivered to the tumor site using the optimization methods was 1.0 to 1.7 times greater than using the conventional method. In all normal organs, percentage of volume receiving more than 60% and 90% of prescribed intensity was about 0.5 to 0.99 times less than using the conventional method.
These results suggest that treatment planning method using the optimization algorithm is possible to minimize the field intensity of normal organs and receive more than prescribed intensity to the tumor site comparing with conventional treatment planning method.

Contribution ID: 497
4. Modelling and Simulation

04.03. Modelling in treatment planning

Beam characterization of ELEKTA Compact linear accelerator (LINAC) machine using Monte Carlo methods

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Linear accelerator (LINAC) is a radiation therapy equipment used to deliver high doses of ionizing radiation to the cancer volume while ensuring the dose to neighboring tissues are minimized. Monte Carlo (MC) method is a tool that can be used to simulate a radiation therapy equipment. In this method, accurate modeling of the LINAC machine will be considered. Radiation transport packages such as BEAMnrc for modelling LINAC head and DOSXYZnrc for calculating dose will be utilized. The data provided by the manufacturer is necessary to accurately model the LINAC machine. Previous studies have showed that every LINAC machine has unique beam characteristics. This study aims to characterize photon beam from ELEKTA Compact LINAC machine and to investigate several factors that affect dose distribution in water. Monte Carlo commissioning will be carried out for 6 MV photon beam for 10x10 and 30x30 cm2 field sizes. The phase-space file (PSF) generated from BEAMnrc includes charge, energy, position and direction of particles at the treatment head of the LINAC machine. The PSF produced will be used in DOSXYZnrc for dose calculation purposes. The calculated percentage depth doses (PDDs) and lateral beam profiles will be compared with the measured data using homogenous water phantom and ionization chamber. The optimum incident beam energy obtained from the simulation was compared with the actual measurements of PDDs and lateral dose profiles. For comparisons, three regions in the profiles were studied: (a) umbra region, (b) penumbra region, and (c) low dose region. To achieve acceptable absorbed dose results, the mean energy and radial intensity should be accurately adjusted. The discrepancy between the simulated and measured data is expected to be ±2%, ±10%, and ±30%, respectively. The phase-space files (PSF) generated from this study can be used for future research and for studies that require dose calculations.

Contribution ID: 755
4. Modelling and Simulation
04.03. Modelling in treatment planning

Investigation of changes in treatment plan for "CyberKnife" system due to presence of MRI contrast media in patients during CT-scanning

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Introduction. In clinical practice there are cases of CT scannning of patients with the residue of magnetic resonance imaging (MRI) contrast agents in their bloodstream, usually gadolinium complexes, that were introduced earlier for MRI purposes. In this situation, it would be appropriate to wait until the contrast medium is completely eliminated from the patient and then repeat CT scan, but this needs time and creates additional patient dose load. So, medical physicists and radiation therapists face a dilemma: repeat the CT or calculate the dose distribution based on already existing scans, despite the residual MRI contrast.
Aim: to assess the change in the treatment plan due to the presence MRI contrast agents patients during CT scanning.
Materials and methods. Were considered two cases of the target localization: liver and brain. All clinical data were obtained in the Oncology Center "Spizhenko Clinic". The simulation of the presence of MRI contrast media was carried out in the «MultiPlan» treatment planning system from Accuray for robotized radiosurgery system «CyberKnife».

Results and discussion. Treatment plans with the simulation of gadolinium use have been created and the difference in absorbed doses for plans with and without MRI contrast agent has been calculated. Additionally the calculation of the change in absorbed dose in each voxel of corresponding CT scans for two types of plans was performed.
For developed treatment plans, investigations have shown a change of a relative dose in volumes less than 1% and a gamma-criterion for scans less than 1%, that is within the acceptable margin of error for a «CyberKnife» system.
Conclusion. Our calculations show the possibility of creating treatment plans based on CT scan data of patients with MRI contrast, which allows omitting extra patient dose load due to additional CT scanning.

Contribution ID: 978
4. Modelling and Simulation
04.03. Modelling in treatment planning

Configuration of volumetric arc radiotherapy simulations using primo software: a feasibility study

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Introduction.
Volumetric Modulated Arc Therapy (VMAT) uses non-uniform intensity fields allowing complex dose distribution patterns. The synchronized MultiLeaf Collimator (MLC) motion and Gantry rotation pose difficulties in the dose distribution calculation by Treatment Planning Systems (TPS). Furthermore, a dedicated Quality Assurance (QA) program and patient-specific dose verifications are requested. Monte Carlo in Radiotherapy (RT) is a key issue in dose calculation given its most detailed description of radiation-matter interaction. Recently, the PRIMO software was proposed, providing several built-in RT units models, including TrueBeam. Nevertheless, VMAT is not implemented yet.
Materials and methods.
TrueBeam was simulated in PRIMO using 6 and 10MeV in Flatness Filter Free mode and at 15MeV with Flatness Filter. The results were validated by Gamma Function (2%, 2mm) based on reference measurements in water tank.
The dynamic delivery is divided into a customizable number of probabilistically sampled static configurations of jaws, leaves and gantry angles. In-house algorithms interpolate the LINAC motion, once the planned information is retrieved from the DICOM plan file.
A graphical user interface (GUI) assists non-expert users to configure and simulate complex deliveries.
Results.
Static simulations in reference conditions always showed > 97% of Gamma points < 1 for PDD and profiles at various depths and fields sizes for the 6, 10 and 15MeV primary beam respectively. The GUI properly reads, manipulates and writes the configuration data in a .ppj format, which is accepted by PRIMO. The dynamic jaws, MLC and gantry motion were positively assessed by visual inspection of the static beam configuration in PRIMO. Dynamic simulations were conducted and the gamma function against reference dose distributions showed good agreement with typical QA criteria.
Conclusion.
A user interface allowed filling the gap in the workflow to drive PRIMO to simulate a general dynamic treatment. Static and dynamic TrueBeam simulations gave reliable outcome.

Contribution ID: 1114
4. Modelling and Simulation
04.03. Modelling in treatment planning

Estimating cardiac intensive care patients' responsiveness to late conservative fluid management using systems analysis

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Due to physiological reactions to surgery and liberal use of fluids during the first postoperative hours, fluid overload is common in intensive care patients. Once a patient reached hemodynamic stability, further increasing the fluid overload should be avoided and excess water accumulated within the body should be removed.
Recent literature therefore suggests a more restrictive use of fluids in stable patients aiming to reach a neutral to negative cumulative fluid balance early during their stay at the intensive care unit. However, patients might not respond to late conservative fluid management resulting in a further increasing fluid overload and requiring active removal of accumulated water to prevent severe organ damage.
The objective of this work is to present a holistic approach for solving the problem of describing patients' complex physiological characteristics having an influence on diuresis in order to detect patients being non-responsive to late conservative fluid strategies at an early stage of postsurgical care. Second order discrete-time transfer function models were identified for 5 responsive and 5 non-responsive, selected cardiac patients staying at the intensive care unit for at least 5 days. For model estimation, the cumulative fluid intake and the cumulative fluid balance time series were used as model parameters. Each individual model was capable of describing the respective patient's cumulative fluid balance trajectory as response to the actually applied fluid therapy. In daily clinical practice, patient-specific models might be used for predicting the responsiveness to planned interventions and for improving the fluid intake regime by focusing on the avoidance of a further increasing fluid overload.
Currently we have been validating the proposed approach within a large study population by implementing a controlled feedback loop, which will then be used as a decision support tool aiding in fluid management in critically ill patients.

Contribution ID: 1137
4. Modelling and Simulation
04.03. Modelling in treatment planning

A study on improvement method of dose distribution using water bath in boron neutron capture therapy for foot tumors

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Purpose: In boron neutron capture therapy (BNCT) for foot tumors, the irradiation is extremely difficult and the irradiation time becomes often long, when the target volume is in medial and/or

lateral part. For the positional reason, it is hard to fix the ideal posture. For the geometric reason, the thermal neutrons generated near the target volume is easy to leak out from the volume. Therefore, we are studying a method for soaking the whole foot in a water bath. This water bath works as neutron moderator and neutron reflector. The effectiveness of this method is introduced, based on the data for the BNCT studies for foot tumors.
Methods: SERA, a dose estimation system for BNCT, was used in the simulation for dose distribution. The comparison was performed for the dose-estimation result between without and with a water bath, in the BNCT studies for foot.
Results and Discussion: Patient is often forced to an impossible posture, when the target volume in the lateral part of foot is directly irradiated with epi-thermal neutrons. The irradiation from the underside of the foot becomes possible and the patient posture becomes comfortable, when the whole of foot is soaked in a water bath. The minimum tumor doses were almost the same among with and without the water bath, when the skin dose is selected as a limitation dose. In the while, the irradiation time for the irradiation with water bath became shortened below one third for the irradiation without water bath.
Conclusion: The effectiveness of this method using water bath was confirmed for some of the BNCT studies for foot tumors which are carried out at KUR-HWNIF. It is planned to confirm for the other BNCT studies, in order to find the proper condition that the effectiveness of this method can be effectively used.

Contribution ID: 1210
4. Modelling and Simulation
04.03. Modelling in treatment planning

A parametrization approach for 3D modeling of an innovative abduction brace for treatment of developmental hip dysplasia

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Developmental hip dysplasia (DHD) is frequently encountered in the pediatric orthopedic practice. DHD is characterized by dislocation of the femoral head in the acetabulum. In Brazil are diagnosed three times more cases than the world average (5-8 cases for 1,000 births). The lack of treatment leads to long-term morbidity, abnormal gait, chronic pain and arthritis. Early detection and treatment with a Pavlik harness results in improved outcomes. After 6 months of age, closed or open reduction with spica casting is required for 4 months to treat a persistent hip dislocation.The plaster is used for orthopedic immobilization due the low cost, moldability and good mechanical resistance. However, there are several risks and complications due to the use of spica cast in DHD treatment: Skin problems due to lack of adequate hygiene (itching, ulceration, dermatitis and infection), formation of pressure areas, plaster fracture (11% of cases) and fever. Digitization techniques and have been explored for production of customized hip abduction brace by additive manufacturing. However, it is not possible to keep a child standing still to perform 3D scanning of the hip and legs region. The goal of this research was to develop a alternative approach for acquisition of the external geometry of the infant to create 3D model of an abduction brace. The parameterization technique created includes: The creation of a virtual 3D model of a child's body using the MakeHuman software; Articulation of the hip region of the model to the position required in the treatment of DHD with the Blender software; Definition of the parameters required for the modeling of an hip abduction brace. A DHD pediatric orthopaedist validated the methodology and a measurement form was created. Innovations in the area of assitive technology can bring many benefits to the user in the process of rehabilitation.

Contribution ID: 1226
4. Modelling and Simulation
04.03. Modelling in treatment planning

Use of 3D printed model to improve the surgical planning of a multiple face fractures clinical case

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Currently, 3D printing techniques have been used in preoperative planning, implant designing, training or as an educational tool. The Additive Manufacture biomodels fabrication assumes great importance in surgical applications, by allowing a better understanding of complex anatomy/morphology, and consequently, a better surgical planning, or the possibility to create customized implants or surgical guides, aldo shortening surgery time interval. The use of 3D printed models is mostly needed in complex cases where anatomy of the area of interest varies from normal, like in polytraumatized patients. The aim of this paper is to present a clinical case of a male patient, victim of a motorcycle accident, in which it was used a 3D biomodel, obtained by stereolithography process. It was used for previous oral and maxillofacial surgery planning, improving some factors like aesthetic and functional results, and consequently, helping to reduce the risk of complications after surgery and supporting the recovery process. The surgeons' priority was the restoration of function, and secondly to achieve facial harmony and symmetry. Through the use of the 3D printed model the surgeons could detect a lack of bone support in the nasal region, which would pointed to the need to perform a bone graft during surgery. Additionally, the use of this technology allowed folding of the plaque to the exactly fronto-nasal angulation according to the golden anatomy of the face, with the objective of determining the angle between the frontal bone and the nasal bone (120º). Postoperative imaging examinations showed satisfactory reduction and fixation and good adaptation of the reconstruction screen. In addition, satisfactory fronto-nasal reconstruction and eyeball alignment were clinically observed.

Contribution ID: 1339
4. Modelling and Simulation
04.03. Modelling in treatment planning

Monte Carlo modelling of linear accelerator therapeutic photon beams and proposal for objective method of entering electron beam parameters estimation

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In this study we focus on a linear accelerator head model with dynamic MLC, especially on issues of the entering electron beam and its characteristics. Energy spectrum and spatial distribution of the entering electron beam are very difficult to measure in clinical conditions, and therefore it is common to approximate the electron beam as monoenergetic with the energy E and a Gaussian spatial distribution defined by FWHM. Optimal parameters of the model are found by comparison of

measured and simulated PDDs and dose profiles. There are several published studies dealing with optimization of the beam parameters for Varian Clinac 2100C/D, but no unified optimization methodology exists. The aim of our work was threefold: i) to propose a robust and reproducible quantitative method for optimization of beam parameters in MC models of accelerator head; ii) to find optimum E and FWHM values for our measured clinical beams; iii) to determine 95% confidence region of the optimized values. We measured and simulated PDDs and dose profiles for different field sizes and different depths. The EGSnrc-based codes were used for simulations. It turned out that PDDs are not very sensitive to energy and FWHM changes. On the other hand, the 40x40 cm2 beam is quite sensitive to both energy and FWHM changes. Sum of squared differences and gamma index were used as cost functions. Simulations and cost function enumerations were performed for 16 combinations of E and FWHM values. The resulting 16 values (4x4 matrix) were fitted with a 2D parabolic surface. Minimum of this surface determines the optimum combination. Finally we proposed, tested and applied a statistical approach which enables to outline a common 95% confidence region of the E and FWHM parameters.

Contribution ID: 1340

4. Modelling and Simulation

04.03. Modelling in treatment planning

The numerical study on specialized treatment strategies of enhanced external counterpulsation for cardiovascular and cerebrovascular disease

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Background: Traditional mode of enhanced external counterpulsation in clinical is not targeted for different diseases. Specialized strategies in the treatment of enhanced external counterpulsation for coronary heart disease and cerebral ischemic stroke are supposed to be distinguished. The goal of treatment for coronary heart disease is diastolic blood pressure / systolic blood pressure = Q ≥ 1.2 after counterpulsation, while the goal of treatment for cerebral ischemic stroke is the improvement of mean arterial pressure.

Materials and Methods: A computational lumped parameter model was established for the simulation of hemodynamic effect of enhanced external counterpulsation on two diseases. Different counterpulsation modes based on different pressurized and decompressed rate, pressurized moment, pressure duration and pressure amplitude were applied to the model and the immediate hemodynamic effects were compared.

Results: Results showed that the pressure duration and pressure amplitude had most influence on two diseases. For cerebral ischemic stroke, the longer pressure duration the higher mean arterial pressure, and when the pressure amplitudes of calf, thigh and buttocks were 300 mmHg, 220 mmHg and 130 mmHg, the mean arterial pressure is highest; while for coronary heart disease, the value of Q is highest when the pressure end moment intervals exist in each part, and the most suitable pressure amplitudes were 300 mmHg, 200 mmHg and 150 mmHg.

Conclusion: When the EECP was applied to patients with coronary heart disease, the pressure end moment should be sequential but not too long for each part. The best pressure end moments of calf, thigh and buttocks were 0.4 s, 0.5 s and 0.65 s in a cardiac cycle, respectively. While for patients with cerebral ischemic stroke, the longer pressure duration of each part, the better immediate hemodynamic effects. So the best pressure end moments were 0.45 s, 0.65 s and 0.65 s, respectively.

Contribution ID: 1392

4. Modelling and Simulation

04.03. Modelling in treatment planning

Electronic-based model of the sensitive type of mycobacterium tuberculosis

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Tuberculosis disease is one of the leading causes of mortality and morbidity in the world. The current diagnosis and method used to detect the Mycobacterium Tuberculosis is time-consuming, invasive, tiring, labor intensive and requires the microbiologist expertise to confirm the accuracy of the results. There is no electrical instrument to detect Tuberculosis automatically and no electronic circuit model for evaluating the device. This paper describes the development of an electronic circuit model of the sensitive type of Mycobacterium Tuberculosis. The process of developing the model include the conversion of the real data to gain, derivation of the model equations using Regression model analysis and confirmation of the results using one-way ANOVA. Three types of model were studied; the first order, second order and third order LC passive low pass filter circuits. The best model of the sensitive type of Mycobacterium Tuberculosis is the second order of LC circuit since it provides less than 10% discrepancy. From the simulation results, it was found that the logarithmic regression model is the best equation that demonstrates the sensitive type of Mycobacterium Tuberculosis

Contribution ID: 1698
4. Modelling and Simulation
04.03. Modelling in treatment planning

Accuracy of a novel head and neck phantom for heterogeneous media verification using an irregular field algorithm

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Background: Better treatment outcome of patient could improve when the algorithm of a Treatment Planning System (TPS) is accurate and fast. Objective: To design a novel head and neck phantom and to use it to test the accuracy of the Irregular Field Algorithm of a Precise PLAN 2.16 treatment planning system (TPS) whether its accuracy is within ±5% International Commission on Radiation Units and Measurements (ICRU) limit for homogenous and inhomogeneous media by rotating the Elekta-Precise Linear Accelerator gantry angle using two fields. Materials and Methods: The locally designed phantom was constructed in the shape of a block with five inserts using a Plexiglas. Acquisition of images was done using a Hi-Speed NX/i Computed Tomography (CT) scanner, Precise PLAN® 2.16 TPS was used for beam application setup parameters and An Elekta-Precise Linear Accelerator was used for prescription. A pre-calibrated NE 2570/1 Farmer-Type Ion Chamber with electrometer was used to measure dose. The mimicked organs were: Brain, Temporal bone, Trachea and Skull respectively. Results: The maximum % deviation for 10cm×10cm and 5cm×5cm for inhomogeneous inserts was 1.62 and 4.6 at gantry angle of 180 degree respectively and the maximum % deviation for 10cm×10cm for homogeneous inserts was 3.41 at gantry angle of 270 degree. % deviation between bone only (homogeneous) and all insert (inhomogeneous) using parallel opposed beams was 2.89 and 2.07% respectively. Also, % deviation of the locally designed head and neck phantom and solid water phantom of the linear accelerator was 0.3%. Conclusions: Validation result of our novel phantom with the solid water phantom was good. Maximum % deviations irrespective of gantry angles and field sizes were below ICRU limit of ±5%.

Contribution ID: 1707
4. Modelling and Simulation
04.03. Modelling in treatment planning

Thermal distribution profile of a CT26 tumor and its surrounding healthy tissues during nano-photothermal therapy: Computer simulation and in-vivo experiments

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Gold nanoparticle-assisted photothermal therapy has emerged as a minimally invasive method for cancer therapy, particularly for the tumors embedded in some vital organs with poorly defined boundaries. One of the most important problems, in this area, is determination of temperature distribution in both cancerous and normal tissues during photothermal therapy. Computational simulation may be helpful to provide useful information about temperature distribution and to develop an effective treatment planning method.
In this study, using Comsol software, Helmholtz and Bioheat equations were applied to calculate the heat generation inside a tumor loaded with gold coated iron oxide nanoparticles (Au@Fe2O3) and irradiated by laser. We used Mie theory for calculating the absorption and scattering cross sections of nanoparticles. Also, to make the geometry of a tumor and nanoparticles distribution map, we utilized 2D MR images axially obtained from CT26 colon tumor bearing mice injected by nanoparticles. To verify the simulation results, mice tumors were directly injected by nanoparticles at concentration of 0.05 mg/ml and after 6h irradiated by 808 nm laser at intensity of 3.5 W/cm2 for 5 min. An IR thermographic camera and a thermocouple (inserted in the center of tumor) were used to measure the real temperature of superficial and central areas of the tumors.
The results obtained from simulation section of this study showed heat generation inside the tumors strongly depends on nanoparticles concentration and laser irradiation conditions (intensity and exposure time). Experiments and simulations were made in an identical situation and the differences in results were only about 10%.
In conclusion, we demonstrated the model developed in this study has a good capability to be used as a promising planning method for cancer nano-photothermal therapy.

Contribution ID: 26
4. Modelling and Simulation
04.04. Modelling for diagnostic imaging

Validation of simind Monte Carlo simulation software for modeling a siemens symbia t spect scintillation camera

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Introduction: The use of Monte Carlo in nuclear medicine is on the rise due to its usefulness in modeling many physical phenomena in this medical specialty. To use the available Monte Carlo codes, there is need to validate them by comparing simulated data with measured data, this is to provide the confidence that what is simulated is a real representation of the physical system being modeled. Therefore, we validated the SIMIND Monte Carlo code for modeling a Siemens Symbia T SPECT scintillation camera.

Materials and Methods: The Siemens Symbia T dual-head gamma camera was used to acquire NEMA stipulated tests which were simulated in SIMIND MC and the results of both measurement and simulation were compared.
Results: The system spatial resolution had values of 14,41mm FWHM and 29.74mm FWTM for measured data and 13.86mm FWHM, 25.86mm FWTM for simulated data. System sensitivity test measurement produced a result of 48.84cps/MBq while simulation produced 47.83cps/MBq and the measured septal penetration fraction was 3.8% with simulated value been 4.2%.
Conclusion: In conclusion, SIMIND MC Code is validated for use for simulation of 131I SPECT studies.
Key Words: Computer Simulation, Code Validation, SIMIND, Septal Penetration Fraction, Monte Carlo
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Contribution ID: 252
4. Modelling and Simulation
04.04. Modelling for diagnostic imaging

Development of a structured breast phantom comprising the ACR BI-RADS® density classification

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The need for diagnostic accuracy in breast cancer screening has stimulated the use of tools known as computer-aided diagnosis (CAD) schemes. However, it is still a challenge to standardize the criteria for evaluating such schemes, since it depends on the access to a large and diversified image database. With this aspect in view, the current work aims at the development of a breast phantom for simulating the four categories of BIRADS® density classification. Eight layers were set composed by PVC film manually prepared to be submerged in paraffin gel with a non-uniform distribution. Such distribution allowed simulating more or less dense regions, according to the concentration of the material. 55 images were acquired using a LORAD M-IV mammography unit with a CR imaging system Agfa 85. A set of 478 images from actual breasts obtained with the same mammography system was used as reference. The phantom percent density was estimated by using the LIBRA® software, resulting in the four categories of BIRADS® density classification. The amount of material used and also its distribution in each layer of the phantom was possible to select from the values obtained for phantom and clinical images in order to get the desired density classification. The breast phantom developed could be considered as a reliable and low-cost alternative for obtaining a large and varied images database. The next step is the insertion of simulated lesions in the images, expanding possibilities of phantom applications as support for tests in visual perception evaluation as well as investigation and validation of CAD schemes.

Contribution ID: 353
4. Modelling and Simulation
04.04. Modelling for diagnostic imaging

Full-range hepatic fat fraction estimation by using magnitude MRI

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Proton density hepatic fat fraction (FF) can be estimated using magnetic resonance (MR) imaging for the assessment of liver steatosis. Methods relying only on opposed- and in-phase (OP/IP) signal magnitude information are known for their limited estimation range up to 50% FF due to an effect called fat-water dominance ambiguity, while additional imaging techniques are needed for greater ranges. This abstract presents a novel technique based on the extraction of topological information from the signal to train an artificial neural network (ANN) to estimate fat fractions ranging from 0.1 to 100% using OP/IP magnitude MR signals. Separate datasets for training and testing were simulated, each consisting of 50000 instances of gradient-echo OP/IP magnitude MR data with 7 data points corresponding to different echo times, FF ranging from 0.1 to 100% and Rician noise with signal-to-noise-ratios ranging from 200 to 25. Each instance carried a single combination of T2* decays representing water and six different lipid moieties modelling the liver tissue. A multilayer perceptron ANN with 4 intermediate layers was trained using as descriptors the distance and angle between each data point, totalizing 42 descriptors per instance. Estimated and simulated FF values were compared by linear regression. Results were compared to a simulation of the multi-interference method proposed by Yokoo et al. run within its plausible range of 0.01 to 40% FF. Regression slope and intercept values were -0.0013 and 1.0031, respectively ($P<0.001$). The range from 0.01 to 100% FF was achieved without visible traces of fat-water dominance ambiguity. Tests using 12 descriptors had similar but slightly worse results. Multi-interference method achieved slope and intercept values of 0.0023 and 1.0425 ($P<0.001$). The proposed method achieved full-range FF estimation simulating a simple imaging method and performed better than a current method.

Contribution ID: 355
4. Modelling and Simulation
04.04. Modelling for diagnostic imaging

Noise effects in hepatic fat fraction estimation methods by using magnitude MRI

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Magnetic resonance (MR) has been used over the last three decades for the assessment of hepatic steatosis by estimating proton density fat fraction (FF). However, magnitude images and derived FF estimation methods are known to be affected by Rician noise. This abstract aims to simulate the performance at different signal-to-noise ratios (SNR) of four FF estimation methods: dual-echo, triple-echo, current state-of-art multi-interference and ANN, a novel method proposed by our group. Each method was tested with simulated datasets consisting of 5000 instances of gradient-echo in-phase/opposed-phase magnitude MR data ranging from 0.1 to 40% FF and Rician noise with SNR 200, 100, 50 and 25. Each instance had 7 data points corresponding to different echo times and carried a single combination of T2* decays representing water and six lipids modelling hepatic tissue. Estimated and simulated FF values were compared by linear regression and binary accuracy using 10% FF threshold. Results are presented in the following order: dual-echo, triple-echo, multi-interference and ANN. For SNR 200, regression intercept

values were -0.0273, 0.0249, 0.0033 and -0.0004 and regression slopes were 0.9312, 0.8819, 0.0421 and 0.9989, respectively. For SNR 100, intercept values were -0.0273, 0.0247, 0.0030 and -0.0003 and slopes were 0.9311, 0.8823, 1.0421 and 0.9981. For SNR 50, intercepts were -0.0278, 0.0241, 0.0033 and -0.0007 and slopes were 0.9329, 0.8843, 1.0404 and 0.9996. For SNR 25, intercepts were -0.0284, 0.0247, 0.0022 and 0.0020 and slopes were 0.9354, 0.8827, 1.0452 and 0.9900. All values had $P<0.001$. Binary accuracy with SNR 25 for each method was 0.9088, 0.9302, 0.9702 and 0.9763. For higher SNR values, accuracies were higher respecting ANN > multi-interference > triple-echo > dual-echo. Despite regression values for triple-echo being further from null hypothesis, it had better binary accuracy than dual-echo at any SNR. ANN outperformed current state-of-art at any SNR.

Contribution ID: 398
4. Modelling and Simulation
04.04. Modelling for diagnostic imaging

Modeling of the influence of acquisition parameters on x-ray digital tomosynthesis reconstruction results

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Digital X-ray tomosynthesis method is a novel pseudo-3D imaging modality, used, for example, in breast cancer screening and in thoracic diagnostics. Radiography equipment manufacturers propose a variety of tomosynthesis equipment models. Main differences between models lies in implementation of x-ray tube and/or detector mechanical movement along scanning trajectory and reconstruction algorithms. Moreover, the same model can use projections taken with various kVs, mAs, additional filtration, antiscatter grids, etc for reconstruction.
There is a need to compare these implementations and algorithms to choose most suitable for specific diagnostic purpose. Because of limited resources it is difficult to compare a big number of existing and prospective equipment in real world with real objects. Therefore our study deals with simulation of all the tomosynthesis process stages with IMASIM software, number of reconstruction algorithms written in MatLAB and proprietary reconstruction algorithms.
First we created phantom with fiduciary markers to measure relative positions of a focus, phantom and detector for each projection used for tomosynthesis. Measured positions were used for simulation.
Then we compared real projections of real phantom and corresponding projections of virtual phantom and found good fit between them.
Real and virtual projections along with measured positions were used in number of reconstruction software.
We compared reconstruction results from real projections of the real phantom and from simulated projections of identical virtual phantom. Simulation results show a good correspondence between reconstructed slices.

Contribution ID: 624
4. Modelling and Simulation
04.04. Modelling for diagnostic imaging

Patient-specific 3D printed pulmonary artery model: A preliminary study

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Purpose: Three-dimensional (3D) printing has shown potential value in medical applications with increasing reports in the diagnostic assessment of cardiovascular disease. The use of 3D printing in pulmonary artery disease is very limited. The purpose of this study was to develop a 3D printed pulmonary artery model and test different computed tomography (CT) scanning protocols for determination of optimal protocol with acceptable image quality, but low radiation dose.
Materials and Methods: A patient-specific 3D printed pulmonary artery model was created based on contrast-enhanced CT images in a selected patient. Different CT pulmonary angiography protocols consisting of 80, 100 and 120 kVp, pitch 0.7, 0.9 and 1.2 with 1 mm slice thickness and 0.6 mm reconstruction interval were tested on the phantom. Quantitative assessment of image quality in terms of signal-to-noise ratio (SNR) was measured in these images acquired with different protocols, while measurements in pulmonary artery diameters were conducted and compared between pre- and post-3D printed images and 3D printed model.
Results: 3D printed model was found to replicate normal pulmonary artery with high accuracy. The mean difference in diameter measurements was less than 0.8 mm (<0.5% deviation in diameter). There was no significant difference in SNR measured between these CT protocols (p>0.05). Radiation dose could be reduced by 55% and 75% when lowering kVp from 120 to 100 and 80 kVp, without affecting image quality.
Conclusions: This study shows it is feasible to produce a 3D printed pulmonary artery model with high accuracy in replicating normal anatomy. Different CT scanning protocols are successfully tested on the model with 80 kVp and pitch 0.9 being the optimal one with resultant diagnostic images but at much lower radiation dose.

Contribution ID: 626
4. Modelling and Simulation
04.04. Modelling for diagnostic imaging

Clinical Value of Patient-specific Three-dimensional Printing of Congenital Heart Disease: Quantitative and Qualitative Assessments

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Purpose: Current diagnostic assessment tools remain suboptimal in demonstrating complex morphology of congenital heart disease (CHD). This limitation has posed several challenges in preoperative planning, communication in medical practice, and medical education. This study aims to investigate the dimensional accuracy of three-dimensional (3D) printed heart model, as well as the clinical value of 3D printed model of CHD in the above mentioned areas.
Methods
Using cardiac computed tomography angiography (CTA) data, a patient-specific 3D model of a 20-months-old heart with double outlet right ventricle was printed in Tango Plus material. Pearson correlation coefficient was used to evaluate correlation of the quantitative measurements taken at analogous anatomical locations between the CTA and 3D printed model. Qualitative analysis was conducted by distributing surveys to 6 health professionals (2 radiologists, 2 cardiologists and 2 cardiac surgeons) and 3 medical academics to assess the clinical value of the 3D printed model in these three areas.
Results
Excellent correlation (r=0.99) was noted in the measurements between CTA and 3D printed model with difference less than 0.5 mm in all of the measurements. Four out of six health professionals found the model to be useful in facilitating preoperative planning, while all of them thought that the model would be invaluable in enhancing patient-doctor communication. All three medical academics found the model to be helpful in teaching, and thought that the students will be able to learn the pathology quicker with better understanding.
Conclusion

The patients' heart anatomy can be accurately replicated in flexible material using 3D printing technology. 3D printed heart models could serve as excellent tool in facilitating preoperative planning, communication in medical practice, and medical education, although further studies with inclusion of more clinical cases are needed.

Contribution ID: 717
4. Modelling and Simulation
04.04. Modelling for diagnostic imaging

Time-efficient Fourier domain evaluation of pharmacokinetic model in dynamic contrast-enhanced magnetic resonance imaging

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Dynamic contrast-enhanced magnetic resonance imaging has become an established tool to obtain information about tissue perfusion and capillary permeability. Following administration of a contrast agent, concentration-time curves measured in each voxel are fitted by a pharmacokinetic model, formulated as a time-domain convolution of an arterial input function (AIF) and an impulse response function (IRF). Since the measurement window contains hundreds of time samples, the discrete convolution is demanding, even when it is performed in the frequency domain via fast Fourier transform (FFT). Additionally, it causes convergence complications in the curve-fitting procedure, because the time-domain discretization causes local optima. Furthermore, it is not applicable to the functions, which have no closed-form expression in the time domain (e.g. tissue homogeneity model IRF). Both issues can be solved when formulating the functions in a closed form in the Fourier domain (as shown recently for tissue homogeneity model). The pharmacokinetic model is thus expressed as multiplication of the IRF and the AIF in the Fourier domain, followed by the inverse FFT and by truncation to the measurement window. To avoid time-domain aliasing, the number of samples in the Fourier domain must be higher than the sum of supports of the functions in the time domain. In the case of the functions with slowly decaying exponential, the support is wide (theoretically infinite), which dramatically reduces the computational performance. In this contribution, we propose a modification of the expressions for IRF and AIF in the Fourier domain to consider the measurement window. Our solution reduces required number of samples to twice the measurement window (in comparison with multiples of ten needed without the modification) and reduces the number of needed FFTs, which provides substantially faster evaluation of the pharmacokinetic model and its derivatives for each voxel in each iteration of the curve-fitting procedure.

Contribution ID: 1112
4. Modelling and Simulation
04.04. Modelling for diagnostic imaging

Probabilistic modelling and estimation of skull conductivity in EEG focal source imaging

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Electroencephalography (EEG) focal source imaging is an ill-posed inverse problem that is prone to errors in the electric conductivity values of the head tissues, particularly the skull. Unfortunately, these conductivities are difficult to determine in vivo. Therefore, we propose to use Bayesian approximation error modelling to take into account the uncertainties in the skull conductivity. First, we postulate a probability distribution for the skull conductivity, draw a set of conductivity samples and generate the corresponding lead field matrices. With these lead fields, we evaluate the statistics of the discrepancies in the EEG data (i.e. the approximation errors) with respect to a standard model with fixed skull conductivity. These statistics are subsequently taken into account in the inversion. We will show with finite element simulations that the uncertainty modelling improves the source estimates in comparison to the standard model, especially when the analysis is constrained into a specific region of the brain following an anatomical-functional atlas. The greatest improvements are achieved in cases when the true skull conductivity is lower than the assumed one and when the focal sources are close to the skull. Subsequently, we will show that in the special case when we can make assumptions on the dipole source orientations, we can simultaneously compute also a low-order estimate for the approximation errors related to the case. This estimate can then be used to obtain an estimate for the unknown skull conductivity. In the future, we will evaluate the proposed modelling technique with experimental data and study the possibilities of combining the probabilistic skull conductivity modelling with other uncertain parameters in the head model.

Contribution ID: 1249
4. Modelling and Simulation
04.04. Modelling for diagnostic imaging

Numerical study of a Microwave Haemorrhagic Stroke Detector

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Microwave systems constitute a novel technology that enables prehospital diagnostics of stroke and intracranial bleedings caused for example by trauma. The healthcare sector is in need of new innovations in both diagnostics and treatment of these diseases in order to further improve patient outcomes. Stroke and brain trauma are very common, they cause huge suffering among patients and are very costly for the society. Effective treatments exist that could benefit many patients. Treatment must however be preceded by diagnostics and a limitation of today's healthcare is the delays in the diagnostics, which has to be made at hospitals with CT. As a result, many patients receive treatment either too late to be effective, or not at all. This is extremely unsatisfactory, since a treatment given in time often can be lifesaving and lead to improved recovery.
Our research aims at developing a portable diagnostic system that can be used in ambulances and is capable of detecting intracranial bleedings. We have previously, with encouraging results, performed several smaller clinical studies to obtain proof-of-concept. Much investigation however remains to optimise the design of the system in order to maximise the performance. To assess the performance of a machine learning algorithm for detection a numerical study of the system has been conducted, simulating microwave measurements of stroke patients. The goal is to study the performance of the detection algorithm as a function of different design parameters of the system and the clinical studies, for example the number of patients included in the training data set.
As a result of this numerical study we conclude that this approach is feasible, but that it may require a large patient group, up to one thousand stroke patients or more, for training the algorithm in order to reach high sensitivity and specificity levels.

Contribution ID: 1476

4. Modelling and Simulation
04.04. Modelling for diagnostic imaging

Noise Rule in Dephasing and Its Influence on Image Quality in Diffusion Magnetic Resonance Imaging (MRI)

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Diffusion Magnetic Resonance Imaging (DMRI), is one of the specific sequence of Magnetic Resonance Imaging (MRI) which provides visual contrast that depends on Brownian motion during axons. Since the DMRI occurs in a shorter time in comparison with conventional MRI, it has lower spatial resolution. In addition, DMRI method suffers from image blurriness causing by magnetic field inhomogeneity.
Dephasing is a factor of magnetic field inhomogeneity, heterogeneity of tissue and etc., which is associated with the signal amplitude; therefor it has a very strong impact on the quality of images.
Random phase variables are described using Langevin equation and characteristic function of Gaussian random variables proposed by Cooke [Jennie M. Cooke, Phys. Rev. E 80, 061102 _2009__].
In this study, Langevin equation simulates noise affecting the dephasing to be calculated precisely signal amplitude.
Diffusion dephasing is solved in a random formalism by Stratonovich algorithm in Fortran. Then diffusion dephasing and signal amplitude simulate with and without considering inertia into account. Then signal amplitude will be analyzed in both cases. Our numerical method comparing with Cooke's analytical approach, which is a good fit. As a result, In the non-inertia approach, the stochastic results are same as classical (not stochastic) method, however, considering inertia, signal amplitude can be achieved with higher accuracy than before. In the next step, besides random phase variables, we consider random magnetic field gradient generated by magnetic field inhomogeneity in order to determine the amplitude of the signal in DMR. Random gradient caused a big gap in results. Thus, gradients in DMRI needs to be optimized and qualify more than conventional MRI.
Key Words: Magnetic Resonance Imaging (MRI), Diffusion Magnetic Resonance Imaging (DMRI), dephasing, Langevin equation and Stratonovich algorithm.

Contribution ID: 1614
4. Modelling and Simulation
04.04. Modelling for diagnostic imaging

Radiation dose rate assessment around patients in PET/CT units

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Radiation exposure assessment for PET/CT units is strongly needed for protection of the work staff and developing the work practice and shielding design. The objective of this paper is to assess the radiation exposure resulting from radioactive patients injected with different activities of 2-[18F] fluoro-2-deoxy-D-glucose (18F-FDG) in Positron Emission Tomography/Computed Tomography (PET/CT) units.
This objective is fulfilled by measuring the dose rates practically inside and outside PET/CT rooms around radioactive patients using a calibrated survey meter. Afterwards, the dose rates are estimated mathematically using Monte Carlo simulation model.

The results show that the dose rates on patient's body surface decrease greatly with distance and it is recommended for PET/CT staff to stand at distances more than 1.5 m from radioactive patients as possible during direct contact.
Also, it is found that, the shielding thickness of 3 mm lead and 25 cm ordinary concrete for the selected room dimensions is adequate and effective for the ɣ-radiation arising from radioactive patients.
The practically measured dose rates around radioactive patients are quite similar to mathematically predicted results and slight differences may be attributed to the difference between the estimated 18F biological half life time and real biological half life time due different biological uptake or excretion time from patient to another.
Key Words: Shielding, Monte Carlo, Positron emission tomography, Radioactive patients.

Contribution ID: 24
4. Modelling and Simulation
04.05. Detector modelling

An analytical X-ray CdTe detector response matrix for incomplete charge collection correction for energies up to 300 keV.

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Gamma and X-ray energy spectra measured with semiconductor detectors suffer from various distortions, one of them being so called "tailing" caused by an incomplete charge collection. Using the Hecht equation, a response matrix of size 321x321 was constructed analytically which was used to correct the effect of incomplete charge collection. The correction matrix was constructed for an arbitrary energy bin. The correction was tested and its adjustable parameters were optimized on the line spectra of 57Co measured in a spectral range from 0 up to 160 keV. The best results were obtained when the values of the free path of holes were spread over a range from 0.4 cm to 1.0 cm and weighted by a Gauss function. The model with the optimized parameter values was then used to correct the line spectra of 152Eu in a spectral range from 0 up to 530 keV and various experimentally measured X-ray spectra. Spectra of „narrow spectrum series" beams N120, N150, N200, N250 and N300 generated with tube voltages of 120 kV, 150 kV, 200 kV, 250 kV and 300 kV respectively, measured with the cadmium telluride (CdTe) detector were corrected in the spectral range from 0 to 160 keV (N120 and N150) and from 0 to 530 keV (N200, N250, N300). All the measured spectra correspond both qualitatively and quantitatively to the available reference data after the correction. To obtain better correspondence between N150, N200, N250 and N300 spectra and the reference data, lower values of free paths of holes (range from 0.16 cm to 0.65 cm) were used for X-ray spectra correction which suggests the energy dependence of the phenomenon.
The study was supported by the Ministry of the Interior of the Czech Republic, project No. MV-25972-2/OBV-2012-2017.

Contribution ID: 452
4. Modelling and Simulation
04.05. Detector modelling

Monte Carlo computational modeling of the ArcCHECK dosimetry system

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Modern radiation therapy treatments like VMAT search for the best conformational set up involving gantry rotation synchronized with multileaf collimator movement and dose rate deliverance. This complex dynamic process requires a very specific QA strategy to verify dose accuracy and potential delivery failures due its complex process on delivering radiation to the patient. It is very known that 2D dosimetric systems as radiochromic films and EPID have limitations to identify dose delivery errors and gel dosimeter has an expensive readout procedure. The most suitable dosimetry systems use 3D dosimetry phantom allowing an entire 3D dose distribution to be compared to those provided by the treatment planning. One of the most recent 3D dosimetry system commercially available is the ArcCHECK detector (sun nuclear), which is a 3D cylindrical phantom containing an array of diodes capable of measuring the dose in a rotating beam radiation delivery. In this work we developed a Monte Carlo computational model of the ArcCHECK dosimetry system using the MCNP6 Monte Carlo code. Several simulations have been performed using two approaches: a) using the FMESH tallies in a cylindrical surface and; b) explicitly modeling the diodes arranged in a helical format. The results were compared to experimental measurement responses when exposed to a 6 MV linear accelerator photon field in different irradiation configurations. The computational model reproduces satisfactorily the measured ArcCHECK responses and become an important resource for ArcCHECK response analysis in different irradiation conditions during the QA procedure.

Contribution ID: 619
4. Modelling and Simulation
04.05. Detector modelling

Monte Carlo study of beta-particle radio-guided surgery feasibility with a variety of radionuclides

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A Radio-Guided Surgery (RGS) technique exploiting beta- emitting radio-tracers has been suggested to overcome the impact of the large penetration of gamma radiation.
The detection of electrons in low radiation background, in fact, provides a clearer delineation of the margins of lesioned tissues. For this reason we developed a probe prototype for beta- RGS. However nowadays, the only β− radio-tracer suited for RGS is 90Y-DOTATOC. We studied the β− probe prototype capability to different radionuclides chosen among those used in nuclear medicine foreseeing new potential radio-pharmaceutical.
To do so we developed a Monte Carlo (MC) simulation of a typical clinical use of the probe importing a PET/CT scan. The CT voxel values have been converted from Hounsfield Units into density and elemental composition and the spatial distribution of the isotopes has been sampled using the FDG-PET scan.

The MC simulation of the probe includes the production and the transport of the optical photons in the scintillating crystal. This probe behaviour simulation has been benchmarked with a dedicated measurement campaign using radioactive sources of electrons and photons of different energies.
Based on the criterion of detectability of a 0.1 ml tumour for a counting interval of 1 s and an administered activity of 3 MBq/kg, the current prototype probe yields a detectable signal over a wide range of Standard Uptake Values (SUVs) and tumour-to-non-tumour activity-concentration ratios (TNRs) for 31Si, 32P, 68Ga, 97Zr, and 188Re. Although efficient counting of 83Br, 133I, and 153Sm proved somewhat more problematic, the foregoing criterion can be satisfied for these isotopes as well for sufficiently high SUVs and TNRs.
The case of 68Ga is of particular interest because of the increasing applications of 68Ga-PSMA in prostate cancer. Such application was tested with a feasibility study on a large sample of PET scans.

Contribution ID: 856
4. Modelling and Simulation
04.05. Detector modelling

Simulation study of parallax error in PET by using LSO, LYSO, BGO and GSO scintillation crystals by GATE simulation software

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The goal of this simulation study is the assess and comparison of Parallax error with different scintillator crystals in Positron Emission Tomography (PET). for this simulation study we use GEANT4 Application for Tomographic Emission GATE. The crystals which simulating in this study are LSO, GSO, BGO and LYSO. In this work we simulate PET scanner with two ring and hexagonal geometries. Full ring PET scanner which consist 26 detectors block which each block consist 96 crystal blocks. In every each crystal block there are 25 crystals. For hexagonal geometry in each head we simulate 620 blocks each one consist 25 crystals. in both of geometries a Pancreas phantom in cylinder shape use in this simulation. we set 350 KeV threshold and 750 KeV upholder. the coincidence window for both geometry is 10 nanosecond. Also we evaluate effect of gantry rotation on parallax error. To extract parallax of each case, we analyze simulation output via ROOT Tree .

Contribution ID: 1283
4. Modelling and Simulation
04.05. Detector modelling

Development of Low Cost Central Monitoring Platform by Modeling and Simulation for Patients Care in Low Middle Income Countries

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This study discusses and presents a medical engineering approach for developing a cost effective central monitoring platform for underprivileged patients in hospitals of the low to middle income countries. With the rapid development and adaption of medical technology, the developed countries have improved their patients care through medical engineering and establishing Central Monitoring Station (CMS). Whereas, economically low middle income countries like Bangladesh is not yet introduced CMS to practice or implement of standard patients care in several critical areas of hospitals due to lack of local expertise and awareness about the technological advancement and

their potential benefits. The main focus is on the development and application of advanced and proven vital parameters measuring technologies by modeling and simulation in the biomedical engineering laboratory. Central monitoring platform is designed and tested for centralized monitoring of vital patient information to observe patients basic parameters i.e ECG, SpO2, NIBP, Temp, RR using simulation. A set of UniPort universal ports was connected to expand the functions modules providing monitoring of IBP, CO2, AAg, BIS, PiCCO and noninvasive ICG which is presently found as very unpleasant. We have seen that the patient care from medical equipment in the middle income countries is found unsafe, unreliable and costly. But simulation results using such CMS has shown that the prevent life-threatening influences can be monitored from a single platform by quickly check patient’s status directly from a standard PC, Mac or tablet PC, a wireless PDA or smartphone. Patients care will be enhanced in many fold with safe and conveniently method in cost effective manner. It is an urgent issue to produce and introduce such medical engineered CMS in hospitals of low and middle income countries which will improve patients care and HTM at overall.
Key Words: CMS, Patients Care, Health Technology Management, Modeling and Simulation

Contribution ID: 340
4. Modelling and Simulation
04.06. Modelling for radiation protection applications

Absorbed dose assessment from decay chain of radon gas in human respiratory system: A Monte Carlo study

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Radon is a natural radioactive gas that can easily enter to the respiratory tract and cause lung cancer. The aim of this study was to determine the absorbed dose from radioactive products of radon’s decay chain in respiratory system using Monte Carlo simulation.
A cubic lung equivalent phantom including 64 air sacs was simulated by MCNPX Monte Carlo code. Then, the absorbed dose from alpha and gamma-emitter products of radon decay chain was separately calculated. The daughter radionuclides understudy were considered in two different geometric states. At the first state, the daughter radionuclides were considered as suspended particles inside the air sacs volume, while in the second one, it was supposed that the radionuclides are deposited on the inner wall of air sacs.
The results showed that alpha decay has more contribution to the absorbed dose by lung in comparison with gamma decay. The administered dose by alpha decay in suspended and deposited states were 6×106 MeV/gr-decay and 4.6×106 MeV/gr-decay, respectively. Polonium 214 was the most dangerous daughter nucleus which had the highest delivered dose in both states understudy. The absorbed dose by gamma decay in each above mentioned states was also equal to the 6.2×104 MeV/gr-decay and 5.3×104 MeV/gr-decay, respectively. In both geometric states understudy, Pb-214 and Bi-214 had almost the same contribution in the absorbed dose by gamma radiation.
From the results it can be concluded that the daughter radionuclides from decay chain of Radon, especially alpha emitter products, can be considered as a dangerous internal radiation sources. In addition, the biological effects of these daughter radionuclides is more severe when are suspended inside the respiratory system. Reducing the biologic effects of these internal radiation sources requires especial schemes to avoid entering the radon and its radioactive daughters to human respiratory system, as much as possible.

Contribution ID: 620
4. Modelling and Simulation

04.06. Modelling for radiation protection applications

Monte Carlo based determination of radiation leakage dose around a dedicated IOERT accelerator

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Evaluating the radiation contamination is a mandatory issue for medical accelerators. The impact of this stray radiation dose on cancer risk incidence is well established. Therefore, surveying the radiation leakage dose is particularly important for both patient and operator from health physics and radiation protection aspects.
Radiation leakage dose around LIAC head, a dedicated intraoperative radiotherapy accelerator, at different electron energy and field sizes have been estimated in this study.
The MCNPX Monte Carlo code was used model the LIAC head and connected applicators. Radiation leakage dose was calculated around the LIAC head at different energy and field sizes through tuning the Monte Carlo results to the practically measured data by ionometric dosimetry. Measurements were performed by Advance Markus ion chamber and inside an automated MP3-XS water phantom.
Results showed that the simulated model is an appropriate model for radiation leakage assessment around the LIAC head because of favorable agreement between the Monte Carlo results and measured ones. Radiation leakage dose was higher at the closer angles to the accelerator head and vice versa. As expected, the radiation leakage dose decreases with increasing the distance from LIAC head. Furthermore, with increasing the electron energy at the same field size, the leakage dose is increased too. Increasing the field size will also increase the radiation leakage dose.
Based on the obtained results, the radiation leakage dose is highly dependent to the electron beam energy, applicator size and distance. According to the results it can be concluded that the maximum contamination dose happens at closer distances to the accelerator and angles lower than 30 degrees respect to the electron beam central axis. The rate of stray radiation and leakage dose from this mobile dedicated IORT accelerator was considerably lower than those produced by standard conventional radiotherapy accelerators.

Contribution ID: 1067
4. Modelling and Simulation
04.06. Modelling for radiation protection applications

Calibration and validation of a Monte Carlo framework for general radiology

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A Monte Carlo framework is considered the gold standard for patient specific dosimetry. However, every framework has to be carefully calibrated and validated. An EGSnrc Monte Carlo framework was adapted for general radiology, requiring new calibration factors and validation. Present study describes how to perform the necessary measurements for the simulation of x-ray protocols.
The most common trunk protocols and related examination settings were extracted with the dose monitoring software (DOSE by Qaelum) used in the hospital. We examined ten trunk protocols: anterior-posterior and lateral views for abdomen, lumbar and thoracic spine examinations,

additional posterior-anterior view for chest and anterior-posterior view for pelvic examinations. For example, the chest posterior-anterior protocol uses a tube potential of 120kV, a 42x35cm^2 field of view and a source to detector distance of 179cm. The x-ray spectra were characterized by half-value layer measurements. Tube output measurements for calibration factors of the different spectra were performed free in air with an ionization chamber. For validation, measurements in three points were performed in a water phantom. Experimental results were then compared to the simulated results.
The calibration factor (unit: histories per mAs) was determined for the ten trunk protocols. Validation results of the ten trunk protocols in three points showed a mean difference of -4% and all results were within ±15%, except for one (-16%). Our data may allow other groups without direct access to x-ray systems to validate their MC frameworks too.

Contribution ID: 1376
4. Modelling and Simulation
04.06. Modelling for radiation protection applications

Technique and gender specific conversion coefficients for estimation of Effective dose from Kerma Area Product during X-ray radiography of Chest

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Purpose: The purpose of this research is to assess Kerma Area Product (KAP) to Effective dose (E) conversion coefficients (CC) specific to gender of patient and type of radiography technique applied during X-ray radiography of Chest.
Methods and materials: A sample of 2042 adult and pediatric patient records examined on 81 X-ray systems was included in present study. Effective dose for each patient examination was assessed using Monte Carlo simulation software PCXMC, version 2.0.1. CC in μSv·/μGy.m^2 were determined using linear fit for “soft” – bellow 100 kV and “hard” radiography techniques with respective tube filtration for males and females respectively.
Results: CC obtained for adult males and females were 1.05 (R2=0.93) and 1.32 (R2=0.97) respectively when using the “soft” techniques. For “hard” techniques CC values were 1,85 (R2=0.98) and 1,98 (R2=0.98) for males and females respectively.
Conclusion: Present study shows technique and gender related differences in conversion coefficients estimated for standard adult patients. CC obtained for pediatric patients contribute to assessment of patient effective doses and hence the risk in individual and population exposures cases.

Contribution ID: 142
4. Modelling and Simulation
04.07. Physiological modelling

A model describing the multiphasic dynamics of mixed meal glucose responses in healthy subjects

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Characteristic features of the postprandial glucose response are associated with the risk of developing diabetes mellitus and an essential criteria for the assessment of glycaemic control in the management of diabetes mellitus. In this context, conventional meals have been shown to produce a wide range of different glucose responses, dependent on various meal and patient related characteristics. For this study we focused on the occurrence of mono- and biphasic glucose responses by developing a suitable parametric model, capable of capturing this phenomenon. A total of 24 meal responses from six healthy male subjects were recorded using continuous glucose monitoring (CGM). The responses were classified into mono- or biphasic profiles using straightforward criteria, implemented in an automated algorithm. A mathematical model consisting of a linear second order differential equation with a novel dual Gaussian input function is proposed to adequately describe the dynamics associated with large variations observed in the recorded meal reposes. The meal classification yielded a 50 % split between mono- and biphasic responses, justifying the need for a highly flexible model structure. R2 values of model output compared to CGM data was 92.8 ± 7.3 %, indicating a good overall model fit. Parameters were found to be related to the mono- and biphasic shape of the response and meal composition. The proposed model is capable of describing a wide range of mixed meal glucose responses in healthy subjects with parameters related to profile shape and meal characteristics, which could be used for the objective assessment of postprandial glucose exposure and therefore improve glycaemic control in diabetic patients.

Contribution ID: 152
4. Modelling and Simulation
04.07. Physiological modelling

Models of physiological parameters for runners and cyclists

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Portable devices able to record continuously data related to health state and changes of various physiological values enormously developed in recent years. The most common physiological data to collect include heart rate (HR), but also oxygen saturation, core body and skin temperature, blood pressure, ECG, oxygen consumption and others. The data obtained are often related to various forms and intensities of physical activity, and in accordance with the principles of personalized medicine evaluated. Some devices even collect all those measurements into small armbands, and combine it with an accelerometer and GPS to track the activity simultaneously. In this way, we can investigate how different physiological parameters change at rest and during physical activity. Mathematical models able to simulate some physiological parameters e.g. heart rate, oxygen consumption etc. during cycling exercise on bicycle ergometer or running exercise on treadmill. Workload intensity (in Watts) on bicycle ergometer and running velocity (in km/h) on the treadmill are taken as input for dynamic models. Determination of dynamic models of heart rate, oxygen uptake, pulmonary ventilation and other parameters is fundamental for athletic training methodology, as well as evaluation of cardiorespiratory capacity and fitness. The present work demonstrates the application of dynamic systems models to the simulation of heart rate kinetics and oxygen consumption during workloads of time-varying intensity. Optimization of free model parameters could be used as an important information about the health condition of the subject with special reference to the cardiorespiratory capacity and fitness age. Models are based on physiological principles, and parameters are being optimized. The models could be used both for athletes as well as for untrained sedentary population.

Contribution ID: 343
4. Modelling and Simulation
04.07. Physiological modelling

Balance control in perturbed conditions: an optimized closed-loop model approach

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It is well accepted that one of the simplest ways to modeling unperturbed upright stance regulation is a closed-loop mechanism which applies an active torque to the considered lower limb joints, correcting for excessive body sway which could lead to fall. One of the first and most used controller to model neural regulation of balance is a PID controller. Nevertheless, this approach can be followed under some a priori assumptions: first, upright stance must be treated through a one DOF plant, typically a single-link inverted pendulum (IP) which considers only one lower limb joint, i.e. the ankle-joint. Second, equations describing the latter must be linearized in order to apply PID-based control.
Here, the application of a PID-based control for the balance maintenance after external perturbations is proposed. Human upright stance was modeled through a single-link IP, requiring the assumption of small perturbations of balance. Thus, control model was evaluated on experimental data obtained from perturbed stance trials consisting of a series of disruptions of the same magnitude and in the same direction (backward). Amplitude of balance disruption (15 cm/s, 5 cm) supported the assumption of small perturbation and thus the model linearization. PID parameters (KP, KD, KI) were estimated through an optimization procedure based on the difference between measured and estimated center of pressure (CP).
Results showed low tracking errors for CP displacement and PID parameters appeared able to describe changes in balance response according with the trial sequence, highlighting an adequate description of how the subject tailors perturbation withstanding mechanisms. This study indicated the suitability, under specific conditions, of using a simple control technique for tracking balance responses also in perturbed conditions; this feature can help to gain further insight on how the central nervous system responds to external perturbation of quiet stance.

Contribution ID: 481
4. Modelling and Simulation
04.07. Physiological modelling

Effect of myocardial infarction size on the simulated ECG morphology based on a 3D torso-heart model

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Objective: Myocardial infarction (MI) is one of the major cause of death. Thus understanding the underlying mechanism of MI and its clinical features, especially its relationship with the common electrocardiography (ECG) measurement, is important. However, the effect of MI size on the simulated ECG morphology is still unsatisfactory.
Methods: Using a simplified 3D torso-heart model, the electrical activation of the heart and its conduction were simulated. The 3D torso-heart model adopted consists of the torso, lungs, and the whole heart components, including atria, ventricles, and blood chambers. Simulation of MI was performed by changing the control parameters of the infarcted region. All infarcts were located in

the anterior wall of the left ventricle. The effect of MI size (three sizes: 0.7 mm3, 381.1 mm3, 2407mm3) on the stimulated standard 12-lead ECG morphology was explored.
Results: The results demonstrated the progressions of heart depolarization and repolarization and revealed the difference of electrical conduction between the normal and MI hearts. Compared with the normal heart, MI heart showed changes in the ECG ST segment for all 12-lead ECGs. There were obvious amplitude depressions in ST segment in I~III, aVF and V4-V6 leads, and the depression ratios increased from 1%~58% with the increase of the MI size. In contrast, the amplitude in ST segment elevated from 8%~49% in aVR and V1 leads. In addition, the amplitude in ST segment hardly changed in aVL and V2 leads.
Significance: This study provided a quantitative analysis for the effect of MI size on the simulated standard 12-lead ECG morphology. The simulated results confirmed the changes in ECG ST segment due to the MI changes are consistent with the clinical futures. Thus it provides an alternative tool for understanding the inherent conduction mechanism of ECG signal.

Contribution ID: 573
4. Modelling and Simulation
04.07. Physiological modelling

The Effect of the Uncertainty in the Contrast Concentration Measurement on the Estimated Pharmacokinetic Parameters in Brain DCE-MRI Studies

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Precision analysis of the estimated PK parameters is essential in DCE-MRI studies, specially, when PK parameters are used as a measure for therapy evaluation or treatment planning. Uncertainties in contrast-concentration measurement, such as uncertainties in intrinsic tissue properties and imaging parameters, can contribute on the estimated PK parameters. In this study, using the modified-Toft-model combined with Model-Selection (MS) technique and Maximum-Likelihood-Estimation (MLE), the propagation of the systematic uncertainties in the contrast-concentration measurement to the estimated PK parameters was investigated in brain DCE-MRI studies. 3450 longitudinal relaxation rate, ∆R1(R1 = 1/T1), profiles for three physiologically-nested models (10 profiles for Model 1: no vascular leakage, 310 profiles for Model 2: leakage without efflux, and 3150 profiles for Model 3: leakage with bidirectional exchange) were simulated with a wide variation of the PK parameters. The uncertainty of the measured contrast-concentration for different systematic biases in flip angle(FA) and pre-contrast longitudinal (T1,0) was analytically calculated with following DCE-MRI parameters: filed strength=3T, temporal resolution=5.035 sec, FA= 20°, TE/TR ~ 0.84/5.8 ms and signal to noise ratio=10. The PK parameters were estimated for each ∆R1 in presence of different percentage biases (-10% to +10%) in flip angle and T1,0. Then, mean percentage error (MPE) of the PK parameters was calculated for all simulated ∆R1s. Among the estimated PK parameters, the blood plasma volume (vp) is most sensitive parameter to uncertainties in measured contrast concentration, especially vp in Model 2 that may overestimate up 800% for simultaneous biases in FA (10%) and T1,0 (10%). The lowest MPE of the estimated parameters is related to the inverse transfer constant (kep), which is ~2% in 10% bias in FA and 10% bias in T1,0. The forward transfers constants for Model 2 and 3 have MPE less than 8% in the investigated range of systematic bias of FA and T1,0.

Contribution ID: 609
4. Modelling and Simulation
04.07. Physiological modelling

Physiological data monitoring of members of air forces during training on simulators

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The members of air forces during training on simulators can in their mission exe-cution often get to many complex situations, which may result in mentally vigor-ous situations or even overload. The aim of the paper is to describe the current state and our contribution to development of systems for measurement of the physiological data of basic member of air force including mission commander, pi-lots, air traffic controllers and ground support staff. The reason for physiological data monitoring is to test the possibility of usage them to estimate the physical and psychological state and eventually for identification of dangerous situations in the staffing of the military mission. Authors present, how the modules of mon-itoring system were designed, training simulators adapted, and measurement and tests were performed. The base for the design of physiological data monitoring was the FlexiGuar system, originally developed at the FBMI CTU. The core of simulators for training of military personnel in aviation was Lockheed Martin's Prepar3D simulation software. In addition, two airplane cockpits were used as simulators for training of two pilots, air traffic control simulator, i.e. a control tower, and an airport ground station for the preparation of aviation ground staff. The proposed systems are used for simultaneous measurement of the working performance and physiological data of members of the four-member team (two pilots, one ATC staff and one ground staff member) during their training. The physiological data (heart rate, body temperature, movement activity and perspira-tion intensity) are transferred to the commander visualization unit for further evaluation. Designed systems and methods could help to monitor, on the base of physiological data and data from simulators, the stress load level and visual load level and based on this knowledge to determine, if the individual training and teamwork is sufficient or can lead to dangerous situations in practice.

Contribution ID: 652
4. Modelling and Simulation
04.07. Physiological modelling

Features of Two Mechanisms of Subarachnoid Space Width Regulation. Proposal of Two New kSSH and kccSS Parameters

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NIR-T/BSS is a new, highly promising diagnostic method. It allows continuous measurement of changes in the width of the subarachnoid space. These changes can be caused by mechanical injuries, the physiology changes or pathological changes. The article contains the further part of the analysis of the experiment described in the previous article. Analyzes are based on the premise that patients should be divided into 2 groups. These groups differ in the subarachnoid space width changes regulation mechanism. The article contains the characteristics of both groups (similarities and differences) and new parameter. New parameter will help to classify patient to one of the group.

Contribution ID: 785
4. Modelling and Simulation

04.07. Physiological modelling

Evaluation methodology and measurement of physiological data to determine operational preparedness of air defense staff

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The aim of the article is to introduce new evaluation methodology to determine operational preparedness of air defense staff based on measurement of physiological data. The individuals working with air defense systems are under very high level of stress and long-term monotone air picture observation workload during the mission. We designed a method of monitoring the actual operator condition, psychological state, tiredness and ability to adapt to a new situation during long-term work on air picture simulator that shows real-time aircraft flight information. Long-term monitoring and recording of potential airborne targets in the area of interest to which operators are subjected is accompanied by monitoring the physiological data such as heart rate, body temperature, movement activity and perspiration intensity of operators. The reason for choosing these physiological data is the ability to use them to estimate the psychological and physical stress and periods of tiredness of operators. We present how the monitoring system was designed, training simulators adapted, and measurement and tests performed. The core for the design of physiological data monitoring was the monitoring system developed at the FBMI CTU to support training of soldiers of the ground troops. The software for air picture simulation on which operators did the training tasks was installed on computers with the possibility of simultaneous monitoring of physiological data of operators. The proposed methodology and measurements were tested on four air defense system operators of the Army of the Czech Republic. Operators took part in a four-hour intensive measurement without any break and their training was evaluated for wrong or missing air target record. Designed methods could help to monitor, on the base of physiological data and data from simulators, the stress load level and operational preparedness. Also, on the base of the knowledge, the individual training can be modified.

Contribution ID: 1017
4. Modelling and Simulation
04.07. Physiological modelling

Dynamic effects of obstructed airways mechanics on the forced expiratory curve

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Spirometry is the most widely used test of lung function. Its status arises from the effort-independence of the registered maximal expiratory flow-volume (MEFV) curve, its reproducibility for a given subject and simultaneous sensitivity to respiratory disorders. A few methodologies to model and simulate forced expiration have been proposed for the last decades: simplified dynamic models built with electrical analogues, and morphology-based complex models assuming a quasi-static flow of uncompressible air. Previous trials have shown that characteristic swings in the MEFV curve, sometimes visible in the case of obstructive diseases, cannot be reproduced by the quasi-static models.
The aim of this work was to test the hypothesis that the aforementioned specific details in the MEFV curve are caused by dynamic phenomena occurring during forced expiration, and that they manifest particularly in obstructive diseases.

To this end, the computational model for forced expiration (including Weibel's bronchial structure, nonlinear mechanical properties and fundamental physical phenomena in quasi-static conditions) was further developed by including the dynamic phenomena: additional flows from narrowing airways, and gas compressibility and inertia. The MEFV curves simulated using the dynamic and quasi-static models were then compared for a variety of respiratory system states.
For most simulated cases of normal lungs as well obstructed airways, the differences between forced expiratory curves computed with the dynamic and quasi-static models were negligible. Only implementing some specific conditions, causing that flow limitation existed right in small airways, yielded a visible alteration and the characteristic swing after the peak expiratory flow (PEF), reported in the literature.
Concluding, the dynamic effects of airway narrowing and gas compressibility and inertia slightly modify the MEFV curve near the PEF only in specific cases. This finding justifies the general use of the quasi-static complex models as an adequate tool for forced expiration simulations.

Contribution ID: 1156
4. Modelling and Simulation
04.07. Physiological modelling

Comparison of ECRES algorithm with classical method in management of diabetes type 1 exercise-related imbalances

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Nutrition and physical activity are important parts of a healthy lifestyle and management of diabetes. Regular moderate-intensity physical activity in type 1 diabetes patients can enhance insulin sensitivity, reduce the risk of cardiovascular disease and improve psychological well-being. Nevertheless, the risk of exercise-induced hypoglycemia is a great challenge for patients with type 1 diabetes and represents an important barrier to physical activity in these patients. Recently, an algorithm called ECRES has been developed with the aim of estimating, depending on patient's own therapy and specific physical activity, the glucose supplement required by the patient to maintain safe blood glucose levels (Francescato et al., 2011). The aim of this study is to compare the ECRES algorithm to classical "quantitative" approach (Perkins at al., 2006). Therefore, we measured and compared glycaemia in 23 patients (mean age: 43±12 years) during one-hour treadmill walk/run maintaining heart rate at 65% of his/her theoretical maximum value for age. For each subject two separate tests were performed: with carbohydrates supplement estimated by ECRES algorithm and by classical approach, respectively. The average heart rate observed during exercise (average progression speed: 5.8±0.8 km/h at 4.2±2.3% inclination) was 111.5±9.4 bpm. Glycaemia measured by portable glucometer showed no significant differences between tests managed with ECRES algorithm and with classical approach, both at the beginning (140±24 vs 145±20 mg/dL) and at the end of the performed exercise (140±42 vs 137±54 mg/dL). The ECRES algorithm, however, estimated a significantly lower amount of carbohydrate needed for physical activity as compared to that suggested by the classical approach (15.8±12.0 vs 23.4±4.7 g; $p<0.05$), while maintaining patients' blood glucose within optimal clinical limits. The study results confirmed the validity of the estimates made by the ECRES algorithm.

Contribution ID: 1192
4. Modelling and Simulation
04.07. Physiological modelling

Parameter search to find ranges of activation and inhibition of wound healing rate in a mathematical model with introduced photobiomodulation

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When light stimulation is used for wound healing therapy, a biphasic dose-response curve is observed, where cells are activated below and inhibited above a treatment dose threshold. Light treatment-dose responses are not yet incorporated into mathematical models of wound healing - yet these relationships would support optimisation of wound healing treatment protocols. This work adapts an existing wound healing mathematical model by exploring parameter values and introducing exogenous photobiomodulation treatment inputs for future applications in model-based experimental research. A wound healing mathematical model, created by Sherratt & Murray in 1990, includes proliferation, migration, and activating and inhibitory chemical terms. This model was implemented and discretized by Forward Euler (FE) in time and the Central Difference Method (CDM) in space in 1D. Travelling wave solutions of cell density and chemical concentration were obtained and used to plot wound closure in time and to estimate the wound healing rate. A parameter search was conducted to identify ranges where model simulations resulted in activation, inhibition, saturation, or numeric instability of wound healing. Published results of photobiomodulation treatment-control studies reporting a percentage change in proliferation were used to scale proliferation terms, thus serving as a proxy for light stimulation. Results showed the inhibition model was more sensitive to parameter variation than the activation model. Changes in the cell migration parameter are most sensitive overall. Most model parameters were bounded by saturation or numeric instabilities, while otherwise demonstrating activating and/or inhibitory effects on the rate of wound healing. Light stimulation simulations were consistent with expectations that increasing the proliferation term increased wound healing rate. To support photbiomodulation model-based experimental wound healing research, the model parameter search identified threshold values categorising activation or inhibition of wound healing rate and this work also adapted a model proliferation term consistent with photobiomodulation biological effects.

Contribution ID: 1198
4. Modelling and Simulation
04.07. Physiological modelling

Activation propagation in cardiac ventricles using the model with the conducting system

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The activation propagation characteristics in an ellipsoidal model of cardiac ventricles with several configurations of an endocardial layer representing the fast conducting Purkinje fibers were compared in this study. To resemble the conduction system, the activation propagation velocity in the conducting layer in the model was set three times higher than in the working myocardium tissue.
The activation propagation characteristics were obtained by two approaches. In the first one, the membrane potential temporal and spatial changes were obtained by the numerical simulation of the reaction - diffusion (RD) equation of the propagation with the ionic transmembrane current density defined by modified FitzHugh-Nagumo equations that was numerically solved in Comsol Multiphysics environment. In the second approach, the electrical excitation of the cardiac tissue was simulated by a cellular automaton (CA) model computed in Matlab environment.
Activation times for the both ventricles were evaluated and compared for the both approaches for the case of model with and without the conducting layer representing Purkinje fibers (heterogeneous and homogeneous model). Activation times were also compared for the model

with one starting point of activation and for several starting points imitating physiological conditions. Pathological maximal activation time higher than 120 ms was acquired in the RD and CA homogeneous ventricular model with one starting point. Realistic activation times of the whole ventricles up to about 80 ms - 120 ms were obtained for models with the conducting layer. The difference of activation times in heterogeneous RD and CA model with one starting point was higher (mainly in the proximity of starting point) that was caused by delayed activation onset in the RD propagation model and lower velocity of propagation in the RD model due to higher curvature of the activation front.

Contribution ID: 1221
4. Modelling and Simulation
04.07. Physiological modelling

Paced Electrical Field Modeling within Ischemic Myocardium

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Cardiac pacing in the ischemic area is very disadvantageous, because of higher pacing thresholds and lower sensed intrinsic signal. An irregular propagation of myocardium activation in ventricles is also a clinical problem of ischemia. The aim of this paper is to model the theoretical electrical depolarization propagation within the ventricle myocardium, using the mathematical and computation methods.
For numerical simulation of different biological or physiological systems, the models utilizing the differential equation are appropriate. The basic model is Hodkin-Huxley, describing the action potentials on the basis of different particular ion channel permeability. Our characteristics of modeled tissues are described according to the Fitzhug-Nagumo model, which is simplification of Hodkin-Huxley. The computation was performed using Comsol Multiphysics software.
The results are composed by several models of ventricles: physiological, with apex or left lateral ischemia, and all three with low or high energy right ventricle or biventricular pacing. Activation times of ten chosen points in our geometry are compared mutually and also to the reference physiological model and to the results of clinical studies. The results of the simulations of right ventricular pacing issue agree with clinical experience. The results confirm the increase of the ischemic dyssynchrony because of different activation times in the right ventricle in comparison with the left ventricle. The apical pacing in the ischemic area shows the latest activation times in comparison with the physiological reference. In this case, the lead reposition would be recommended.
Our models show the similar ischemic tissue characteristic as commercially available physiological mapping systems. The location of ischemic lesion within the model is variable and can be used also for the pacing effectiveness assessment and planning.

Contribution ID: 1236
4. Modelling and Simulation
04.07. Physiological modelling

The electric conductivity of human cerebrospinal fluid in vivo

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Cerebrospinal fluid (CSF) is a clear, highly conductive liquid. Due to its much higher electric conductivity compared to other intracranial tissues, its influence is significant, for example, in volume conductor models, current distribution and heat generation in RF surgery. Previous research has shown that it is important to include CSF in models to achieve more accurate results. It is common that conductivity values measured in vitro are used in modelling because in vivo values are not available. We have developed a method for taking calibrated in vivo human CSF conductivity measurements with a needle electrode. We used this method to take CSF conductivity measurements from four patients during brain surgeries that were conducted to remove tumours. The selection of the patients was made so that the surgical path went through a ventricle to make sure that there was enough CSF volume to take the measurements. Two of the patients had meningiomas and the other two had gliomas. Measurements taken from clear CSF with our method resulted in conductivity values of 1.81–1.79 S/m. Impurities such as blood or the presence of cystic brain tumours decreased the measured electrical conductivity of CSF. Our results support the findings that the previously suggested conductivity value of 1.79 S/m for human CSF at 37 degrees Celsius, taken from in vitro measurements, is applicable for modelling purposes.

Contribution ID: 1349
4. Modelling and Simulation
04.07. Physiological modelling

Modelling details for simulations of deep brain stimulation

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Deep brain stimulation (DBS) is a well-established technique for symptomatic treatment of e.g. Parkinson’s disease and essential tremor. Computer simulations using the finite element method (FEM) are widely used to estimate the affected area around the DBS electrodes. For the reliability of the simulations, it is important to match used simulation parameters with experimental data. One such parameter is the electric field magnitude threshold EFt required for axon stimulation. Another is the conductivity of the perielectrode space (PES) around the electrode. At the acute stage after surgery the PES will be characterized by an increased conductivity due to inflammation and edema while the later chronic stage will be characterized by a lower conductivity due to gliosis and minor scar formation. In this study, the EFt and the electric conductivity of the PES have been estimated by comparing FEM simulations with clinical studies of activation distance, pulse length and electrode impedance. The resulting estimates are an EFt of 0.2 V/mm at the common pulse width of 60 μs and a chronaxie of 62 μs for other pulse widths. Estimated electric conductivities for the PES are 0.14 S/m in the acute stage and 0.05 S/m in the chronic stage, assuming a PES width of 250 μm. These values are thus experimentally justified to use in FEM simulations of DBS.

Contribution ID: 1393
4. Modelling and Simulation
04.07. Physiological modelling

Thermophysiological and thermopsychological modeling of local radiant heating effect on human thermal comfort in electric vehicles

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A new localized cooling or heating technology that can provide low energy consumption and thermal comfort for the passenger in an electric vehicle at a level similar to that of the conventional HVAC (heating, ventilation and air conditioning) system is needed. This study aims to develop a thermal comfort model for local radiant heating in an electric automobile cabin. A MATLAB-based simulation program for predicting human thermal comfort was developed and an experiment on an actual vehicle was conducted in a cold environmental chamber to verify the effectiveness of the model. Infrared heaters were used for local radiant heating with two subjects, one in the driver's seat and another one in the passenger's seat. To verify the effect of the infrared heaters, the experiment was conducted in two parts, a base experiment using an existing cabin HVAC, and an IR experiment with reduced amount of air conditioning and added infrared heaters. As confirmed by the subjects' responses, the infrared heater was effective in increasing the thermal sensation of the lower body more rapidly. From the IR experiment, the correlation coefficient between overall thermal sensation response of the subject and local thermal sensation calculated at each site was found largest in both shins and back thighs where heating was directly applied. Therefore, it can be pointed out that the local heating has a big influence on the overall thermal sensation while heating in a cold place. We selected five areas with high correlation coefficients and found that the weighted average of skin area reflects the tendency of overall thermal sensation similarly. Based on our thermophysiological and thermopsychological model, we intend to establish a local radiation heating strategy in an electric vehicle that is comparable to or better in terms of occupant thermal comfort, with energy saving compared to existing HVAC systems.

Contribution ID: 1403
4. Modelling and Simulation
04.07. Physiological modelling

Simulation of respiratory impedance variations during normal breathing using a morphometric model of the lung

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The forced oscillations technique (FOT) enables a non-invasive monitoring of respiratory mechanics, returning the impedance of the respiratory system (Zrs) at chosen frequencies. Recently it has been shown that the intrabreath variations of Zrs are correlated with respiratory diseases, mainly due to sensitivity of Zrs to morphological changes in the respiratory system. Direct inference to the respiratory system state from the Zrs swings is, however, questionable because of the complexity of the lung structure and underlying physical phenomena.
The aim of this study was to develop a morphology-based computational model able to adequately simulate the variations of airway dimensions during quiet breathing and the resulting temporal changes in Zrs.
The model assumes the Weibel structure of the bronchial tree, separate lung and thorax wall viscoelasticity, as well as nonlinear properties of the upper airways and the mechanical load imposed by the FOT device. It takes into account the distributed character of pressure loss along the airways and flow-limiting mechanisms based on the compliant airway walls. Quasi-dynamic simulations are performed with sampling period of 0.01 s, and for each instant the distributed properties of airways are recalculated to a lumped parameter net corresponding to the momentary Zrs.
The implemented model enabled the simulation of primary signals characterising quiet breathing of a normal subject, as pleural and alveolar pressures, airflow or tidal volume. Additionally, the

intrabreath variations in Zrs were extracted for both the normal case and specific patterns of airway constriction.
The simulation results recovered the marked flow- and volume-dependent variations of Zrs observed in healthy subjects and their alterations associated with uniform bronchial obstruction. However, testing specific hypotheses about the manifestation of inhomogeneous lung diseases in the intrabreath FOT data involves future incorporation of structural heterogeneity into the model.

Contribution ID: 1424
4. Modelling and Simulation
04.07. Physiological modelling

A highly-detailed 3D model of the human atria

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Atrial fibrillation is the most common sustained arrhythmia and it is expected that its prevalence will continue to increase as the population ages. It is considered a major cause of morbidity and mortality, resulting in a significant impact in health systems budgets. However, prediction, prevention and treatment of atrial fibrillation is still a great scientific challenge. Multiscale cardiac modelling has greatly advance since it is a powerful tool to better understand the physiopathology of this disease. In this study we present a “true” 3D model of the human atria with anatomical and functional heterogeneity. For the first time, the model includes a realistic definition of the atrial wall thickness (from 0.5 to 7 mm) and transmurality in fibres orientation. The model of Courtemanche was used to solve the electrical activity and tissue propagation was described by the monodomain formalism. To reproduce the heterogeneity in the atrial properties, nine cellular models and ten atrial tissues were defined. The electrical behaviour of the new model was validated by comparing the propagation sequence in sinus rhythm with respect to the experimental local activation times. Then, the electrical remodelling was also included through the variation of the maximum conductance of Ito, IcaL, Ik1, Ikur y Iks, producing a 56% reduction in the APD90 and adding vulnerability for atrial fibrillation. We compared the fibrillatory activity of the new model with two models less detailed anatomically but with the same electrophysiological properties. The three models reproduced different fibrillatory patterns with the appearance of rotors in different areas, demonstrating that the anatomical properties of the model affect the electrical behaviour of the simulation. In conclusion, we demonstrate that that it is very important to implement detailed models to obtain results as close as possible to the real system.

Contribution ID: 1474
4. Modelling and Simulation
04.07. Physiological modelling

A hybrid cardio-pulmonary simulation platform – an application for extracorporeal assist devices

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Food and Drug Administration USA agency is encouraging to use modeling and simulation in medical device evaluation, in order to reduce validation process and animal experiments. In the European Union Directive 2010/63/EU is also encouraging to reduce animal experiments and to find alternatives experimental methods. To address this challenge, the variety of models and simulators are developed, playing the role of artificial/virtual patients or animals. In the case of

cardiovascular and respiratory systems, the popular approach is to develop hydraulic or pneumatic mock-up simulators, allowing the interaction with physical cardiovascular (ventricular assist devices, heart valves prosthesis etc.) and respiratory (respirator, spirometer) devices. The evolution of mock-up systems are so called hybrid (physical-numerical) simulators, inheriting an interaction with physical medical devices, from mock-up systems, and moreover, inheriting also the advantages of numerical models like flexibility and accuracy of cardio-pulmonary physiology reproduction (modeling).
In our Institute, the pneumo-hydro-numerical cardio-pulmonary simulation platform (HCPSM) was developed. It is the hybrid comprehensive cardiovascular-respiratory simulator, designed for multi applications connected with mechanical circulatory and respiratory assistances. Thanks to the numerical cardio-pulmonary model implemented, various heart and lungs diseases are possible to simulate.
In this study, a hybrid (hydro-numerical) interface dedicated to extracorporeal circulatory assistance, was developed. It enables new applications for HCPSM – the interaction of percutaneous extracorporeal assist devices and extracorporeal membrane oxygenation (ECMO) systems with HCPSM numerical cardiovascular system. ECMO system can be connected to HCPSM by both veno-venous and veno-arterial configurations. In this study ECMO hydraulic model was connected to HCPSM, where as its membrane oxygenation capabilities was simulated numerically. The application for extracorporeal assist devices extends the whole HCPSM functionalities in terms of the heart and lungs assistance simulations. HCPSM can be used by wide range of stakeholders, as a test-bench for various medical assist devices, as well as for educational purposes.

Contribution ID: 1481
4. Modelling and Simulation
04.07. Physiological modelling

Physical breast model as a simulator of pathological changes

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It’s well known that there is a relationship between skin temperature and many pathological changes. Local increase of temperature on a skin surface can represent symptoms of such diseases as: bacteria or viral infections, viral diseases as well as it might indicate an occurrence of a tumor. For verification and validation medical devices and products based on the registration of local temperature changes, a simplified physical breast model was designed and constructed. Breast model is based on PCBA with matrix of resistors, which generate areas of temperature higher than surrounding parts of the phantom within range from 0,25 to 2 degrees Centigrade. Proposed idea is based on conversion an electrical energy into thermal energy in controlled way dependent on a value of current flow. It provides different thermal surface reaction based on activation particular local heat sources (single or multiple resistors) which can simulate inflammation, local skin changes connected with temperature increase e.g hormones variation or cancer. Therefore, the physical breast model can work with medical devices equipped with thermometer, infrared camera, contact thermography device or thermo-optic indicators. In this study we present a simulation of breast cancer for a needs of contact thermography (Braster) and simulation of inflammation for needs of thermo-optic indicator (termochromic pigment and liquid crystal foil).

Contribution ID: 1483
4. Modelling and Simulation
04.07. Physiological modelling

VirRespir – an application for virtual pneumological experimentation and clinical training

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Last years, modeling and simulation are more and more common tools, supporting both engineers and physicians in their activities. Numerical (computer) models are the most popular implementation, to perform different simulation scenarios. They provide users a powerful and flexible instrument for virtual experimentation. Merging various numerical models of cardiovascular and respiratory parts (heart, lungs, blood vessel etc.), makes it possible to develop one system – a virtual patient (ViP).
Although, there are several complex models of the cardiovascular system, their pulmonary part is usually simplified in comparison to the other parts. The authors of such models often not focus on pulmonological system phenomena, so much. Therefore, VirRespir – the ViP system in the form of web application accessible form http://virrespir.ibib.waw.pl/, was developed in Nalecz Institute of Biocybernetics and Biomedical Engineering, Polish Academy of Sciences. The intention of VirRespir was to deliver a comprehensive, pneumological ViP as a pulmonary supplement to user's models of the heart and systemic circulation (HSC). A possibility to join VirRespir with external HSC models is an unique feature. VirRespir provides also an embedded, simple HSC model, if necessary. It enables to perform virtual spirometry, mechanical ventilation or spontaneous breathing in health and various obstructive and restrictive diseases. Together with an external HSC model, it can be extended by e.g. mechanical circulatory assistance scenarios. VirRespir is executed on a local machine (computer), thus the connection with user's external HSC model is realized by local TCP/IP protocol. Thanks to it, the HSC model can be developed in any programming language. Mutual data exchange between the VirRespir and external part is performed by a specified interface. VirRespir is free accessible and can be used in research and for educational purposes (medical students and clinical personnel training).

Contribution ID: 1529
4. Modelling and Simulation
04.07. Physiological modelling

The effects of expiratory flow limitation and different inspiratory and expiratory airway resistances on dynamic hyperinflation of the lungs

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Dynamic hyperinflation occurs when mean alveolar pressure exceeds the mean airway pressure measured in the airway opening. The dynamic hyperinflation develops as a consequence of insufficiently short expirium terminated by the subsequent inspirium. Two main principles are supposed to create the dynamic hyperinflation during high frequency oscillatory ventilation (HFOV): expiratory flow limitation and different inspiratory and expiratory airway resistances (Re>Ri). The aim of the study is to design and test a physical model of the respiratory system comprising both the mechanisms causing dynamic hyperinflation and to characterize their effect upon dynamic hyperinflation or hypoinflation development during HFOV. The models were created using a rigid volume and passive pneumatic components mimicking the required characteristics of the airway resistance. The models were connected to a HFOV ventilator and different ventilator setting was applied in order to investigate the parameters having the most significant effect on dynamic hyperinflation development. The main result of the study is that the expiratory flow limitation corresponds better with the observed and published properties of the respiratory system during HFOV. The magnitude of dynamic hyperinflation depends on ventilator setting. The acquired results are supported by recently published studies using mathematical-physical modeling and correspond with results of the published clinical trials.

Contribution ID: 1530
4. Modelling and Simulation
04.07. Physiological modelling

Design and evaluation of a complex physiological model for testing of novel lung ventilators with a closed-loop oxygen fraction control

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Recently published clinical trials document that manual control of oxygen fraction in the inspiratory gas in neonates is not prompt enough to react to the rapidly changing physiological status of a neonate. As a result, the arterial blood oxygen saturation exhibits significantly long periods when the actual oxygen saturation level goes outside the desired safe range. The closed-loop systems are able to optimize the inspiratory oxygen fraction in steady-state situations, but they do not perform well when a rapid change of physiological parameters occur. As a consequence, new algorithms for the closed-loop control of the inspired oxygen fraction are been searched nowadays. The aim of our study was to create a physiologically-realistic model of a neonatal organism allowing testing the newly developed algorithms for oxygen control in neonates. The design of the model is based both on the theoretical and up-to-date knowledge of the physiological principles and on the well documented natural changes of the neonates' statuses observed in the NICU setup by the authors. The simulated outputs of the model well correlate with the real situations observed in the clinical setup.

Contribution ID: 1784
4. Modelling and Simulation
04.07. Physiological modelling

Identification of components from distant fibers in recorded single muscle fiber potential – a simulation study

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Single-fiber EMG (SFEMG) is used as a routine procedure to study physiological and morphological parameters of motor unit. The most important usefulness of SFEMG is to evaluate neuromuscular transmission and fiber density. The aim was to study the impact on jitter measurement and fiber diameter determination in case when recorded single fiber potential (SFP) is contaminated by distant fibers.
Morphological counterpart of SFP were studied using computer simulations and a model of the linear source of a muscle fiber potential since its properties are well understood and are consistent with experimental measurements.

The criteria defining SFP in case of SFP contaminated by distant fibers were analyzed and the influence of the second fiber contamination on the jitter and fiber diameter determination were analyzed.
We found that SFP criteria prevent the detection of SFP from fibers smaller than about 30 µm in diameter, but do not prevent a classification of a potential as an SFP even though it is formed by two or more fibers. This means that the presently used criteria may lead to incorrect interpretation of SFP potentials.
The results suggest that contamination of other fibers may impact jitter measurement.
SFP contaminated by distant fibers may fulfill the SFP criteria but a negative peak may be shifted in time and therefore impact jitter and diameter measurements. The contamination tends generally to decrease the jitter as well as determined diameter.

Contribution ID: 1809
4. Modelling and Simulation
04.07. Physiological modelling

Biomechanical modelling of the semicircular canal of the inner ear to simulate vertiginous syndromes

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The vestibular system is the sensory part of the inner ear in charge of maintaining and promoting body balance, in a complex connection with eyes and gait. Vertigo is a kind of dizziness, occurring mainly as a consequence of a vestibular system disorder. Generally, the patient has the perception of a spinning motion and, in severe cases, as a part of the vestibular rehabilitation program, specific maneuvers have to be performed. However, it is not totally explained how this procedure works.
The study of the movements made during the vestibular maneuvers is the most important step in the course of the rehabilitation process. Since this work aims to computationally simulate the biomechanical behavior of this complex system, a 3D model of the vestibular system was developed. The model is composed of three main parts; a small shell ring (built using triangular shell-elements) representing one semicircular channel (SCC), particles representing the fluid inside (simulated with smoothed particle hydrodynamics) and the cupula. The model representing the vestibular membrane of the SCC is defined as rigid body. The properties of the model, for the components described, were obtained from the literature.
One of the objectives of this work is to simulate the fluid behavior and the study of its interaction with the soft tissues of the vestibular structure. The developed model allows the simulation of the maneuvers of the vestibular rehabilitation, under different conditions and disorders, virtually allowing to improve its results and the quality of life of patients suffering from vertigo.

Contribution ID: 380
4. Modelling and Simulation
04.08. Computational biology in BME

Numerical study for lung microwave ablation in different thermal and electrical properties

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Microwave ablation (MWA) is a minimal invasive operation for treating lung cancer, and it has been widely used in clinic. Lung contain tracheas and bronchus, and the properties of thermal conductivity, electrical conductivity and density change by variations in the lung's internal air volume. Thus, it is difficult to control the precise formation of coagulation zones. In this paper, we propose to use finite element method (FEM)to simulate the microwave ablation for lung cancer in a simple lung model. We set the power as 10 watts for 10 seconds at 2.45GHz. We built the lung model and a small bronchus was placed close to the opened-tip coaxial antenna with airflow at the rate of 3[L/min]. We operated 8 patterns including the collapsed and aerated lung in different thermal conductivity, electrical conductivity and density to simulate. The results showed a predictable ablation shape which affected by airflow. In addition, we found that under the same density and electrical conductivity, with the decreasing of the thermal conductivity, the ablation region expanded.

Contribution ID: 1511
4. Modelling and Simulation
04.08. Computational biology in BME

The study of the multi-scale modeling method to determine the reason of the graft's non-patency based on transit time flow-meter

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Transit time flow-meter (TTFM) has been usually used in coronary artery bypass grafting (CABG) to detect whether a graft is patent or not, but it can't determine the reason of the graft's non-patency. The graft's non-patency is mainly caused by two reasons: competitive flow and anastomotic stenosis. To solve this problem, several CABG multi-scale models with different degrees of competitive flows or anastomotic stenosis have been constructed in this study to calculate their graft flow waves. The shape of the waveform, the average flow, pulsating index (PI), diastolic velocity time integral fraction (DF) and fast Fourier transformation (FFT) ratio have been obtained from calculation results. According to the analysis, the shape of the waveform and FFT ratio could be the indexes to determine whether the reason of the non-patency is competitive flow or anastomotic stenosis.

Contribution ID: 237
4. Modelling and Simulation
04.09. Mimicking phantoms

RF ultrasound based estimation of pulsatile flow induced microdisplacements in phantom

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Mechanical stimulus is key component to estimate tissue stiffness. Few techniques have been developed to induce external mechanical stimulus into tissues. We hypothesize that the natural tissue motion due to cardiovascular activity could be employed for this purpose. The assessment of elastic sub-millimeter tissue displacements is one of the leading developments for ultrasonic characterization of tissue stiffness. The objective of this study was to investigate the feasibility to parametrize the phantom tissue response to pulsatile flow. The displacements were evaluated in a tissue mimicking phantoms with known stiffness.

The three agar phantoms, having vessel imitating channel with controlled pulsatile flow inside, were manufactured (agar concentrations 10, 6 and 3 g/l in distilled water, predicted Young modulus was 26, 10 and 7 kPa respectively). The pulse water flow in channel was produced by centrifugal pump MultiFlow (Gampt) with period of 1 s. The length of channel was 14 cm embedded in the tissue mimicking agarose gel. Linear array transducer L14-5 (5-14 MHz) driven by scanner SonixTouch (Ultrasonix) was used for the echoscopy of phantom and ultrasound RF data acquisition. The collected beam formed B-mode RF data (125 fps) were used for the displacements estimation applying phase-correlation technique. Output matrix of phase-correlation was decomposed into principal components. Only first and second principal components were processed in sub-sample algorithm. The pulsation of channel diameter and displacements of material were estimated at few distances from channel border in all phantoms.
The pulsation of diameter and displacements of material were parametrized extracting double amplitudes. Amplitudes of displacements of material were normalized according to pulsation amplitude of channel diameter. The relation of amplitude parameters with concentration of agar is obtained. Displacement shows correlation with stiffness. The method may provide the technological background for future studies characterizing in-vivo tissue stiffness from vascular generated displacements.

Contribution ID: 628
4. Modelling and Simulation
04.09. Mimicking phantoms

Creation of computational breast phantoms with extracted abnormalities from real patient Images

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Early diagnosis of breast cancer can significantly increase the probability for successful treatment of the disease. Therefore, many efforts are focused on improvement of the existing imaging techniques or investigations of new ones. Along that, anthropomorphic phantoms, either physical or computational, are widely used in the relevant research studies.
This work presents an approach for creation of complex computational breast phantoms, with included breast abnormalities.
In-house developed and validated software tool, called BreastSimulator, is used to create different models of healthy breasts, by varying parameters like shape, size, duct tree features, Cooper ligaments, skin, etc.
Separately, different 3D tumour models are constructed from segmented tumour regions on sets of real tomosynthesis images from real patients. A semi-automatic algorithm was developed to segment the abnormalities in the images. The algorithm applies a series of image processing operations and region-growing techniques with minimal interaction from the user to find the areas of the lesions. The flat tumour images are then correctly stacked and stored in a 3D voxel matrix, matching the desired resolution. Relevant information about the lesion (voxel size, matrix size, geometrical centre, etc.) is also saved.
Selected tumour models are then inserted at various locations into the computational models of the healthy breasts. Examples of simulated mammographic and tomosynthesis images from such breast phantoms are presented to illustrate the potential of the proposed approach.
Combining mathematical breast modelling with segmented real 3D tumour shapes results in the creation of realistic breast phantoms. The approach allows implementation of multiple scenarios and unlimited number of cases, which can be used for further software modelling and investigation of breast imaging techniques.

Contribution ID: 989
4. Modelling and Simulation
04.09. Mimicking phantoms

Investigating ballistic gelatin based phantom properties for ultrasound training

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The simulation has become an important tool for healthcare practitioners who have difficulty in accessing patients to learn ultrasound imaging modes. The ultrasound phantoms are specially designed objects that are used or imagined to evaluate, analyze and adjust the performance of test devices. These phantoms for ultrasonography devices are expensive, and low-cost alternatives have provided an educational experience that does not give the best result. Ballistic gelatin is a member of the 250-Bloom hydrogel family that resembles human muscle tissue in terms of its mechanical properties. The 250-Bloom Ballistic Gelatin (BG) is prepared with different mixing ratios to be made the mechanical tests such as gunshot, compression and electrical conductivity measurement. The results are compared with the mechanical results of human muscle tissue in order to measure the similarity of the 250-Bloom BG we prepared to human muscle tissue. It is showed that the 250-Bloom BG phantom model has very close mechanical properties to human muscle tissue at time-dependent characteristics of mechanical test results. It is also measured how long it can last without degradation with the time required to use it in the simulation and it is coated with the thermal insulation material needed to extend the degradation period. Based on these results, 250-Bloom BG phantom is recommended as a model for the creation of phantom limb model. Consequently, this model is a much more affordable alternative and easy to produce, it facilitates to work with any organ model in ultrasound imaging for healthcare practitioners.

Contribution ID: 995
4. Modelling and Simulation
04.09. Mimicking phantoms

Quality assurance in medical 3D-printing

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Introduction:
In the strive towards patient specific healthcare, medical 3D-printing has proven to be of great value. With the growing possibilities in applicability of these 3D-prints, quality control of the complete surgical 3D-printing workflow: 1. scan segmentation, 2. 3D-printing and 3. sterilization, has never been of more importance. The objective of this study was to provide a quality control methodology to assess the reproducibility, accuracy and stability of a medical 3D-printing workflow.
Method:
With computer-aided-design (CAD) software a quality control (QC)-phantom was designed with dimensional characteristics based on commonly used surgical guides. Seven identical QC-phantoms were 3D-printed and labeled (n=1..7). Their dimensional parameters were determined by physical measurements. Through comparison with the CAD-drawing, information was gained on the performance of the 3D-printer. The first phantom was then scanned on a CT-scanner with a slice thickness of 0.2 mm. The 3D-segmented phantom was 3D-printed and its characteristics compared to the original. The other six phantoms (n=2..7) underwent a number of sterilization cycles (3 min, 134 °C) corresponding with their label.

Results:
The overall printer accuracy was found to be within 0.2±0.05 mm deviation. In the segmentation case shrinkage of the slots and holes of max. 0.4±0.05 mm occurred compared to the original phantom. Furthermore, within a cycle of six sterilizations (n=2..7) the accuracy and durability of the materials does not deteriorate.
Conclusion:
By design of this phantom, a method to implement overall QC of a medical 3D-printing workflow was developed. Execution of this method showed that the quality of the complete medical 3D-printing workflow can be assured and that it provides insight in the influences of each of the different steps in the workflow. In this study the strongest effect on the dimensional characteristics was observed in the segmentation step. In following cases, the identified effects will be taken into account.

Contribution ID: 1834
4. Modelling and Simulation
04.09. Mimicking phantoms

Patient-specifc phantom: craniopagus twins for medical training

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Craniopagus twins are conjoined twins that are fused at the cranium. Usually, if the twin's health allows, a separation surgery is done after careful evaluation of the development of the twins, to maximize the success of the surgical procedure and the individual evolution of each. Each craniopagus patients have particularities, that requires a complex study around the surgery procedures to line up all professionals involved in the case.
Tissue mimicking phantoms are useful for medical training. However, for some specific cases of surgery, a dedicated phantom is needed in order to train the abilities the surgeon and to plan the hole surgery procedure. The development of patient-specific simulators would support medical planning and training with a trustworthy model.
In this study, we develop an head model of craniopagus twins for medical training and surgical planning. The twins are two 19 months old girls. They are attached by the top of the head with the bodies symmetrically positioned on opposite sides. To develop the phantom, the CT images were segmented with the aid of InVesalius software (Centro de Tecnologia da Informação Renato Archer, Campinas, Brazil). A digital 3D model of the twin's head was reconstructed and exported to a 3D printing compatible file. Therefore, a 3D printer (Zmorph 2.0 S, Wroclaw, Poland) was used to reproduce the skull of the craniopagus twins. The 3D printed skull was covered with molten styrene-ethylene/butylene-styrene (SEBS), a homemade copolymer. This phantom model is being used by physicians to simulate the skin cutting and post-surgery suturing. The morphology, the visual aspects and the texture of the structures of the skin and the skull successfully mimic the real case according to the surgeons evaluations

Contribution ID: 649
4. Modelling and Simulation
04.10. Bioinformatics

Nanopore single-molecule DNA sequencing simulation in raw current space

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The accuracy of basecalling on Oxford Nanopore Technologies' (ONT) MinION single-molecule real-time DNA sequencing platform has recently increased to above 90% with the help of a multitude of recently released deep/convolutional neural network basecallers. Nevertheless, a significant challenge facing researchers attempting to train these neural networks is the lack of accurately labeled training data. ONT basecalling is confounded by the fact that the characteristic picoampere level current measured in a pore while a DNA strand passed though it is representative of at least 5 adjacent bases. While the reference sequence that the read comes from is often known, it is insufficient to accurately reconstruct which segments of the current diagram correspond to each nucleotide transition in the current waveform. Insertions and deletions are significant sources of error in ONT basecalling, and the basecalled reads are difficult to map to exact points in the time-current domain. We hypothesize that a simulator capable of modeling the underlying physical process can allow more efficient training of basecalling algorithms.
We introduce a new simulation algorithm, SimuPore, which accurately models the characteristics of the physical process, and is constructed from empirical data to allow the creating of perfectly labeled training sets. Our model uses an Erlang distribution to sample the individual timings, which correspond the the motor protein's cycle of nucleic acid binding, release and translocation, along with empirically determined current levels corresponding to each k-mer. We demonstrate the accuracy of current generation basecallers on a wide range of simulated data sets, and allow researchers to flexibly and efficiently perform a wide range of simulations before undertaking a sequencing experiment.

Contribution ID: 1255
4. Modelling and Simulation
04.10. Bioinformatics

Protein subnetworks involving sHSPs during acclimatization process in living organisms.

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Small heat shock proteins (sHSPs) are low molecular weight (12–40 kDa) chaperones that have been associated with stress tolerance by preventing irreversible aggregation of misfolded proteins. Abiotic stress and developmental changes trigger sHSP gene expression and protein synthesis in all living organisms, suggesting the existence of a complex chaperone-network to maintain cellular homeostasis after heat stress (HS) exposure. Acclimatization process is characterized by the exposition to mild HS (35-38 °C) before severe HS (41-45 °C) exposition and is related to chronic adaptation to abiotic stress conditions. However, acclimatization might be involved in the adaptation of plants and animals to global warming. Identifying key regulatory and master regulators during this process, might contribute to agricultural and medical areas for better breeding programs coping with global warming. In order to describe which are the possible strategies developed by different organisms to face HS, we made an exhaustive bibliography curation process to identify experiments of HS, in the presence or absence of an acclimatization process. After assigning the corresponding Uniprot ID of co-regulated genes up-regulated in non-acclimated and acclimated HS organisms, predicted protein-protein interaction analysis (PPIs) were performed using STRING database. We identified similar gene chaperone network members, mainly represented by HSPs: HSP100, HSP90, HSP70 and sHSPs. Notably, a conservative subset of sHSPs are shared between co-expressed genes during HS in different model and nonmodel organisms (human, drosophila, wheat, Arabidopsis, rice, tomato and potato). Particularly, at least one of each mitochondrial, chloroplastic and cytosolic class I sHSPs, were present in all datasets analyzed. Despite small variations in their order of appearance, HSP90, HSP70 and HSP100 proteins were identified and constitutes the first barrier or fence in response to HS conditions in different organisms. Our findings suggests that a conservative subnetwork could be involved specifically during acclimatization in living organisms.

Contribution ID: 38
4. Modelling and Simulation
04.11. Biological modelling

CFD Simulation of Sneezing in a Full Realistic Human Upper Airway

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In this study, we have modeled the sneezing in a 30 years old man. The CT scan images were used and the maximum air flow as well as mean outflow were measured using spirometer . A three dimensional geometry including the nose, trachea, and bronchial.The flows were considered as the boundary conditions of the model. The hybrid, prism, tetrahedral and octahedral meshing were used . The air flow was considered as steady, in compressible , and turbulent. ANSYS software was used for numerical simulations. The results including velocity/pressure contours show that the mean velocity of air flow exiting the mouth and nose are 5.5 and 12.1 m/s . In the case of maximum flow, the outlet velocity of exiting air are 26.2 and 11.3 m/s. The maximum pressure was found in trachea which was 14 kpa. The deformation of the trachea was obviously high during sneezing and should be studied in detail.

Contribution ID: 436
4. Modelling and Simulation
04.11. Biological modelling

Basic Cardiovascular Computer Models Show System Degeneracy When Used in Reverse on Standard Measured Parameters

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Physiology based computer models are used to simulate cardiovascular system. When used in reverse the state of cardiovascular system is determined from measured values and results are used in patient specific medicine. However, reverse approach is limited by system degeneracy - a situation where the measured values are same but the system states are different. By using uniqueness analysis we explored the origin of system degeneracy by studying it in the most basic two parameter cardiovascular physiological models: Wind-Kessel model of aortic flow and Hill model of muscular fibre mechanics.
For both models a 2D parameter space (WK: compliance, resistance; H: contractility, activation time) and a measurement space (WK: peak pressure, mean pressure; H: sarcomere length pattern in time) were generated. The parameter space formed discrete parameter pairs obtained by gradually increasing each parameter throughout its physiological range. The measurement space had simulations for each parameter pair. Then in measurement space a family of similar values was found to each simulation where similarity was a realistic level of measurement error. The

family members when presented in the parameter space formed connected components. Number and shape of these components served us to determine the degree of degeneracy.
We found that the component in parameter space remains non-divided for all parameter pairs in both models. However the shape of the component is asymmetrical and depends on the parameter value. In both models one parameter (WK: compliance; H: activation time at low contractility) showed large uncertainty (50% of its physiological range).
Large uncertainty in one parameter is a form of degeneracy and we found that it exists already when using the simplest physiological two parameter model. Models and measured parameters used in reverse engineering needs to be carefully evaluated for degeneracy.

Contribution ID: 550
4. Modelling and Simulation
04.11. Biological modelling

A sliding mode control model for perturbed upright stance in healthy subjects

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Human upright stance and balance maintenance in quiet conditions have been extensively evaluated throughout the years. However, relatively less information is available on how the central nervous system (CNS) acts to maintain balance after sudden perturbations of stance. Here, a sliding mode (SM) control model for the characterization of balance maintenance after external perturbations is proposed. Human stance was modeled as an inverted pendulum (IP), which described kinematics and dynamics of balance in the sagittal plane; the choice of a SM controller allowed to avoid model linearization, commonly employed when using a single-link IP for bipedal stance modeling, thus providing a more accurate description of the human-stance system dynamics.
Model was applied on experimental data obtained from perturbed stance trials consisting of a series of disruptions (backward direction) of the same magnitude. This experimental condition was able to elicit a well-known feature called "habituation rate", which refers to the subject capacity to self-adapt his responses to identical perturbations. SM control model parameters were selected through a robust optimization procedure (Artificial Bee Colony), based on the difference between measured center of pressure (CP) and the IP model output. Further, a parameter which weighted the role of the subject disruption knowledge was also considered in the SM controller.
Results showed limited tracking errors for CP displacement and velocity and for the ankle torque. SM controller parameters exhibited clear trend from the first to the last trial, seeming to change in accordance with the trial sequence and thus being able to quantify the "habituation rate" effect. The application of such a control model to the non-quiet stance can provide additional information in understanding how the CNS tailors balance responses in different conditions. Further studies will involve the expansion to multi-link IP models and different experimental conditions, e.g. sensory deprivation and progressively higher disruptions.

Contribution ID: 669
4. Modelling and Simulation
04.11. Biological modelling

Using an agent-based model of the budding yeast cell cycle as a base model for the development of cancer drugs

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Kinetic parameters are a key aspect when studying reactions involving proteins; unfortunately, these are often unknown or hard to measure in the laboratory, therefore, modeling phenomena involving protein reactions without using kinetic parameters can be a big advantage. In this work, an agent-based model of the budding yeast (Saccharomyces cerevisiae) cell cycle was created based on a network of key regulators of the cell cycle, in order to obtain the correct sequence of states of the regulatory proteins. Comparing the results to a Boolean network model, having similar results, both models reached in most of the cases the biological G1 stationary state of the cell. Yeast cell cycle is highly conserved among other eukaryotes, meaning that is regulators works similar than the ones in humans; knowing that, yeast cells can be mutated to have a behavior similar to a specific tumor and then treated with different drugs to check which is better to kill that specific tumor. This model could be a starting point for being used in the development of cancer drugs adding cell cycle mutations that match a specific type of tumor cell cycle and an agent representing the drug or treatment.

Contribution ID: 773
4. Modelling and Simulation
04.11. Biological modelling

Genetic algorithms applied to estimate 6-parameters model which define analytical function to simulate the Motor Unity force from experimental measures

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An individual twitch of motor unity MU force can be simulated by 6-parameters model, then a train of repeated pulses evokes a tetanic contraction. However, is a hard issue to estimate the parameters for one twitch, and the way to put many of them, such that can reproduce a shape tailored a muscle contraction generated by a set of stimulation pulses. In this work, genetic algorithms are applied to estimate nine parameters from experimental measures, where six are used to define a 6-parameters model, and the other three are used to generate a train of pulses, which simulate muscle contraction. The measured data by dynamometer were used with genetic algorithms to estimate the nine parameters, after that, their information was compared with data measured by electromyograph. The results show that calculated parameters, like as latency time, contraction time, repetition time, half contraction, intermediate time of relaxation force and number of pulses, can be applied to generate a set of successive twitches to simulate the muscle contraction, with an error less than 5%. Besides, the simulation results prove that force level depends directly on repetition frequency, number of pulses and amplitude of stimulation signal. finally, in this work the genetic algorithms worked like an excellent tool to optimize and validate a theoretical model with the experimental data, a despite the process last more than forty hours for each training, the method was friendly to apply and to reconfigure many options before to find the best solution.

Contribution ID: 1142
4. Modelling and Simulation
04.11. Biological modelling

Study on effect of surrounding fluid property on sperm motility

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The swimming process by which mammal spermatozoa progress towards an egg within the reproductive organs is important in achieving successful internal fertilization. The viscosity of oviductal mucus is more than two orders of magnitude greater than that of water, and oviductal mucus also has non-Newtonian properties. In this study, we experimentally and numerically investigated sperm motion in various fluid flow in order to investigate the effect of surrounding fluid properties on sperm motility. We calculated the three kinds of sperm velocities, that are straight-line velocity (VSL), curvilinear velocity (VCL) and average path velocity (VAP). The results indicated that the increase in viscosity brought about the decrease in the sperm velocity, whereas in non-Newtonian fluids the linearity(VSL/VCL) increased. Additionally, increasing the viscosity brought about large changes in the sperm flagellar shape. At low viscosities, the entire flagellum moved in a curved flapping motion, whereas in the high-viscosity, only the tip of the flagellum flapped. These results suggest that the bovine sperm has evolved to swim toward the egg as quickly as possible in the actual oviduct fluid, which is a high-viscosity non-Newtonian fluid. The results will provide valuable information for improving the success of artificial insemination in animal husbandry and for the development of microfluidic devices to treat infertility.

Contribution ID: 1167
4. Modelling and Simulation
04.11. Biological modelling

A computer model for individual patient parametrizing of ventricular tachycardia termination algorithms

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Background:
Antitachycardial pacing (ATP) is a painless method for terminating ventricular tachycardias (VTs). If ATP does not succeed (in terminating the VT) a painful high energy shock has to be delivered. A method for maximizing the ATP success rate would, therefore, prove highly beneficial for the individual patient. ATP can be parametrized in several ways using scan, ramp or scan+ramp approaches and can be applied in the right ventricle or in both ventricles (biventricular). In the multicentric randomized ADVANCE-CRT trial the different ATP protocols were tested and it could be shown that biventricular ATP is safe, but there was no significant difference between right ventricular and biventricular ATP. A computer simulation model is presented capable of finding the optimal ATP protocol for an individual patient.
Methods:
A computer model of the individual patient's ventricle generated from a 3D/4D data set and a hybrid automaton
was used for modeling and simulating different VT scenarios. For each VT scenario (cycle lengths ranging from
288 [ms] to 408 [ms]) different ATP protocols derived from the ADVANCE-CRT trial were applied in order to evaluate their effectiveness in terminating the VT.
Results:
This computer simulation study reconfirmed the results of the ADVANCE-CRT trial. Biventricular (BiV) ATP did not prove to be more effective than right ventricular ATP.
Conclusions:
The availability of a computer model for the individual patient combined with knowledge of the ischemic area and the underlying mechanism of the VTs will allow these models for optimizing ATP

management. The number of painful high-energy shocks resulting, possibly, in adverse effects could, therefore, be minimized while maximizing the ATP success rate.

Contribution ID: 1300
4. Modelling and Simulation
04.11. Biological modelling

Monitoring of yeasts growth by bioimpedance spectroscopy

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Industrial bioprocesses usually occur in bioreactors, where the stages of the microorganism growth must be monitored to optimize the whole process. Off-line analytical methods are considered gold standard for such monitoring, but they are time consuming and may postpone important decisions making. Thus, there is always demand for the development of real time (on-line) monitoring methods for bioprocesses. Despite the existence of some methods used to measure the concentration of biomass in real time, such as optical density or turbidimetry, many of them are not able to distinguish living microorganisms from other materials, including dead microorganisms. This work proposes an on-line method for monitoring of total biomass and of viable cells using a bioimpedance spectroscopy based on the current response to a step voltage excitation. To evaluate the proposed method, we performed an experiment of growth with yeast strain Saccharomyces Cerevisiae species with initial inoculum of 0.1g/L and 0.5g/L. The total amount of microorganism (using Neubauer chamber), the number of viable ones, and bioimpedance data were collected every hour during a period of 12h. For each initial inoculum three series of data were collected. The results indicate the proposed technique present good prediction of the total amount of microorganism (R=0.918) and of the number of viable ones (R=0.858).

Contribution ID: 1351
4. Modelling and Simulation
04.11. Biological modelling

Investigation of the cardiac dynamic using a three coupled Van der Pol oscillators model

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Heart is a rich Multiphysics problem. Its functioning involves muscular contractions, electric impulses and blood flows. As an organ that performs an essential physiological role, several mathematical models were develop to describe and reproduce its behavior. Some of these models are related to the electrical impulse of the cardiac rhythm. The muscular contraction is accomplished by the Action Potential (AC) that, generated in the sinoatrial node, spreads to the atrioventricular node and later to the complex of His-Purkinje. The AC is an electrochemical impulse that can be measured by the Electrocardiogram (ECG). The measured wave in the ECG is due to the depolarization and repolarization of the muscular cells. This paper deals with a model

composed by three coupled Van der Pol oscillators with time delay that is able to reproduce the ECG. Time delays considered in the model are due to delays experimented by the AP in the atrioventricular node and in the His-Purkinje complex. Using this model, numerical simulations are performed in order to investigate the occurrence of some pathologies: atrial flutter, atrial fibrillation, ventricular flutter and atrial fibrillation. Normal and pathologic behaviors of the cardiac cycle are analyzed by Poincaré map, constructed by defining a proper plane in phase space, and the Lyapunov exponent is used to quantify each behavior. Bifurcation diagrams are constructed showing the route from normal functioning to the pathologies.

Contribution ID: 1486
4. Modelling and Simulation
04.11. Biological modelling

Approximate entropy as a dynamical measure of osmotic water permeability across cell membrane

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Approximate entropy is a statistical measure, which indicates level of regularity and predictability, thus a level of new pattern generation. Increased value of this parameter is reflecting a higher system complexity, represented by a more random behavior. Decresing of approximate entropy thus could be associated with regularity and predictability in analysed data sequences.
The aim of this study was to investigate changes of water dynamics, reflected by nonlinear parameter of approximate entropy, due to the changing adaptation of water diffusion across cell membrane under different osmotic conditions.
At the first, a mathematical model of water diffusion across eukaryotic cell membrane was build in regard to different hypotonic and hypertonic extracellular conditions, reflecting the classical approach based on Fick's and van’t Hoff 's laws of cell osmotic processes. The coupled system of ordinary differential equations has been derived from the temporal evolution of volumetric flow rate and intracellular ion concentration resulting from osmotic adaptation.
Next, the water permeability through cell membrane was defined as a proportion of diffusion coefficient and membrane thickness for each given osmolarity. Computational method for derivation the water permeability through cell membrane was established using model theoretical time constants.
Finally, the approximate entropy parameter was expressed for different sequencies of water permeabilities as calculated for different intervals of osmolarities. The results showed that a higher water flow velocity, characterized by increased kinetic energy, resulted in significal increase of approximate entropy and thus a more complex behavior. Therefore, the approximate entropy parameter could be considered as a sentitive measure to the characteristics of water flow pattern across cell membrane.

Contribution ID: 42
4. Modelling and Simulation
04.12. Hemodynamics

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Right ventricular outflow tract (RVOT) reconstruction traditionally is treaded by open repair with pulmonary valve implantation or replacement. Percutaneous pulmonary valve implantation (PPVI) has evolved as most exciting development surgical strategy with dysfunctional right ventricle-pulmonary artery conduits. However, size restrictions of the currently available valves for PPVI application prevents development in a larger pool of patients. We examined the hemodynamic and functional consequences of ePTFE-valved conduits and compared with bio-prostheses and prostheses valves in an in-vitro model. We used a mock circulation system that mimics a pulmonary circulation looped system to analyze the hemodynamics of different prosthetic valves and handmade ePTFE-valved conduits. By using a mock circulation system, three quantified determinants were employed to validate the results: pulmonary regurgitation, regurgitation fraction, and ejection efficiency. Additionally, the prosthetic leaflet behavior was assessed with an endoscope camera and the pressure drops through valves were measured. All the in vitro parameters indicated that the ePTFE-valved conduits did not have an inferior outcome compared with commercial mechanical or tissue valve conduits and could decrease the regurgitation volume and increase the efficiency. Compatible early clinical outcomes were also found among ePTFE-valved conduits and other valved conduits used for RVOT reconstruction, and ePTFE-valved conduits could be implanted in patients of a significantly smaller size. In vitro experimental study provided evidence that a handmade ePTFE-valved conduit could be an attractive alternative to other commercialized valved conduits used for surgical RVOT reconstruction.

Contribution ID: 251

4. Modelling and Simulation
04.12. Hemodynamics

Hemodynamic effects of conduit position on systemic-to- pulmonary shunt: a numerical study using virtual design

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The systemic-to-pulmonary shunt is a widely used palliative procedure in the therapy of congenital heart defect (CHD). Although it improved over the years, the anastomosis position of the conduit related to the control of pulmonary flow in the procedure is still one of the controversial issues. Based on patient-specific medical images, a three-dimensional (3D) vascular model was reconstructed in the present study. Four possible surgical positions of the conduit implantation for the systemic-to-pulmonary shunt were virtually devised by computer-aided design (CAD). Pulsatile simulations were done by the technique of computational fluid dynamics (CFD) to capture the physiological information of blood flow. The results indicated that higher pressure and wall shear stress were generated in the conduit. It may increase the risk of blood cell damage. While, the quantitative analysis showed that a relatively good balance of blood flow distribution and appropriate pressure drop between systemic and pulmonary circulations were achieved when the conduit was anastomosed at the innominate artery or subclavian artery than that was at the ascending aorta. The numerical study based on the virtual design is a useful approach for the preoperative prediction of local hemodynamics and provides more detailed information for the choice of patient-specific surgical design.

Contribution ID: 428

4. Modelling and Simulation
04.12. Hemodynamics

Application of FSI approach to a patient specific haemodynamical simulation of a ruptured cerebral aneurysm

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Computational fluid dynamics provides many possibilities for the analysis of the haemodynamical risks of a cerebral aneurysm rupture. Wall shear stress values for the rigid approach and the FSI approach were compared for a patient with a ruptured cerebral aneurysm. The domain of maximum risk of rupture was determined by using patient specific information i.e. geometry, blood flow rate waveform and Young's modulus value for the aneurysm tissue. The location of this domain has a good coincidence with a clinical case. This is the first study using complete patient specific information for a boundary conditions setup.
This study was supported by a grant from Government of Russian Federation No. 14.W03.31.0002.

Contribution ID: 448
4. Modelling and Simulation
04.12. Hemodynamics

Assistance ratio: An approach to quantify the hydraulic load distribution in LVAD therapy

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Left ventricular assist devices (LVADs) have grown in popularity for treating patients with severe heart failure. In many cases rotary blood pumps (RBPs) are used as LVADs, which are set to a fixed rotational speed in the clinical environment. The physicians rely on practical guidelines, available measurements and experience in choosing the rotational pump speed. This often leads to poor or unfavourable patient support, possibly even dangerous operating conditions. Hence, there exists great potential to implement closed-loop control of LVADs to overcome these problems. However, the choice of the control variable is not trivial.
This paper presents a methodological approach to deriving a variable to control in the closed-loop control of LVADs. To simplify the setpoint choice for clinicians, an assistance ratio is introduced to represent the sharing of hydraulic workload between the LVAD and the native heart. Available measurements include the left ventricular and aortic root pressure, pump flow and aortic flow rate, with the latter estimated using a Kalman filter. Based on these measurements, assistance ratios based on flow, work, power and pulsatiltiy are proposed.
The merits of different assistance ratios are assessed based on their ability to provide insight into hemodynamic support, myocardial protection and left ventricular unloading, along with their ease of implementation and robustness of their calculation. Their implementation is tested in a hybrid mock circulatory loop and retrospectively on data from animal experiments. An assistance ratio based on flow is shown to be the most robust, whilst giving some indication of hemodynamic support. The closed-loop control using an assistance ratio therefore makes it easier to achieve different

therapeutic goals. There will be less interventions by the clinician and therapy protocols may be defined independent of pump-type or patient.

Contribution ID: 483
4. Modelling and Simulation
04.12. Hemodynamics

Numerical simulation of fluid-structure interaction under the condition of pulsatile blood flow of renal artery with radiofrequency electrode

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Abstract: To investigate the effect of Fluid-Structure Interaction of the renal artery with radiofrequency electrode under the situation of pulsatile blood flow, the ideal renal artery model that contains electrode was constructed by Solidwoks. The renal arterial bifurcation vessel model with electrode and non-containing electrode was selected for comparison. Comsol software was applied to mimic the pulsatile blood flow. Six key points was selected for the analysis of hemodynamic parameters. The distribution of the wall shear stress and the deformation of the vascular wall were obtained. The research found that wall pressure were influenced by the variation of pulsating velocity. The wall pressure inside the bifurcation vessel is higher than the outside. Under the pressure variation caused by the velocity change, different degrees of deformation occurred. After the electrode was inserted, the blood velocity and wall pressure were affected by the electrode, which affected the distribution of wall shear stress. It is essential to carryout multi-field coupling simulation when researching arteries inserted electrodes to avoid unnecessary damage.
Keywords: fluid-solid coupling; Numerical simulation; Pulsating flow; Hemodynamics; radiofrequency electrode
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Contribution ID: 485
4. Modelling and Simulation
04.12. Hemodynamics

Hemodynamic interrogation in flow pattern and wall stress in descending aortic aneurysm using fluid structure coupling

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Clinical observation indicate that potential rupture risk of aneurysm is correlated to the change of wall stress and abnormal flow pattern. However, such investigation in the descending aortic aneurysm has not yet be quantified properly. In this paper, we are investigating the potential relationship with abnormal flow pattern and wall stress using fluid structure interaction in a patient specific geometry. We formulated the boundary condition based on the physiological flow profile. The fluid model was formulated as Carreau model which is a non-Newtonian model. The wall itself was defined as a hyperelastic model to allow the deformation for evaluation of the wall stress distribution. It was found that a disturbed flow pattern was observed at the aortic arch closer to the aneurysm site. Our particle track showed that there was no particle was accumulated at the aortic aneurysm may reduce the chance of potential intraluminal thrombus. High wall stress was

observed at the entrance of aneurysm. The corresponding high wall stress match with high wall shear stress location may indicate the initial rupture location. Such high wall shear stress may be triggered by large recirculation introduced by the unique geometry of thoracic aortic aneurysm. A stagnation region at the aneurysm sac with extremely low shear rate may indicate the potential damage to the endothelial cell. The presenting results indicate that it is worth to further study the potential change of mechanical factors in thoracic aortic aneurysm that may help to predict the progression of aortic aneurysm and potential rupture risk.

Contribution ID: 554
4. Modelling and Simulation
04.12. Hemodynamics

Local hemodynamics in coronary bypass in the presence of competitive flow and different diameter ratios between graft and host artery

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Background
Coronary bypass graft patency is strongly influenced by local hemodynamics characteristics in the anastomosis region. Graft failure is mainly caused by intimal hyperplasia development associated to regions with low values of Wall Shear Stress (WSS). Among the factors that alter the local hemodynamics environment are taken into consideration the presence of competitive flow, type of graft, suture configuration, anastomosis angle or ratio between graft and native artery diameters.
Aim
The aim of this paper is to analyze the influence of competitive flow on local hemodynamics associated to anastomosis region in bypass configurations with different ratio between graft and native stenosed artery diameters.
Methods
In this study were considered straight bypass configurations with graft diameter between 3 mm and 6 mm accordingly to the internal thoracic artery and saphenous vein diameters frequently used as graft, as described in the literature. The stenosed coronary artery was supposed to have the occlusion severity of 50%, 75% and 100%. Anastomosis angle was 30o and the coronary artery diameter was considered to be 4 mm. The numerical analyses were performed under steady-state conditions using as inlet boundary condition the mean flow rate associated to coronary circulation.
Results and Conclusions
The hemodynamic parameters analysed were Wall Shear Stress along the bed of the host coronary artery and the pressure drop in the bypass configuration. The most significant variation of WSS appears in the anastomosis region, being strongly influenced by the presence of the fluid jet through the partially stenosis in case of competitive flow and graft diameter. The largest recirculation regions associated to zones with low WSS appear in case of full occlusion. These results permit a better understanding of the phenomena that occur in the anastomosis region, contributing to the improvement of surgical techniques, and, therefore, increased graft patency.

Contribution ID: 556
4. Modelling and Simulation
04.12. Hemodynamics

Non-invasive quantification of coronary artery disease in arterial bifurcations using CCTA and CFD: comparison to fractional flow reserve measurements

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Recent advances in coronary computed tomography angiography (CCTA) allow the calculation of various functional indices of coronary artery disease (CAD). smartFFR is our proposed new index for the assessment of the significance of coronary stenoses in coronary bifurcations. The aim of the current study is to compare smartFFR with the Fractional Flow Reserve (FFR) values deriving from direct invasive pressure measurements from a dedicated pressure wire.
In the context of the SMARTool study, 22 patients with chest pain symptoms and intermediate pre-test likelihood of CAD underwent CCTA as well as FFR measurement. The 22 left arterial branches which included the LAD and the LCx were reconstructed using our in-house developed software. We performed two computational blood flow simulations for each case to calculate the smartFFR for each 3D model. Regarding the inlet, the average patient-specific pressure at rest was applied as a boundary condition. Assuming a myocardial blood flow of 2 ml/s and 6 ml/s during rest and under stress for the Left Main artery, respectively, we calculated the flow for each branch using Murray's law and applied it as outlet boundary conditions. smartFFR was calculated for each branch by computing the ratio of distal to proximal pressure for a range of flows between 0 and 4 ml/s, normalized by the respective ratio of a normal artery. The required average process time was less than 20 minutes. Strong correlation (r=0.87, P<0.0001) was found between the two methods. All pathological cases presenting ischemia, were correctly categorized by our method as hemodynamically significant lesions.
smartFFR demonstrated a high diagnostic accuracy for distinguishing hemodynamically significant lesions in a matter of minutes, and may represent a valid non-invasive tool for comprehensive characterization of CAD.

Contribution ID: 562
4. Modelling and Simulation
04.12. Hemodynamics

Computational fluid dynamics analysis of coronary stent malapposition

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Background: Stent thrombosis is a major complication of percutaneous coronary interventions, classified as: early (0-30 days post-stenting), late (>30 days) and very late (>12 months). Numerous pathological and intravascular imaging studies have been conducted on the attempt of identifying the mechanisms underlying stent thrombosis. Stent underexpansion and malapposition have been associated with early thrombosis, while delayed endothelization and late malapposition (related to vessel positive remodelling or clot lysis) have been linked to late and very late thrombosis. It has been suggested that flow disturbances leading to increased thrombogenicity are

likely to occur at the site of stent malapposition. These flow alterations include zones with high Wall Shear Stress (WSS) that induce platelet activation and recirculation regions associated with low WSS and endothelium dysfunction, conditions susceptible to high thrombogenic risk.
Aim: The aim of this paper is to analyse the effect of stent malapposition on flow conditions in relation to stent thrombosis, using computational fluid dynamics techniques.
Methods: Several simulations comparing the ideal well-apposed stent situation and different degrees of stent malapposition under steady-state conditions were conducted in this study, for simplified stented coronary artery geometries. Three stent malapposition degrees were considered, for gap distances between the vessel wall and each stent strut of 100 µm, 200 µm and 400 µm, according to scientific literature. The main hemodynamic parameters investigated were: near-wall recirculation regions evolution and WSS distribution along the stented area.
Results and conclusions: The presence of the stent struts induces the development of recirculation regions in the vicinity of each strut and their evolution depends on the degree of strut malapposition. Consequently, WSS distribution is strongly influenced by the strut position to the vessel wall. These findings may improve the understanding of the mechanisms correlating stent malapposition and stent thrombosis, a severe and multifactorial complication of coronary artery stenting.

Contribution ID: 667
4. Modelling and Simulation
04.12. Hemodynamics

Mathematical modeling of ocular pulse blood filling in rheoophthalmography

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The work examines the blood flow of the anterior part of the eye. In rheographic studies, the proportion of the ratio of volume and resistance is used to calculate the increment in blood volume. The coefficient of proportionality depends on the form of the biological object, its spatial heterogeneity, as well as other factors. For ophthalmology, the proportionality coefficient has not previously been calculated. It is possible to calculate the proportionality factor using the parameterized model defined in this paper. It is necessary to use the increment of pulse volume and the total volume of the orbit.
Accordance to the morphology of the eyeball, the vascular layer can be divided into three components: iris, ciliary body, choroid in our model. The model is a figure of rotation with an axis that coincides with the anteroposterior axis of the eye.
In work, signals were analyzed in a group of patients with an anophthalmos. In total, six records with a duration of two minutes each were analyzed. For the model, the calculation was made in the absence of the eyeball. All surrounding tissues were preserved. In the simulation, a spherical element was introduced as a glass prosthesis.
The simulation allowed to determine the relationship between changes in the volume of the eyeball and the rheoophthalmic signal change. This ratio takes into account not only the presence of eye and surrounding tissues but also their pulse fluctuations.

Contribution ID: 684
4. Modelling and Simulation
04.12. Hemodynamics

Light transmission refractometry for multi-phase polymers

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In order to measure biological flows with Particle Image Velocimetry (PIV) the refractive index adjustment of the biological model and the working fluid is of utmost importance, because biological models are characterize by a high complexity in geometry. The standard procedure for refractive index matching is a fluid based method, in which the fluid index of refraction (IOR) is changed to match the IOR of the flow model. Transparent hydrogels are used to nearly match the IOR of water or fluids with a high water content like blood plasma, through their superabsorbent properties. Furthermore, the degree of absorbency can be controlled, so that properties like Young's modulus and IOR are adjustable. Swollen hydrogels form an thin, outer fluid layer.
Conventional measurement systems are based on the total reflection method derived from Snell's Law. For hydrogels, the outer fluid layer interferes with the measurement. Hence, the IOR of hydrogels cannot accurately be measured. In order to overcome this problem, a light transmission setup for hydrogels immersed in their working fluid has been developed. A laser beam passes orthogonally through the hydrogel and is refracted at the polymer-water interface, which is located at a 30° angle concerning the entry surface. The displacement of the laser beam is measured through a line-sensor one meter away from polymer-water interface. The line sensors resolution is 3648 pixels with a height of 8 µm. Therefore, the systems theoretical solution is in the range of ΔIOR = 10-4. The IOR is calculated through an embedded algorithm derived from of Snell's Law and the Pythagoras' theorem. The system is validated with different samples of known IOR.
We developed a system to measure the IOR of swollen hydrogels for refractive index matching in biological PIV applications.
Acknowledgment: This research project was funded by "MOBILISE–Mobility in Engineering and Science"

Contribution ID: 852
4. Modelling and Simulation
04.12. Hemodynamics

Velocity measurement at carotid siphon: qualitative and quantitative comparison of Phase Contrast MRI and Computational Fluid Dynamics

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Phase contrast magnetic resonance imaging (PC MRI) and the computational fluid dynamics (CFD) are two of the most important technologies in the investigation on the velocity field in blood vessels in vivo. In order to qualitatively and quantitatively compare the differences between the two methods, the blood flow velocity measurements based on PC MRI and patient-specific CFD were conducted at internal carotid artery from 9 healthy volunteers. The velocity profile measured by PC MRI at the inlet of the carotid siphon was used as the boundary condition of the CFD simulation. A free outflow was set for the outlet. The vascular wall was simplified as rigid wall with a non-slip boundary condition. The 3D velocity field calculated from PC MRI data were compared with CFD simulation in 5 planes covering the carotid siphon. Then the resistance index (RI), correlation coefficient and errors in the magnitude and direction of velocity were calculated between the two methods. The results showed that the flow patterns of PC MRI and CFD were similar, and the velocity distribution and RI was in good agreement. But there were significant differences in the velocity magnitude near the posterior knee and vessel wall, while the directional error was larger at the center of the artery. Thus, the curvature was inferred to be associated with the variation between PC MRI and CFD. In addition, fluid type was found not associated with the variation by considering blood as Newtonian fluid and Non-Newtonian fluid respectively, and comparing the simulation results. These comparison between PC MRI and CFD may guide the utility of CFD technology in the hemodynamic investigation on tortuous arteries.

Contribution ID: 944
4. Modelling and Simulation
04.12. Hemodynamics

Model studies of the flow in an abdominal aortic aneurysm

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Purpose
Pulsatile flow in an abdominal aortic aneurysm (AAA) model has been examined in order to understand the hemodynamics that may contribute to the development of thrombosis within an AAA.
Method
Therefore, a patient-specific geometry of an AAA is transferred to a physical flow model consisting of super-transparent silicone. In the experimental setup two pulsatile flow curves (model-curve 1, 2) are generated by an artificial blood circuit. The created silicone model is flowed through with a mixture of water and glycerin. Flow patterns in the AAA were recorded and analyzed using flow visualization techniques.
Results
For all of the simulated series a flow separation within the expansion of the aneurysm cross section is shown and in consequence a complex system of generated vortices occurs. Regions of low velocity and stagnation, and slow oscillatory flow near the walls were seen in the main body of the AAA. The flow field of the model-curve 1 shows a laminar character, whereas the more finely scaled vortices in the flow field of the model-curve 2 indicate a fluid flow that at times seems to be transitional. A significant influence of the flow through the renal arteries on the flow configuration within the downstream located aneurysm cannot be detected.
Conclusions
The flow structures within AAA are complex, with features that may predispose to thrombus formation.

Contribution ID: 956
4. Modelling and Simulation
04.12. Hemodynamics

Comparisons of different method of estimate arterial compliance based on reservoir-wave model

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Introduction
Arterial compliance is the ability of the arterial to increase volume with increasing pressure. It is a marker of preclinical vascular disease and cardiovascular risk factor. Reservoir –wave model of aortic circulation assume that aortic pressure is sum of: quotient of blood flow (Q) and aortic impedance (Z); and reservoir component described by two element Windkessel model (arterial

resistance (R) parallelly connected with arterial compliance (C)). The aim was to compare three different methods of non-invasive compliance estimation.
Method
We use reservoir-wave model with given blood flow and assumed model parameters ($0.1<Z<0.4$, $0.6<C<2.0$, $0.5<R<3.0$), to calculated the aortic pressure (P). Based on P and given Q we estimated compliance using: pulse pressure method (Cpp), area method (Carea) and from diastolic time decay (Cdias)(τ = C* TPR) TPR was calculated as a ratio of mean P and mean Q.
Results
Correlation coefficient between C and Cpp is 0,8, for C and Cdias is 0,56 and for C and Carea is 0,21.
Averaged value of Cpp is 0,37±0,12, for Cdias is 1,09 ± 0,77 and for Carea is 1,30 ± 0,49.
Calculated TPR differ from R, used to calculate aortic pressure. Mean error was 79% and varied between -58% to 475%.
Conclusions
Basing on this simulation we concluded that result obtained from three methods of arterial compliance estimation (Cpp, Carea and Cdias) were considerably different, and application of reservoir-wave model gave the poor estimation of C, used to calculate aortic pressure. However, our findings should be verified in healthy subjects.

Contribution ID: 1010
4. Modelling and Simulation
04.12. Hemodynamics

Effect of left-right heart during biventricular assist device support by Speed synchronization: A computer study

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Biventricular assist device (BiVAD) is a treatment for the end-stage heart failure patients. Normally, after left ventricular assist device (LVAD) implanted in the end-stage heart failure patients, a right heart failure immediately appeared. Then, the right ventricular assist device (LVAD) was implanted. Both LVAD and RVAD implanted so call BiVAD. Additionally, the speed synchronization is a novel concept for remaining the high preload and increasing the cardiac output. It is a potential to promote a bridge to recovery treatment.
The cardiovascular, RVAD, LVAD and speed synchronization models (co-pulse mode) are implemented using MATLAB. The normal heart and pathology heart are used in this study. The pathology level of the heart was regulated by a level of maximum elastance (Emax: 30% of normal heart value) in the heart model. The constant speed mode (partial support and full support) and co-pulse mode (increasing pump speed in systolic period between 8k – 11k rpm) are simulated using the MicroMed-DeBakey VAD model. The hemodynamics, ejection fraction, pressure-volume loop and pressure volume area (PVA) of different heart condition and pump mode are simulated. Additionally, the unbalance of BiVAD support are simulated by increasing the systemic vascular resistance.
The results indicated both the aortic pressure and pulmonary artery pressure in co-pulse mode are higher than the constant speed mode. Additionally both PVA and ejection fraction in co-pulse mode are higher than the constant speed mode on both normal heart and pathology heart. In unbalance of BiVAD support, both PV-loop and PVA of right ventricle are reduced.
In conclusion, this computer simulation can re-generated the hemodynamics and cardiac function parameters. Co-pulse mode can maintain the high preload and increase the cardiac output. Therefore, co-pulse mode can potentially use for the bridge to recovery treatment in BiVAD heart failure patients.

Contribution ID: 1087
4. Modelling and Simulation
04.12. Hemodynamics

New mechanism for the simulation of a low cardiac output circulatory model

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Regional restoration by using artificial organs is commonly applied to the patients with severe vascular or heart diseases. Therapeutic intervention techniques using vascular stents or stent grafts are useful especially for the elderly patients by their minimal invasiveness. On the contrary, the installation of vascular prostheses may cause the hemodynamic matching of impedance in the ventricle and the vascular afterload, followed by deterioration of cardiac function. In this study, we focused on the end-systolic variation of the mechanism in the mock ventricular models and developed a silicone rubber-made model driven by a mechano-pneumatic actuator. The ventricular model consisted of a conical-shaped silicone-rubber sac covered by an acrylic casing, an elastic balloon-shaped head, and a linear actuator. The linear actuator tip was connected with the balloon head and compressed it to generate pneumatic pressure applying the systolic contraction of the ventricular model. As the balloon head had a release valve, the passive stress relaxation was to be designed in diastole. We examined the effects of the linear actuation on the hemodynamic function with the ventricular model against the different condition of afterload settings in the mock circulatory system. As a result, the elastance characteristics obtained in the ventricular model exhibited the variation associated with its volumetric changes, which was capable of representing low cardiac output conditions. Therefore, the natural hemodynamic characteristics could be simulated, and its elastance changes might be regulated based on the mechano-pneumatic sequential mechanisms.

Contribution ID: 1127
4. Modelling and Simulation
04.12. Hemodynamics

Proposal of physical model of cardiovascular system; improvement of mock ciculatory loop

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Each heart ejection gives the blood a pressure force and it creates a pulse wave which travels from the heart to peripheral blood vessels (blood vessel in fingers, toes,...). This pulse wave travels during arterial tree and it depends on arterial properties as elasticity, stiffness or thickness of the artery wall. It will be very useful to describe the relationship between blood pressure, pulse wave propagation and hemodynamics parameters in real or very similar conditions as are in real cardiovascular system. The whole cardiovascular system can be described as an electrical circuit with resistors (resistivity of blood vessels R), capacitors (compliance of blood vessels C) and inductors (inertance of blood vessels L). It is possible to evaluate all of parameters of arteries and developed physical model of cardiovascular system. Physical model has to simulate real conditions which are in human cardiovascular system. It would bring a better knowledge about the behavior of cardiovascular system and improve its treatment. In this paper are describe possibilities how to model cardiovascular system and developing of physical model of cardiovascular system.

Contribution ID: 1637
4. Modelling and Simulation
04.12. Hemodynamics

A new numerical model of the intra-iortic balloon pump as a tool for clinical simulation and outcome prediction

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Counterpulsation is the form of circulatory support provided by the intra-aortic balloon pump (IABP), a device widely used in the clinical setting to assist the left ventricle by mechanical control of blood volume displacement within the aorta. The principles underlying the IABP function are well established but the interactions with the cardiovascular system make its performance rather complicated and still not completely understood. Here we propose a novel numerical model of the IABP as a tool with potential for clinical application in terms of simulation and outcome prediction in critical patients. Staring by the software simulator CARDIOSIM© developed in the Cardiovascular Numerical Modelling Lab of Institute of Clinical Physiology (Rome), a new lumped parameter numerical module reproducing both the behaviour of the systemic arterial tree and the IABP was modelled and inserted into the software simulator.
The new model presented in this work permits to change (in real time) the temporization of the IABP drive in relation to ECG timings and the driving and vacuum pressures of the drive. Moreover, it allows to synchronize (when desired) the IABP temporization with the dicrotic notch (of the systemic arterial pressure waveform) that precedes the inflation point of the balloon.
The analysis of IABP assistance is presented in terms of the effects on stroke volume, mean aortic diastolic pressure, aortic end-systolic pressure, aortic end-diastolic pressure, endocardial viability ratio and pressure-volume loop shift.

Contribution ID: 1711
4. Modelling and Simulation
04.12. Hemodynamics

A numerical analysis of the thrombus formation in a dissected aorta with a flexible wall

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Aortic dissection can be a life-threatening condition. Many conditions involved in the mortality and morbidity risk of this disease. Thrombus formation in the false lumen (FL) is one the important factors that should be monitored. Using a two-way fluid-structure interaction (FSI) approach, we investigated the effect of the wall movement on the probability of the formation of the thrombus in the FL. Furthermore, the stress distribution and the wall displacement were also investigated.
The coupled equations of the blood flow and the vessel wall stress field and displacement were solved using COMSOL Multiphysics for an idealized model of the dissected descending aorta. The

aorta was characterized by a dilated diameter and a double-entry FL. An isotropic hyper-elastic material model was used for the arterial wall. The effect of the tear morphology on the probability of the thrombus formation was investigated. To ensure that the results are not dependent on the size of the mesh, the grid was refined until a relative error lesser than 5% was obtained.
During the initial stage of the aortic dissection, the area proximal to the entry tear experiences the maximum stress before the mid-systole. Areas proximal to the false lumen were observed to have the maximum stress during a cardiac cycle. The maximum flap displacement occurred before the mid-systole near the entry tear. Larger maximum displacement and stress were observed for larger tears. Reverse flows were observed exiting from the entry and flow into the false lumen through the re-entry, with velocities equivalent to the inlet velocity at the peak systole. The effect of the reverse flow on the risk of the thrombus formation was analyzed.

Contribution ID: 1754
4. Modelling and Simulation
04.12. Hemodynamics

The Embryonic Cardiac Outflow Tract Features Double Helical Flow that Aligns with Aorticopulmonary Septation

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Fluid mechanical force stimuli are known to play a role in cardiac development and congenital malformations. The embryonic outflow tract (OFT) is originally a single vessel, but splits into the aorta and pulmonary artery as aorticopulmonary septum develops. Previous investigators hypothesized that OFT fluid forces are important stimulus for proper septation. We performed ultrasound-based Computational Fluid Dynamics Simulations (CFD) on HH25 chick embryonic OFT, just prior to aorticopulmonary septation, to understand its flow dynamics and test this hypothesis. High-frequency 2D B-mode cine-ultrasound imaging was performed at multiple planes for 3 chick embryos. Cine-images were ensemble-averaged temporally using quadratic mean, and reconstructed in 4D via spatial and temporal correlations. OFT wall motion was described mathematically with 3D Fourier model in a curvilinear cylindrical coordinate system. Pulsed-wave Doppler was used to measure velocities at the proximal OFT for specifying boundary conditions. Dynamic-mesh CFD was performed with ANSYS FLUENT. Results showed that OFT Flow was highly laminar and orderly with no flow separation. Wall shear stresses (WSS) were in the range of 0-7Pa, and were higher at the two locations where the lumen periodically collapses. Since flow was significantly pulsatile due to the pumping action of ventricle, and due to the absence of valves at this early stage, WSS was significantly oscillatory in nature. The OFT anatomy contained a gradual non-planar 90° bend, which induced a double helical flow pattern, in which the two helical flow features were observed to spiral round each other as we move from the proximal to distal end of the OFT. Interestingly, the dividing plane between the two helical flow structures seemed to be co-located along the formation plane of aorticopulmonary septum, which also develops in a spiral form. This observation corroborated with the hypothesis that flow dynamics play a role in proper OFT septation.

Contribution ID: 1757
4. Modelling and Simulation
04.12. Hemodynamics

Human Fetal Hearts with Tetralogy of Fallot has Altered Fluid Mechanical Force Environment from Normal Fetal Hearts

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Tetralogy of Fallot (TOF) is the most common cyanotic congenital cardiovascular malformation (CCM), and consist of 4 defects: right ventricle (RV) hypertrophy, an overriding aorta, pulmonary stenosis and a ventricular septal defect (VSD). These drastic anatomic alterations should cause major changes to the cardiac fluid mechanical environment, and could be altering the fetal heart development to lead to disease progression. It is thus important to study the fluid dynamics of the human fetal TOF heart, but to date, this has not been performed. We applied a previously established computational fluid dynamics (CFD) technique to study 3 TOF human fetal hearts (at 22 and 31 weeks of gestation), and 15 healthy fetal hearts. Dynamic-mesh CFD was performed based on 4D ultrasound images of fetal hearts from the National University Hospital, Singapore. Results demonstrated that there were high flow rates through the TOF RV, which exceeded the RV stroke volume, resulting in extensive diastolic flow shunting from RV to LV, and intensified vortex dynamics in the RV. Consequently, WSS in the TOF RV was elevated above normal RVs, but WSS in the TOF LVs were similar to that in normal LVs. Further, in the TOF heart, Intraventricular-pressure-gradients (IVPG), systolic flow energy losses, and work required for ejecting a unit volume of blood were all elevated, but diastolic flow energy losses were not. This was most likely due to the pulmonary outflow tract obstruction. Pressure elevations were substantial, at approximately 6.9% and 3.7% of the mean arterial pressures for the 31-weeks and 22-weeks old fetuses respectively, and affected both RV and LV equally, due to their connection by the VSD. We hypothesize that the TOF RV was hypertrophied but not the TOF LV, because the RV experienced elevated pressures and WSS, while the LV only experienced elevated pressures.

Contribution ID: 1890
4. Modelling and Simulation
04.12. Hemodynamics

In vitro evaluation of hemodynamic performance for right ventricular outflow tract reconstruction with trileaflet ePTFE valved conduits

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Right ventricle to pulmonary artery (RV-PA) continuity reconstruction traditionally is rendered by open repair with pulmonary valve implantation or replacement. Percutaneous pulmonary valve implantation (PPVI) has evolved as one of the most exciting surgical strategies dealing with dysfunctional right ventricle-pulmonary artery conduits. However, size limitation of the currently available valves for PPVI application hinders possible treatments in a substantial proportion of patients. We propose a formula for designing handmade trileaflet-valved conduits with different diameters. The formula is derived from a trigonometric function and can be used to estimate the optimal parameters for ePTFE-valved conduits for young adults and children. The purpose of this study is to investigate the hemodynamic and functional consequences by using a mock circulation system to test our new design. We recorded the diastolic valve leakage and calculated pulmonary regurgitation, regurgitation fraction, and ejection efficiency in pulsatile setting. Additionally, the prosthetic leaflet behavior was assessed with an endoscope camera and the pressure drops across valves were measured. All the in vitro parameters indicated that the ePTFE-valved conduits did not have an inferior outcome compared with commercial mechanical or tissue valve conduits and could decrease the regurgitation volume and increase valve efficiency. Our vitro experimental study successfully provided evidence that a handmade ePTFE-valved conduit could be an attractive alternative to other commercialized valved conduits used for surgical right ventricle to pulmonary artery (RV-PA) continuity reconstruction.

Contribution ID: 1823
4. Modelling and Simulation
04.13. Neurodynamics

Effect of electrode polarity on paresthesia coverage in spinal cord stimulation

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Purpose/Objective: according to the gate control theory, large A-beta nerve fibers of dorsal columns must be activated to extend paresthesia to a maximum number of dermatomes corresponding to neuropathic areas. That fiber recruitment depends on electrode polarity, among other parameters. The objective of this study was to predict the best electrode polarity performance to get the maximum number of activated nerve fibers on dorsal columns in spinal cord stimulation.
Methods: a 3D mathematical spinal cord model of T10 vertebral level was developed in COMSOL Multiphysics to simulate the electric field distribution using several electrode polarities in single lead stimulation (bipolar 1, bipolar 2, guarded cathode and dual-guarded cathode) (see Figure 1). A current myelinated nerve fiber model was programmed in MATLAB and used to predict neural activation on dorsal columns of the spinal cord. Several parameters (activating area and depth, paresthesia threshold and recruitment ratio) were calculated to quantify the efficacy of the stimulation.
Results: we found (see Table 1) that dual-guarded cathode produces the maximum activating area and depth. However, the minimum recruitment ratio is achieved when guarded cathode polarity is performed, so it is the best polarity to activate selectively dorsal column fibers. Instead, although bipolar 1 and bipolar 2 polarities present higher activating area and depth than guarded cathode, both are suitable to produce dorsal root activation, due to the high recruitment ratio obtained.
Conclusions: we developed a new model that can be used to predict the stimulated nerve fibers area on dorsal columns of the spinal cord. The model suggests that dual-guarded cathode could maximize the number of activated nerve fibers and so, produce an efficient stimulation. But, if paresthesia is reduced to only two dermatomes due to dorsal root fibers activation, then the best electrode polarity to selectively activate dorsal column fibers is guarded cathode.

Contribution ID: 16
4. Modelling and Simulation
04.14. Transport and physiological modelling

A numerical study on the effects of segmental aqueous humour outflow on ocular drug delivery

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There are concerns that the recent discovery of segmentation in aqueous humour (AH) outflow can potentially cause scenarios of 'over-treating' and 'under-treating' glaucoma. This was hypothesized to be due to the preferential flow of ophthalmic drugs through the trabecular meshwork (TM) caused by the segmentation [1]. Using a CFD study, we show that the effects of segmental outflow on ocular drug delivery are significantly less dominant than the effects of gravity. A 3D human eye model was developed for this study. AH flow inside the anterior and posterior chambers is assumed to be driven by gravity (thermally-induced buoyant forces) and by its production and drainage. We modelled segmental outflow by prescribing the TM permeability as a rectangular function of space, where active and non-active outflow regions of the TM are represented by the non-zero and zero regions of the functions.
Simulations were carried out for different active outflow locations. The results obtained showed that the path of drug transport is not governed by the location of active outflow across the TM. Instead, it is driven mainly by the hydrodynamics of AH, which is influenced primarily by thermally-induced buoyant forces and the orientation of the eye. Our numerical results contradicted the experimental observations of Chang et al [1], which we hypothesized to be caused by the absence of buoyancy in their study, since their experiments were carried out at a constant temperature. To verify this, we repeated the simulations for the model without buoyant forces and the results were found to agree with the observations of Chang et al [1]; thus confirming our hypothesis.
In conclusion, our numerical results showed that there is no cause for concern over the potential of irregular ocular drug delivery due to segmental AH outflow.

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Contribution ID: 82
4. Modelling and Simulation
04.14. Transport and physiological modelling

Depth dose and 2D dose distribution monte carlo simulation of for some radionuclide patch sources in a skin phantom

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Background: Skin cancer in the head and neck region is one of the most common types of cancer, probably because these parts of the body directly exposed to the sunshine. Superficial brachytherapy is a promising alternative treatment method for skin cancers, where high-energy beta emitting radio-nuclides such as 32P, 90Y, 188Re and 166Ho are used to overcome the disadvantages of radiotherapy and surgery. In superficial brachytherapy, prescribed dose can be delivered to the affected area without excessive damage to the neighboring normal tissues. This study aimed to calculate the absorbed dose distributions of above radionuclides that could be used for treatment of various skin cancers. Methods: We have calculated the absorbed depth dose distributions along the central axis and two dimensional (2D) dose distributions along the x-axis of 188Re, 32P, 166Ho, and 90Y patch sources in a skin phantom based on Monte Carlo (MC) simulations for the isotropic dose distribution inside and on the surface of the phantom. Results: The evaluated absorbed doses of the chosen sources were compared with each other, and 90Y, 188Re, 32P, and 166Ho radioisotopes are comparable in terms of dose delivery. Our results for 188Re and 166Ho are also in good agreement with the Mont Carlo and/or experimental results reported by others. Conclusions: Treatment of superficial skin cancers is more conveniently done by 166Ho, 32P and 188Re are more effective for thicker tumors in interior layers. 90Y source delivers dose to the muscle tissue located under the adipose layer; therefore, this source is not suitable for this kind of treatment. Among the above sources, 32P is a suitable radioisotope for such therapeutic application, it is a pure beta emitter and due to its short range, there will be negligible radiation dose to the underlying healthy normal tissues and bone.

Contribution ID: 100
4. Modelling and Simulation
04.14. Transport and physiological modelling

Study of the near-infrared measurement of subcutaneous adipose tissue thickness with monte carlo simulation

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Obesity seriously affects health and quality of life, which causes a variety of chronic diseases such as metabolic syndrome and cardiovascular diseases. Subcutaneous adipose tissue (SAT) thickness is accepted as a body fat indicator since 40–60% of total body fat is in the subcutaneous regions. Many techniques have been used to measure the subcutaneous fat thickness, among which near-infrared (NIR) light is a noninvasive and convenient approach. However, its measurement accuracy still needs to be improved. The purpose of our study is to investigate the optimal distance between the detector and the light source, and the wavelength of incident light, which may affect the measurement of SAT thickness.
The subcutaneous-muscle tissue model was established, and with the wavelength of incident light between 400 ~ 1000nm, the walking path of all photons in the tissue was obtained by Monte Carlo simulation. The photons emitted from the upper surface of subcutaneous fat were counted and the photon emission ratio were calculated. Besides, the effective photons were counted and effective photon ratio were calculated with the setting constraints. The optimal distance between the detector and the light source was determined by the emission position of effective photons with different SAT thickness.
The results showed that the photon emission ratio increased and the effective photon ratio decreased with the increase of SAT thickness. The photon emission ratio reached the maximum with the wavelength between 800 ~ 900nm, and the effective photon ratio increased with the increase of wavelength. The wavelength has no effect on the optimal detection distance.
This study proposed a method to determine the distance between the light source and the detector, and the wavelength of incident light. It provided the theoretical foundation for the development of measuring device and the follow-up human experiments.

Contribution ID: 302
4. Modelling and Simulation
04.14. Transport and physiological modelling

Application of computational aerodynamics on the risk prediction of PM2.5 in congenital tracheal stenosis

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PM 2.5 is one of the particulate pollutants in atmosphere. It refers to the matter size smaller than 2.5μm. Long-term explosion can lead to health problems, especially to the respiratory system.

Although many reports have been published on its harm, there are little researches focused on its risk prediction to the children with congenital tracheal stenosis (CTS). In the present study, we used the method of computational fluid dynamics (CFD) to investigate the aerodynamic characteristics of airflow with PM 2.5 in the trachea. The motion of airflow and the risk of PM2.5 were predicted in the normal and patient-specific tracheal models, respectively. Compared with the tracheal aerodynamics and PM 2.5 distributions in the main airway, the potential risk of PM 2.5 to CTS were disclosed. The results indicated that more deposited areas of PM2.5 were observed at the downstream of the trachea stenosis in one breath cycle and the bronchus around the bridging bronchus were more likely affected by PM2.5. Due to more complex turbulence flow generated in trachea with CTS at the expiratory phase, the explosion area of PM2.5 was much larger than that in the normal trachea. This implied that the trachea with CTS was more vulnerable and PM2.5 can aggravate the tracheal stenosis. The applications of computational aerodynamic analysis could be used for the risk prediction of PM2.5 in CTS.

Contribution ID: 603
4. Modelling and Simulation
04.14. Transport and physiological modelling

New dosimetric mode for XRMC: comparison of macroscopic quantity for reliability evaluation

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The objective of this project is to establish the reliability of the new implemented dosimetry mode in XRMC by comparing the energy absorption profile to simulations performed by using Geant4, version 10.02.p02 (henceforth called Geant4). This is the first stage (of one ongoing project) for the validation of this new XRMC version. The XRMC is a Monte Carlo toolkit focused on x-ray photon transport simulation that makes extensive use of variance reduction techniques. It was initially developed to generate transmission imaging and spectroscopy experiments. Now it is improved in the way to make possible the simulation of absorbed energy in volumes. The reliability evaluation consists in compare the XRMC depth dose profiles against Geant4 simulations, both performed under same irradiation conditions. Homogeneous phantoms of dimensions 10 x 10 x 5 cm3 of different composition (cortical bone, fat and water) irradiated by monochromatic beams (20 keV up 140keV, in steps of 20keV) were simulated and the energy absorbed profiles were recorded to the whole phantom and to its partial volumes. The preliminary results show internal consistency on profiles simulated by XRMC. In the comparison to Geant4 systematic differences on energy deposition were observed. Geant4 presented always larger energy absorption variating between 2% up 6%. It is consistent to the differences on cross sections used by both Monte Carlo toolkits: XRMC uses xraylib and Geant4 uses EPDL (for photon transportation). Another difference is that Geant4 simulates electrons as secondary particles, but the kinetic energy of those is low for the incident photons simulated, being its energy quasi-locally deposited. It was observed, to some cases, significant reduction on simulation time on XRMC (when compared to Geant4).

Contribution ID: 747
4. Modelling and Simulation
04.14. Transport and physiological modelling

Validation of Monte Carlo calculated dose distributions for low energy Pd-103 brachytherapy sources

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Dose calculations for clinical brachytherapy treatments are based on the TG-43 formalism of the American Association of Physicists in Medicine (AAPM). Although this method is currently the standard approach used by the brachytherapy community, it is based on the unrealistic assumption that all tissue is equivalent to water which leads to significant errors for low energy sources such as Pd-103. One potential solution to this problem is to use model based dose calculation algorithms (MBDCA) such as Monte Carlo which can accurately account for the effects of tissue heterogeneities and interseed attenuation (ISA).
My research is focused on calculating dose distributions for low energy Pd-103 seeds using the newly available, brachytherapy specific Monte Carlo user code egs_brachy distributed with EGSnrc. Accurate models of the IsoAid Advantage Pd-103 seed have been produced and used to perform TG-43 style dose calculations as a test of the egs_brachy code. The dose rate constant for this source was determined within 2% of the consensus value although significant differences are observed within 1cm of the seed. The calculated dose distributions were also used to determine relevant TG-43 parameters including the radial dose function and anisotropy function.
The next step in this process will consist of experimental validation of the Monte Carlo calculated dose distributions using optically stimulated luminescence dosimetry (OSLD) as a necessary precursor for the clinical implementation of MBDCA. Many studies have examined the sensitivity of MBDCA to the effects of tissue heterogeneities and ISA but there is a lack of experimental verification to support the use of these advanced techniques in a clinical setting which will be addressed by my research.

Contribution ID: 1321
4. Modelling and Simulation
04.14. Transport and physiological modelling

Computational Modeling of Drug Delivery for Treatment of Age-Related Macular Degeneration

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Age-related macular degeneration (AMD) is a progressive, neurodegenerative ocular disease. It involves cell proliferation and uncontrolled growth in blood vessels leading to leaking of blood and proteins, scarring of the macula region, and, eventually, irreversible loss of vision. AMD results from uncontrolled expression of the vascular endothelial growth factor (VEGF) and is treated primarily with the anti-VEGF macromolecular drugs, administered by intravitreal (IVT) injection. A less invasive, less risky system of delivery involves transcleral delivery from thermally responsive hydrogels of poly(N-isopropylacrylamide) (NIPAM), placed episclerally. In this case, most of the drug load is released by convection, and the remaining, close to 30% of weight, is released by diffusion. Moreover, it was recently indicated that the chronic exposure to oxidative stress and a decline in lysosomal activity of retinal pigment epithelium (RPE) cells is a possible cause for RPE degeneration. An exogenous delivery of recombinant hHsp70 chaperone can protect RPE cells

from oxidative stress and thus has the potential to be a therapeutic option against AMD. In this study, delivery of rhHsp70 from an episcleral hydrogel implant has been simulated with an anatomically and physiologically correct model of the human eye. The average drug concentration in sclera, choroid, retina and vitreous is compared, when the rhHsp70 is released at the limbus and the posterior of the eye. The results indicate that transcleral delivery from thermally responsive hydrogels, placed episclerally, is more effective as the currently practiced through IVT injection.

Contribution ID: 373
4. Modelling and Simulation
04.15. Ultrasound simulation

Equivalent scatters concept validation with coded excitation pulses for computational modelling of ultrasound phantoms

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The presence of speckle corrupts ultrasound signals and can bring difficulties for medical diagnosis. Its inevitable occurrence is related to the great number of randomly distributed scatters in a resolution cell (RC) following Rayleigh statistic. Many studies also analyse this problem under different non-Rayleigh statistical distribution models, such as Nakagami, Rice, among others, using it on tissue characterization. Nonetheless, the equivalent scatters concept (EQS), which came from the understanding that the transducer pulse bandwidth (PBW) limits the useful ultrasonic spectral information, shows that it is possible to model a sparse set of equally spaced scatters that can give rise to the same backscattered signal (BS) obtained from original randomly distributed ones.
Coded excitation (CEP) techniques bring the ability of elongate the transmitted pulse through modulations, subsequently compressing the output, at the reception, to recover the spatial resolution. As a result, their RC is huge compared to the conventional short-pulses (CP) leading to a great scatters density per RC. In CP pulse-echo simulations, results showed that the BS echo error between original and EQS is around 0.5%, but the continue validation and application limits of EQS with CEP has not been evaluated so far.
Our work presents a deployment study of two different chirp waveforms and a pair of Golay codes for EQS applications. We modelled a 5 MHz single-circular-element transducer. Phantoms were made of scatters as complex variables in a non-attenuation medium. Specific markers were inserted into it to validate the EQS. EQS were replicas of PBW. We simulated a set of scanlines looking for the limit condition that makes EQS still valid, plotting the relative and RMSE errors of our findings.
Our results show that a prior knowledge of the used coding characteristics makes EQS with CEP feasible and useful to reduce phantom complexities and speed up computational simulations.

Contribution ID: 595
4. Modelling and Simulation
04.15. Ultrasound simulation

Modelling of a hyperthermia corrected equivalent dose

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The introduction of hyperthermia (HT), complementarily to external beam radiotherapy (EBRT), constitutes a promising new approach in cancer treatment. HT role is to sensitize tumor cells to ionizing radiation [1].
Evidences suggest that the radiosensitization effect of heat involves cellular DNA repair mechanism so that damages induced by radiation are more difficult to be repaired [2,3].
The goal of this work is to find an equivalent dose definition to be applied when EBRT is coupled to high intensity therapeutic ultrasound hyperthermia, by introducing a modifying parameter that takes into account the synergic effect of hyperthermia in the expected biological effects of radiation. This parameter is expected to be a complex function of several factors, among them the local temperature, how heat is generated and delivered, the heating duration, the temperature distribution within the region of interest, the physical and biological characteristics of tissues, etc.
In order to improve efficacy, safety and applicability of high intensity ultrasound treatments, a precise characterization of the pressure distributions in water and in-vitro and in-vivo experiments is needed.
From the perspective of high intensity ultrasound, the context of such characterization measurements is ideal to develop and improve numerical simulation tools aimed to predict ultrasound field and temperature distributions in the regions of interest, valid in its various applications.

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Contribution ID: 1415
4. Modelling and Simulation
04.15. Ultrasound simulation

Development of a blood vessel phantom with multiple bifurcations applicable for the experiment of ultrasound drug delivery

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We are developing a therapeutic system that uses acoustic radiation force to control a micro object in blood vessel aiming to reach target sites such as tumors. To realize this system, we have proposed a method to analyze the 3D structure of blood vessel network by fusing the Doppler-mode and B-mode ultrasound volumes, including the blood vessel network near the target area. However, there was limitation to perform verification experiments with blood vessels in vivo, because of the difficulties of inserting a micro object into an actual blood vessel. Therefore, for 3D reconstruction of blood vessel, we considered to fabricate a phantom with the actual shape of blood vessels which can be imaged by both B-mode and Doppler-mode ultrasound. First, we prepared six types of materials including silicon and rubber to mimic vessel wall, which can be fabricated by a 3D printer. Next, we prepared two types of materials; agar and PEGMA, to mimic surrounding tissues, and blended graphite powder to reproduce speckles on echograms. After verification with echograms, the optimal combination selected was UV-curable resin as vessel wall and agar as surrounding tissue. The fabricated phantom with water flow to mimic blood flow was examined for visualization of the branched structure by both Doppler-mode and B-mode. As a result of 3D reconstruction of the ultrasound volumes, the branched structure of the blood vessel

was clearly visualized. Then, we demonstrated an experiment of the thin catheter induction through the phantom for drug delivery with a robotic assistant.

Contribution ID: 20
4. Modelling and Simulation
04.17. Other

Geant4-DNA cross section models for nitrogen, propane and DNA

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Until recently, Geant4-DNA physics models have been available only for use in liquid water. Simulations involving biological targets have thus relied on the approximation of water (and its associated cross sections) as a substitute. While this approximation is considered sufficiently realistic down to the micrometric scale, inaccuracies may arise in track structure simulations involving detailed particle interaction. Densely ionising radiation, such as ions with an energy corresponding to their maximum stopping power, or low-energy electrons below 1 keV, are of particular concern as these particles deposit a large fraction of their energy within volumes of a few cubic micro- or nanometres. The unsuitability of water as a substitute extends to other applications, such the comparison of Geant4-DNA simulations with micro- and nanodosimetry experiments. Microdosimeters often use tissue-equivalent gases comprising a mixture of propane, nitrogen and carbon dioxide, while nanodosimeters are usually operated with nitrogen or propane. Appropriate cross section models for these gases are therefore needed.
This work recommends cross section models to implement in Geant4-DNA for the interaction of electrons, protons and alpha particles in nitrogen and propane. These models are based on evaluated cross section data for ionisation and excitation as well as alpha particle charge-transfer and elastic scattering of electrons. The recent implementation of DNA cross sections in Geant4-DNA (10.4 beta version) will also be discussed.
Cross sections of nitrogen and propane for light ions (100 keV to 20 MeV) and electrons down to the ionisation threshold have been evaluated and implemented into the PTB track structure code (PTra). PTra simulations using these data have been successfully benchmarked with nanodosimetry experiments for protons and alpha particles.
Implementation of the proposed cross section models for nitrogen and propane in Geant4-DNA could benefit the micro- and nanodosimetry community by improving the accuracy of track structure simulations.

Contribution ID: 62
4. Modelling and Simulation
04.17. Other

Numerical simulation of selective withdrawal pertinent to efficient cell encapsulation

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Cell encapsulation represents a growing technology of dealing with immunogenicity of cells transplanted for disease treatment and regenerative medicine. The development and standardization of an efficient encapsulation method will render cell transplantation the therapeutic modality of choice, significantly contributing to treatment of severe chronic diseases, e.g., diabetes mellitus type 1, and repair of damaged tissue. Complete, uniform-thickness coating of differently-sized cells or cell clusters, e.g., pancreatic cell islets, is necessary for preservation of graft integrity and function. We propose a method of cell encapsulation based on selective withdrawal from the lower of two immiscible-fluid layers. Optimal encapsulation results, when the perturbed fluid-fluid interface is kept stable and transition to viscous entrainment is prevented. The physical model consists of a finite-size tank containing the two immiscible-fluid layers and a withdrawal tube with radius much smaller than the tank size and its inflow tip below the interface. An Arbitrary Lagrangian – Eulerian (ALE) method is utilized in the numerical model to track the motion and deformation of the fluid-fluid interface, and critical conditions for selective withdrawal are established. The results of the simulations indicate that the mean curvature at the hump tip of the interface depends on the withdrawal flow rate and the distance of the tube inflow tip from the unperturbed interface.

Contribution ID: 103
4. Modelling and Simulation
04.17. Other

Basic concepts of sensing respiratory sounds at the surface of human chest

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Acoustic sensors for recording lung sounds at the chest surface should meet some basic requirements: (a) achievement the acceptable sensitivity or sensitivity threshold to the useful signal, (b) sufficient noise immunity, and (c) a linearity of frequency response. Specific condition of recording acoustic wave propagating through human thorax is its registering on the border of the body with air medium. This border can be regarded as an acoustically soft. Existing types of acoustic sensors usially used here may be divided into contact and non-contact receivers.
Non-contact receivers are still exotic to some extent. Currently, three types of acoustic receivers mounted in contact with the chest surface are used to record respiratory sounds. They are acoustic accelerometer, stethoscope sensor with microphone, and so called “contact” sensor, in which the sensitive piezoelement is situated between the surface of the chest and the sensor housing.
Any acoustic sensor having a mass when placed on a layer of soft tissues (skin and adipose layer) having hardness should inevitably have some eigenfrequency of suspending. According to ratio of working frequency range and the eigenfrequency of suspending all mentioned sensors are modeled as the receivers of oscillatory acceleration, velocity, displacement or dynamic force.
Experimental study and theoretical estimates indicate that there is no one optimal sensor meeting all basic requirements for all scenarios of acoustic investigation of lungs. Hence a passive recording of lung sounds at chest is more frequently performed with a stethoscope sensor, containing microphone (especially at low frequencies) or with “contact” sensor. Whereas recording under active transmission sounding is performed better with an accelerometer or “contact” sensor. All known sensors (contact and non-contact) have certain advantages as well as disadvantages in their usage. New studies are welcome to design more optimal sensors.
The study was supported by the RFBR grant 16-08-00075-a.

Contribution ID: 310
4. Modelling and Simulation
04.17. Other

Geant4 Simulation For Commissioning Of Proton Therapy Centre

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In anticipation of the new Proton Therapy Centre in Singapore at 2020, the medical physicists and physicists in NCCS and NUS have come to together to do several preparation/preliminary works. Of which, one of the most important programme is to develop the monte carlo simulation capability using Geant4 toolkit. We simulated the entire proton therapy system based on specifications given by Hitachi, and the results of the Dose-Depth curve in water phantom together with in-air spot size agrees well with measurement data provided by Hitachi. We will show the complete methodology of simulation leading up to the comparison with measurement data. In particular, we focused on 3 main aspects - 1) The choice of physics models 2) The determination of initial phase space of proton based on Twiss parameters from beam profile measurement and 3) The Choice of cut-off energy and step size. This simulation is important for the commissioning of the Proton Therapy System and the methodology presented will be helpful for other upcoming centre who are interested in doing the same.

Contribution ID: 315
4. Modelling and Simulation
04.17. Other

Electromagnetic compatibility of cardiostimulation technology in relation to human body - the introductory study

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The session deals with interdisciplinary topic of the electromagnetic compatibility of cardiostimulation devices that are used in patients with cardiac pathology. This study is thematically interested in physical and energy impacts of artificial electromagnetic fields, particularly in the influence of strong energy time-variable fields, on cardiostimulation system implanted into human organism. We consider implanted electronic device, pacemaker or cardioverter-defibrillator with fixed electrodes, and human heart, especially cardiac conduction system, as a whole. In this article we present the functional principles of implantable cardiac pacemakers and describe its interaction with the source of external interference by using modelling and simulation methods by electric circuit substitution. Subsequently, we discuss the physical mechanisms of disturbance signals and methods to minimize its consequences. The aim of the study is the theoretical analysis and the introduction to this issue and also the definition of the terms. This session does not occupy with medical clinical problems but the emphasis is put on physical and energy aspects of external electromagnetic fields on heart implanted device and to refer and analyze the possible risks of interaction.

Contribution ID: 326
4. Modelling and Simulation
04.17. Other

The influence of central corneal thickness towards glaucomatous optic nerve damage in a human eye

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Central corneal thickness (CCT) is considered as an independent risk factor in the pathogenesis of glaucoma. Statistical analyses from clinical studies suggest a strong correlation between CCT and glaucoma progression. A 3D numerical model of the human eye is developed to investigate the underlying mechanisms in the mechanical engineering point of view. Structural mechanics analyses are carried out, considering the nonlinearity in material properties of the cornea, sclera and lamina cribrosa (LC). The influence of the geometrical factor of the CCT towards the posterior displacement of the LC, as a surrogate indicator of the optic nerve damage, is observed. Results from the in silico study shows a greater posterior displacement of the LC with respect to a lower CCT. This supports the clinical hypothesis that a thinner cornea has a higher susceptibility to glaucomatous optic nerve damage. Under similar conditions in terms of the mechanical properties, a thicker cornea allows more room for stretching, which subsequently causes lower transferred hoop-stress via the corneo-sclera shell to the LC. The slight difference of LC posterior displacement with respect to CCT changes may indicate that corneal thickness may not be the dominant factor in optic neuropathy. The numerical results suggest that CCT measurements can be vital within the risk assessment procedures in glaucoma management.

Contribution ID: 527
4. Modelling and Simulation
04.17. Other

Deployment of circular vs D-shaped stent in the mitral annulus

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Approximately 30% of patients suffering from severe mitral regurgitation (MR) are non-compliant to the gold standard of open heart surgery. Without the necessity for open valve surgery and cardio-pulmonary bypass, transcatheter procedures are of particular benefit to multi-morbid patients. Apart from showing promising results following aortic and pulmonary valve implantation, transcatheter procedures for the treatment of diseased mitral valves have been gaining traction in recent years. At present, there are a few commercial transcatheter devices for mitral valve replacement that have been tried in humans with fairly promising short term results. However, there is always this continuous debate on whether to deploy a circular stented valve or a D-shaped stented valve in the saddle-shaped highly complex mitral annulus. While CardiaQ, Intrepid, HighLife & NCSI NAviGate are some of the circular valves being tested, Neovasc Tiara, Tendyne & Caisson are the D-shaped valves that are being evaluated. Firstly, from a design standpoint, stent crimpability is an essential criterion where the stented valve has to be crimped to a smaller profile (18F – 24F) which is crucial for implantation through a femoral approach. Secondly during and after deployment in the mitral annulus, excess radial force onto the annular tissues especially on the aortic side is undesirable as it will lead to obstruction of the aorta and the left ventricular outflow tract (LVOT). Hence this work aims to evaluate the mechanics of both a circular and the corresponding D-shaped stent during their crimping and deployment in the mitral annulus. Our results showed that both the stents could be crimped without much problem and the anchorage in the D-shaped mitral annulus between the circular and the D-shaped stents was comparable

Contribution ID: 670

4. Modelling and Simulation
04.17. Other

Prototype measurement system for the eye-hand coordination test of the developmental test of visual perception

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The Developmental Test of Visual Perception (DTVP) is one of the most used tests to identify the presence and degree of visual-perceptual and visual-integration deficits in children from 4 to 12 years of age. The current version of the test (DTVP-3) consists in five main sub-tests including the eye-hand coordination test (EHCT), which must be performed by an examiner with knowledge on the DTVP-3 assessment. Currently, the EHCT is based on observations of the examiner and requires a post-hoc analysis using the DTVP information, this is a time consumption task which it is not exempt of examiner´s errors. Thus, there is a need of a medical device to automatically measure, assess and report the test scores obtained from applying the DTVP-3 assessment, leading to an overall decrement in the time of the post-hoc analysis and an improvement in the accuracy of the EHCT score. According to EHCT specifications, we determine that the device must allow to track the stylus position in two dimensions with a resolution of 1 mm and it must be a low-size system to not interfere with the test. For this reason, in this study we proposed a system based on hall-effect technology sensors, which allows to indirectly estimate distances from magnetic field magnitudes using low-size sensors. A first prototype consists in a matrix array of hall-effect sensors, and it was used a radial basis function to model the magnitude-distance response of each sensor, the model was estimated using a multivariate linear regression, and it was found, that the proposed model for 1mm resolution tests, has an average accuracy score of 96 % and an average R-squared of 94 %, showing that this kind of technology is suitable considering the EHCT specifications.

Contribution ID: 705
4. Modelling and Simulation
04.17. Other

Computer simulation in the analysis of computed tomography exam times

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Computed Tomography (CT) is one of the most important tools in diagnostic imaging. In Brazil, among medical imaging devices, 4.7% were CTs, representing eighth place in exam numbers and first in costs. The aim of this study was to evaluate the effect of faster CT equipment on total exam time (from patient arrival to departure). To this end, exams were divided into six steps: patient arrival, patient movement in the examination room, patient positioning, data entry, image acquisition and patient exit. Step duration was measured on 107 exams with 1, 2, 4, 16 and 128-slices CTs in 8 private clinics/hospitals, in 2014/2015. Models were created in the MedModel software and thirty days were simulated for a hospital operating 24h/day. Scenarios were simulated for the five types of CTs using the average times obtained from the exams. Except for the acquisition stage, times were similar, stressing the similarity among exam procedures. Simulations showed that, for example, running inpatient examinations at night (8:00 PM - 6:00 AM) would decrease total exam time by approximately 30%; while replacement of a single slice CT by a

(more expensive) 4 slices model would result in a much smaller overall time reduction. In conclusion, productivity gains may be smaller than expected when replacing simpler models with more sophisticated ones, and patient care time is not only a function of the speed of data acquisition, since organizational changes can produce considerable decreases in these times.

Contribution ID: 1117
4. Modelling and Simulation
04.17. Other

Effect of Bristle Geometry on the Cell Collecting Performance of Oral Biopsy Brushes : A Finite Element Study

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Oral premalignant lesion is referred as a morphologically altered oral mucosal tissue in which cancer is more likely to occur than in normal tissue and has a risk of malignant transformation rate varying between 5-18% . Early recognition and diagnosis of these lesions is vital to improve patient survival and reduce treatment-related morbidity. Exfoliative cytologic techniques are among the adjunct methods and devices to facilitate detection of oral premalignant lesions, and they evaluate oral mucosal cells collected via brush biopsy. Even though the sensitivity and specificity of cytology have been questioned, brush biopsy is considered as a minimally-invasive and well-tolerated method; its use has been advocated in clinical practice for patients where scalpel biopsy may not be possible, and for follow up of mucosal lesions with prior definitive diagnosis .
Despite several papers explaining the methodology for harvesting the sample cells for cytological examination, the number of studies investigating the effect of the brush itself is limited. The present study aims to develop a finite element model to simulate the cell harvesting process using ABAQUS. It is suggested that the finite element model can provide an insight on the effect of several brush parameters and the way the cell harvesting technique is applied. The mechanical properties and shear - strain response of tissue is modelled as a viscoelastic material with hysteresis behavior. The performance of cell harvesting process is evaluated by using results of shear stress rates corresponding to different bristle geometry features.

Contribution ID: 1146
4. Modelling and Simulation
04.17. Other

Heat transfer analysis of the temperature-controlled ablation electrode in arrhythmias

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We numerically investigated the heat transfer of the temperature-controlled ablation electrode to eliminate cardiac tissue caused by arrhythmias. The purpose of study is set up the numerical modeling of the temperature-controlled ablation electrode including the flow problem about the blood circulation and the saline irrigation flow.
The problem we wish to solve is the temperature distribution of cardiac tissue, electrode and blood when the saline is injected through the electrode including 6 irrigation holes. The model is based

on coupled electric-thermal-flow problems. The governing equations are Energy equation, Navier–Stokes equation and Maxwell equation. To solve the coupled problems, we use AC/DC Module, Heat Transfer module, and CFD module in COMSOL multiphysics software. In the properties of the materials, the electrical and thermal conductivity of cardiac tissue are temperature-dependent function. We consider a temperature-control ablation on the electrode tip. To control the temperature of the electrode tip, the model is implemented standard proportional-integral(PI) control system by setting the probe of temperature at the electrode tip. In the flow problem, the inlet velocity boundary condition is applied on the left surface to impose a blood flow 0.1 m/s. In the thermal boundary conditions, the temperature of the outer surface is constant 37℃. And the temperature of the saline injected through the electrode and catheter body is constant 20℃ at the entrance of catheter body.
The results of the numerical models show that the thermal lesion of parallel position, respect to the cardiac tissue surface, is lager than the thermal lesion of perpendicular position. The temperature of electrode tip with the saline irrigation is reduced for several seconds due to convective heat transfer between electrode and saline irrigation .

Contribution ID: 1202
4. Modelling and Simulation
04.17. Other

Microrobot Design for Intracranial Surgical Operations via Finite Element Method

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Endoscopic third ventriculostomy (ETV) is the optimal minimally invasive surgical approach, which is widely preferred in the last decade for the treatment of obstructive hydrocephalus. The limited dexterity of conventional endoscopic instruments greatly affects the success rate of ETV operations. Especially, hemorrhages and damages to the neural structures are the most important and fatal intraoperative complications that occur in the endoscopic surgeries. Several approaches like flexible endoscopic tools have been proposed to increase the dexterity of the surgeon to avoid such complications.
In the last decade, microrobotic solutions for intracorporeal operations have attracted great interest in robotic research communities. Untethered microrobot systems in which power is transferred by electromagnetic fields are considered as dexterous approaches for cardiovascular and intraocular surgeries. For such systems, the design of the microrobot, which is the end-effector of robotic system, is critical and depends on the task to be performed by the microrobotic system.
In this study, a magnetic microrobot is designed by finite element method for manipulation of intracranial tissues in electromagnetic microrobotic system that has been developed in our laboratory. A scenario is designed as rupturing and tearing of dura layer, which is considered the hardest region of brain tissue. For this purpose, a 3-D dura membrane is modeled in ABAQUS with nonlinear stress-strain relations. Rupturing of this membrane is simulated in ABAQUS with different microrobot models at different geometries and rupturing speeds. Best microrobot geometry is selected considering the required force and magnetic field gradient by comparing simulation results.

Contribution ID: 1215

4. Modelling and Simulation
04.17. Other

Development and validation of a methodology using additive manufacture for the production of silicone ear prostheses

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Since 600 BC, the auricular reconstruction is present through skin flaps implants. In the current years, prostheses have been developed to replace the patient's organ without the use of surgeries. Facial prosthesis production methods have undergone little change in the last 40 years. Even today, manual techniques are used for the production of prostheses, which are usually cast in wax over a replica of the patient's anatomy. Silicone is the most appropriate structural material used in the production of atrial prostheses due to its mechanical and chemical characteristics. Recently, new technologies, such as anatomical acquisition and additive manufacturing techniques are being applied in the production of auricular prostheses, aiming at obtaining a product with I better cost/quality relation when compared to the manual manufacturing process. In this research, a methodology was developed to investigate the use of four methods of acquiring the external structure of a volunteer's ear (photogrammetry, 3D scanning, 3D reconstruction of computed tomography images and parameterized 3D modeling) for the production of auricular prosthesis molds by additive manufacture (melt deposition technique). The silicone ear prosthesis produced with this methodology presented an excellent esthetic result with only 3% dimensional error. In addition, mechanical analysis (tensile strength and hardness tests) of the silicone used showed that the prostheses produced have excellent mechanical resistance that is not altered by the pigmentation process. The results demonstrate the feasibility of an accessible methodology for the production of ear prostheses using free softwares, technologies and supplies available in the market.

Contribution ID: 1436
4. Modelling and Simulation
04.17. Other

Problematic ventilation of infant with lung inhomogeneity, studied using hybrid respiratory simulator

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Lung inhomogeneity of premature and full term infants is a phenomenon, which is relatively little studied in relation to artificial ventilation of the lungs. The objective methods of assessment of lung inhomogeneity and the search of the best method of ventilatory support are still on the investigation stage. Artificial ventilation of infant with lung inhomogeneity can constitute a challenge to anaesthesiologists, especially when there is a large discrepancy in the resistance-compliance properties of both lungs, e.g. in diaphragmatic hernia.
The aim of the work was to study the problem of artificial ventilation in the case of infant lung inhomogeneity, by simulation, based on clinical (literature) data and using an infant hybrid (numerical-physical) respiratory simulator. The physical part of the simulator enables to connect "the artificial patient"(numerical lung RLC model) to a ventilator. The structure of the numerical lung model, implemented in the hybrid simulator gives the possibility to simulate lung inhomogeneity of different type and severity levels.

Different modes of conventional ventilation for various type of lung inhomogeneity were compared. Our simulations proved that the higher discrepancy in the resistance-compliance properties of both lungs, the higher impedance of respiratory system, and then the highest level of: PIP(peak inspiratory pressure), MAP (mean airway pressure by breath), PIF (peak inspiratory flow), PEF (peak expiratory flow) and WOB (work of breathing by ventilator) were reached to obtain required ventilation of the patient.
The results obtained within the in-vitro experiments on the infant hybrid respiratory simulator are consistent with clinical studies results.

Contribution ID: 1507
4. Modelling and Simulation
04.17. Other

Measurement of Electrical Property for Sacrificed Pig muscle and Prototype of Electromagnetic Phantom for Low Frequency Band

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This paper describes the measurement of electrical property of Pig muscle sacrificed within 1 hour and prototype of electromagnetic phantom. Various electrodes were used for measurement to evaluate the effect of electric double layer, we found that the best electrode is Ag-AgCl electrode. Electrical properties, including the anisotropy of tissue, of pig muscle immediately after sacrifice were measured using Ag-AgCl electrode including the anisotropy of tissue. This result is important in order to obtain an index of electrical characteristics at the low frequency band. Based on the results, we investigated the improvement of the electrical characteristics of the high-hydrous electromagnetic phantom in the low frequency band. In order to give the phantom anisotropy, carbon fiber was added. The direction of the carbon fiber, furthermore, was controlled by applying a strong magnetic field. As a result, anisotropy was given to the proposed phantom. This finding is a very important for the development of a high-performance phantom.

Contribution ID: 1526
4. Modelling and Simulation
04.17. Other

Breathing experiments into the simulated avalanche snow: Medical and technical issues of the outdoor breathing trials

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Avalanche burials represent one of the most dangerous risks associated with winter activities in the mountains. Asphyxiation occurs as a consequence of blocked airways; or, due to a severe hypoxia and hypercapnia resulting from rebreathing previously exhaled gas. Recently, outdoor breathing experiments with healthy volunteers were conducted in order to investigate the gas exchange limitations and work of breathing effects on the probability of survival under avalanche snow. Ambient conditions during the experiments differed significantly from the recommended operating conditions of the medical devices. Therefore, special measures need to be applied during future experiments not only to assure proper functioning of the devices used for the monitoring of the breathing subject, but also ensuring their required precision and accuracy. As the subjects starts to suffer from hypoxia and hypercapnia at the very beginning of the breathing trial, careful and detailed monitoring and advanced safety precautions must be adopted. Using our experience from

real outdoor breathing trials, we aim to recommend both the technical and medical precautions that should be undertaken in future studies.

Contribution ID: 1887
4. Modelling and Simulation
04.17. Other

Discrete event simulation model for the analysis of centralized front office service in a regional hub hospital

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Today, hospital rankings are based primarily on basic clinical indicators. The aim of the project shown in this article is to develop a methodology able to improve non-clinical front office operation for the patients (like booking exams, delivering medical reports etc.), keeping the costs under control. The service center serves 600 users every day and it is the core of a great reorganization process, focused on centralization of office activities of the Careggi University Hospital of Florence, to ensure the best services to patients. For this reason, Discrete Event Simulation model (DES) have been used. The project of the model was made according to the real process ob-served during the confrontation with staff, document verification, field ob-servation stage and study of data stored in hospital's databases. These re-searches provided parameters necessary for model running, such as number of accesses, service time, available resources and patient's waiting time. Validation confirmed that model is formally correct, and shown that wait-ing time of patients is substantially equal between real data and simulated outputs. The mean waiting time of all patients calculated by the model (7 minutes and 9 seconds) is only 2.6% lesser than real one (7 minutes and 20 seconds). Weekly workload of the model (3048 patients) is equal to reality, proving that the schedules of patient's accesses are correct. We used a sta-tistic test to confirm the results. This paper shows that DES is a valuable tool that can be used to save money and improve clinical processes. In the future this model will be used to evaluate the reorganization of the Service Center with the aim to allow everyone (not only technical staff) to use it, through a web based support, a predictive machine and a user interface.

Contribution ID: 920
5. BME and MP Education, Training and Professional Development
05.08. Keynote lecture

KEYNOTE LECUTE: Preparing young medical physicists for future leadership roles

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In today’s highly competitive world, being a good scientist is not sufficient for a professional to prosper; good leadership, managerial and strategic planning skills have become essential. Leadership is of concern to all healthcare professions, but it is even more crucial for small professions such as Medical Physics. Preparing future leaders should be done in two ways: first by direct interaction with successful leaders who would share their experiences (role modelling) and secondly through a formal course in Medical Physics leadership. This presentation will provide

examples of both. The author will present his own experiences of leadership and present a practical 'to do' list for successful leadership. This will be followed by a description of the leadership module of the EUTEMPE network (MPE01 Leadership in Medical Physics - Development of the profession and the challenges for the Medical Physics Expert http://eutempe-net.eu/modules/) which is presently the most comprehensive module in Medical Physics leadership worldwide. It can be described as a 'Mini MBA for Medical Physicists'. The module achieves its learning objectives using a combination of online and face-to-face phases. The online component consists of a series of sets of compulsory readings, followed by online discussions involving real world case studies. The online phase is asynchronous so that participants would not need to take time off their clinical duties and there will not be a problem with time zones. This is followed by an onsite phase (one week, first two runs held in Prague February 2015, 2017, next run Prague February 2019 with online phase starting November 2018, applications open). Presentations during the onsite phase are by established leaders and followed by discussions in which participants can discuss challenges they are facing in their own country with a panel of established leaders. Total learning time (readings, presentations, online fora etc) 80 hours.

Contribution ID: 1546
5. BME and MP Education, Training and Professional Development
05.08. Keynote lecture

KEYNOTE LECTURE: Professional development through e-learning: A walkthrough of the AAPM Online Learning Center

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The American Association of Physicists in Medicine (AAPM) maintains an Online Learning Center (OLC) as a benefit to all of its members. The OLC center can be divided into two parts. The Virtual Library (VL) contains captured presentations from AAPM meetings, schools, and workshops dating back to 2001. These online presentations are a valuable resource for medical physicists needing information or instruction on virtually any topic in medical physics provided by experts in the field. Subjects include diagnostic radiology, nuclear medicine, radiation protection and radiotherapy as well as lectures on medical physics education, professionalism and others. The second part of the OLC is the continuing education (CE) credit and self-assessment (SA) modules. These are quizzes that are linked to either recent VL modules or published scientific papers. When possible, these quizzes are created by the lead speaker or author of the work and peer reviewed by AAPM reviewers. AAPM members may elect to take these quizzes and receive CE credit from CAMPEP as well as SA credit from ABR. These credits are sufficient to fulfill the annual CE and SA requirements for the ABR maintenance of certification. AAPM members can get all of their required credits online for an annual fee of $75 (US). The OLC also offers for purchase thumb drives of special meetings and summer schools the year that they are created. Those individuals who could not attend the meeting but wish to access the content right away can purchase these. In summary, the OLC provides a vast educational resource for the medical physics community.

Contribution ID: 46
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Biomedical engineering education in Georgia

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In the paper Study Program in Biomedical Engineering (BME) and Medical Informatics (MI) in Georgia is described. This program are realized in Georgian Technical University, at Biomedical Engineering Department. Implementation and sustainability activities are presented. The broad fields of Biomedical Engineering (BME) and Medical Informatics (MI) are among the most prominent and fastest developing scientific areas. These are considered as key, out of a few, challenges within crucial research and innovation strategies worldwide. Almost every university wanting to be in accordance with a technological progress offers a curricula in BME&MI at master and doctoral levels, and numerous offer bachelor level degrees, as well. Where it is not the case, state and universities authorities are making efforts to open dedicated study programs. Following the evident needs European Commission promotes such actions through its educational strategies and corresponding projects, Tempus being one of these. Department of GTU is one of the participant of BME-ENA – Biomedical Engineering Education Tempus Initiative in Eastern Neighbouring Area, Project Number: 543904-TEMPUS-1-2013-1-GR-TEMPUS-JPCR, is a Joint Project within the TEMPUS IV program and is 90% financed by the Commission of the European Communities. The following short study highlights the main guidelines of BME&MI study programs development, respecting European good practice.

Contribution ID: 80
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

International teaching-learning strategy for the promotion of collaboratively developed open-source medical devices

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The path towards universal healthcare requires the best possible trained biomedical engineers, which will be: those capable of implementing and working within international and multidisciplinary teams for adequately understanding the needs of local populations; those having an important cultural background, as a basis for mutual understanding between countries and lifestyles; those combining a well-balanced background in scientific-technological, social-economical and ethical issues; and those conscious of the relevance of mobility and of the related internationalization of their careers, as a key linked to lifelong learning. In this context, the "UBORA: Euro-African Biomedical Engineering e-Platform for Innovation through Education" project is developing a set of teaching-learning activities, which are setting the foundations of an global formative strategy for the promotion of collaboratively developed open-source medical devices, as we illustrate in this study.
Structured around a set of international medical device design competitions and intensive design schools and supported at every time by the UBORA e-Platform, a sort of "wikipedia" of open-source medical devices, to which teaching materials and open online courses are being incorporated, these teaching-learning actuations are already attracting researchers, designers and students from several countries and universities across Europe and Africa. Besides, these actuations are helping to disseminate common good practices and systematic development methodologies, aimed at the collaborative development of safe and accesible biodevices, while helping to arrange a cohort of well-trained young biomedical engineers with shared views and the potential to transform the way patients' needs are addressed and to reinvent the medical industry

in the decades ahead. Main cases of success and current detected challenges are systematically analyzed and discussed.

Contribution ID: 139
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Education system for biomedical technicians, biomedical engineers and clinical engineers in Czech Republic

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Biomedical Technician, Biomedical Engineer and Clinical Engineer are professions that are included among controlled professions. Education system for these professions is defined by state legislative (one law, two state decrees, one government regulation and two Ministry of Health guidelines). The education system has 3 levels of qualification. First level (bachelor’s degree) is for biomedical technician, second level (master’s degree) for biomedical engineers and third level (postgradual specialised education for biomedical engineers with attestation examination) for clinical engineers.
The law defines the studies branches at Technical Universities to obtain the Biomedical Technicians and Biomedical Engineers qualification. The minimum requests for the content of these studies branches are defined by one state decree and more detailed requests (number of ours for individual study subjects) by one Ministry of Health guideline. The government regulation defines the branches of postgradual specialised education. The education programme for obtain the clinical engineers qualification is defined by Ministry of Health guideline. One state decree defines works activities that the professions mentioned above may exercise.

Contribution ID: 387
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

A low-cost pedagogical environment for training on technologies for image-guided robotic surgery

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Courses related to Image Guided Surgery (IGS) and Robot-Assisted Surgery (RAS) taught in the degrees and masters of biomedical engineering of the Universidad Politécnica de Madrid (UPM) have had a theoretical approach until now. Pedagogical methodologies applied involved theoretical sessions and master classes in which the knowledge that the students have to acquire is presented. In the best scenario, guided practical sessions are carried out in which learners can observe the results of applying that theoretical knowledge to a specific simulated case. On the contrary, project-based learning allows the students to direct their own learning process, increasing their commitment and motivation through a team-based research methodology.

However, the high cost of real IGS and RAS environments makes them inaccessible for biomedical engineering training. Thus, this research presents a new methodology and a novel low-cost pedagogical environment for increasing learners' motivation and autonomy, giving them an active role during their didactic process and based on experimental training methods. The environment proposes a simplified surgical simulation use case: the movement of insertion and extraction of a needle, similar to an image-guided biopsy situation.
The training environment is composed of a 3D-printed phantom, a CT scan of the phantom, a virtual reality environment that includes haptic information, an ad-hoc 1 DOF robotic system for insertion/extraction and a Novint Falcon, an inexpensive 3 DOF manipulator that allows achieving haptic feedback. A first pilot experience has been carried out in the "Surgical Simulation and Planning" course of the Bachelor of Biomedical Engineering at UPM. Results of the surveys carried out (by teachers and learners) show that the new project-based methodology improves in all cases the values of student's satisfaction obtained using the classical methodology based on master classes and practices.

Contribution ID: 532
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Cooperative medical physics education between Heidelberg University in Germany and Gono University in Bangladesh

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In 1994, a post graduate course on health physics was launched at the Physics Department of Bangladesh University of Engineering and Technology (BUET), Dhaka. Supporting this initiative, five seminars and workshops were conducted at BUET between 1996 and 2000 in cooperation with the German Society of Medical Physics (DGMP) enhancing public awareness and encouraging physicists to become medical physicists (MP). In 2000, a department of Medical Physics and Biomedical Engineering (MPBME) was founded at Gono University, offering a master (120 credits) and since 2005 a bachelor (192 credits) course in MPBME. The syllabus of these courses is based on the documents of the DGMP, AAPM and IAEA.
In the years 2003-2006, nineteen students and teachers were educated and trained at German Cancer Research Center and Heidelberg University Hospital within a DAAD-financed student-teacher-exchange program between Gono and Heidelberg University. This collaboration was extended in 2014 including Mannheim Medical Center for another 4 years from 2014-2017, educating 40 MP for research, teaching and clinical practice in Germany and in Bangladesh. So far, approximately 30 MSc and 73 BSc degrees were granted and promising research work was initiated. A planned future project to expand centrally the cooperation with hospitals and universities in Bangladesh and abroad is the foundation of a "South Asian Centre for Medical Physics and Cancer Research" (SCMPCR), a cooperative training institute for medical physics and cancer research which will be open to students and universities in Bangladesh and the South Asian region.

For Bangladesh a need of 160 radiotherapy centers and 700 MP is estimated. Presently there are 17 centers and 30 MP. A training and accreditation program for MP supervised by IOMP and IAEA could help the 220 students studying in the MPBME department of Gono University today to contribute significantly to cover the manpower requirements in Bangladesh.

Contribution ID: 548
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Attract, retain and develop new nuclear talents beyond academic curricula - ENEN+ H2020 project

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The lack of new talents electing nuclear careers is closely linked to an early loss of interest in nuclear sciences and insufficient information about the nuclear careers available to both secondary school pupils and university students entering the Bachelor, Master of Science and PhD levels. The primary motivation of the ENEN+ project is to substantially contribute to the revival of the interest of young generations in careers in the nuclear sector.
This is to be achieved by pursuing the following main objectives: attracting new talents to careers in nuclear; developing the attracted talents beyond academic curricula; increasing the retention of attracted talents in nuclear careers; involving the nuclear stakeholders within the EU and beyond and sustaining the revived interest for nuclear careers.
The ENEN+ consortium will focus on the learners and careers in the following nuclear disciplines: nuclear reactor engineering and safety; waste management and geological disposal; radiation protection and medical physics.
For the ENEN+ project it is imperative to provide activities focused on the three main target groups of potential talents:
Secondary school pupils: attractive basic information on careers in nuclear will be developed, made available in national languages and complemented with an EU wide competition of pupils. A summer camp will be organized for the winners of the competition.
Bachelor students: most of the nuclear academic curricula within the ENEN association concentrate on master students. The existing efforts to attract bachelor students to pursue master education in nuclear will be strengthened by increasing the level of academic preparation for bachelor students. Young professionals after graduation: the nuclearization of graduates of non-nuclear sciences and technologies has been a considerable source of the nuclear talent throughout the nuclear era.
Coordinated Support Action in the H2020 EURATOM NFRP12 Support for careers in the nuclear field (2016-2017)

Contribution ID: 600
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

A virtual CPR (cardio-pulmonary resuscitation) learning system using motion capture device

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1. Introduction
The general content of CPR (Cardio-Pulmonary Resuscitation) includes patient consciousness confirmation, chest compression, artificial respiration and electric shock by an AED (Automated External Defiblirator). Earlier and appropriate CPR is important to save patient's life. However, according to a survey in Japan, only 31.7% of adults answered that they can use AED when they see persons of sudden illness or injury.
In order to disperse CPR, we develop a virtual CPR learning system that includes patient, an AED and chest compression simulation.
2. Methods and scenarios
Our virtual CPR is implemented using Unity 5.4.1 game engine and a Leap Motion sensor. Leap Motion is a very tiny and low-cost ($69) motion capture device specialized for hand motion. The trainee can move 'virtual' hand to operate 'virtual' AED and compress chest.
To determine CPR scenarios for our system, we investigated an existing AED trainer (TRN-2100, Nihon Kohden Corporation, $949) as a reference. Our scenarios include the phases of booting the AED, pasting electrode pads on appropriate position of the virtual patient's chest, waiting for ECG analysis, electric shock and chest compression.
3. Virtual chest compression
In the phase of chest compression, Leap Motion detect the position of trainee's hand while he/she repeatedly compresses chest of virtual patient. Then the system evaluates the position, depth and tempo of the compression. If the compression is insufficient, the system visually alerts it to the trainee.
4. Result
AED trainer is widely used for CPR training courses, but its pricey ($949) and is not intended for public use. Our system has more learning functions than the AED trainer has. Moreover, our system can automatically evaluate trainee's hand movement and more suitable for self-learning of CPR.

Contribution ID: 631
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Certification of Clinical Engineers in Sweden

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The Swedish Society for Biomedical Engineering and Physics has certified clinical engineers since 1994. The certification is performed at two levels, Master of Science and Bachelor of Science.
The Swedish Society for Biomedical Engineering and Physics, a section in the Swedish Medical Association, started already in 1956 and has about 800 members who are active in health care, academia and industry. The Society formed a working group in the early 1990:s that developed guidelines for certification of Clinical Engineers that started in 1994.
The certification is performed at two levels:
• level of a Bachelor 's degree in engineering.
• level of a Master's degree in engineering.
Applications can be sent to the Society twice a year. They are assessed by a Certification Committee mandated by the Board of the Society. The Certification Committee consists of six to

seven persons, a Chairman who preferably is the president of the Society. There is at least one university professor in biomedical engineering, and four experienced certified clinical engineers.
The requirements besides the exam, are courses in biomedical or clinical engineering, medicine and related subjects corresponding to at least 30 ECTS credit points. The courses can be university courses or courses given by other organizations or by companies. Credit points are assigned to each course by the Committee.
To become a certified clinical engineer, the person should have at least three years work experience as a clinical engineer. Since 1994 we have received a total of 753 applications, and 98 persons have been certified on the Master's level and 329 at the Bachelor's level respectively.
For the future, we have started a discussion with the universities to harmonize in biomedical engineering. A discussion is initialized with the National Board of Health and Welfare to create a license for clinical engineers.

Contribution ID: 632
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Interdisciplinary work as a pedagogical innovation for biomedical engineering and health sciences students

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The real world requires new professionals who know how to work in interdisciplinary teams to solve different types of problems efficiently. However, at university, students have few scenarios to acquire and consolidate these necessary skills. One way to approach this problem is to offer interdisciplinary elective courses in which different active and collaborative learning techniques (AcoLT) can be applied, simulating "real" professional contexts. The aim of this study is to implement and evaluate AcoLT to promote significant learning environments and communities of practices in an interdisciplinary course (Assistive Technology - AT) for Health Sciences and Biomedical Engineering students. The activities in this course were designed to improve skills such as: communication with professionals from different disciplines, hands-on technology skills, working under pressure and problem solving skills. Among the selected and adapted AcoLT are: Case study, role-play, hands on technology and hackathons.
A combination of an only post-test one-group design using a survey, and a semi-structured interview to know the students' perceptions about the AcoLT implemented in the AT course were used. The constructs measured in the survey were Satisfaction with Learning (SL) and Communities of Practice (CoP) through a 7-point Likert scale. Descriptive statistics were used and a Spearman correlation between CoP and SL constructs was calculated. Fourteen students participated in the study, 43% from Occupational Therapy, 7% from Psychology, 21% from Biomedical Engineering and 29% from Physical Therapy. The data collected includes one academic year (two semesters). As a result, we found a strong correlation between SL and CoP and the students were satisfied with the opportunity to solve problems through interdisciplinary team-work relating to the project they were developing. Placing the students in "real" simulated situations of their professional practice allowed them to acquire competences such as team-work, problem solving and critical thinking skills.

Contribution ID: 657
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

A Ugandan in-service biomedical engineering training program targeting laboratory equipment critical to the HIV clinical cascade

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Issues
Uganda is home to 37 million people, including 1.5 who are living with HIV. As the country works to attain the global 90-90-90 targets, functioning lab equipment for initial and ongoing viral and immunological testing is critical for success. The Ministry of Health (MOH) and President's Emergency Plan for AIDS Relief identified a large gap in the capacity of Ugandan biomedical engineers and equipment technicians (biomeds) to properly conduct routine equipment maintenance, repair, and calibration. Cooperation among lab and biomed teams also presented challenges.
Description
With PEPFAR support, American International Health Alliance (AIHA) launched in 2015 a project to provide in-service training on preventive maintenance and repair of lab equipment vital to the HIV clinical cascade. Working with MOH's Health Infrastructure Division (HID) and Central Public Health Laboratories (CPHL), AIHA is helping Uganda address the country's barriers to maintaining and repairing lab equipment. Using a step-wise approach, partners first focused trainings on non-automated equipment and a specialized biosafety cabinet calibration and certification training program before transitioning to automated equipment.
Lessons Learned
The project has shown that taking a comprehensive, staged approach to capacity building among biomeds can have significant impact over a short time. Within one year, the program rapidly transitioned from non-automated equipment to highly automated equipment (e.g., GeneXpert). Working collaboratively with multiple stakeholders, as well as equipment vendors, the project team is putting systems in place across Uganda to ensure adequate local capacity to keep lab equipment functioning.
Next Steps
This program increased capacity of a cadre often excluded from working in lab settings, despite its vital role in lab accreditation and the quality of diagnostic services. The program is a replicable model low- and middle-income countries can use to work with all stakeholders, including private sector, to strengthen biomeds' skills and implement a sustainable training mechanism.

Contribution ID: 732
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Evaluation of the impact of an international Master of advanced studies in medical physics

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Introduction
The Master of advanced studies in medical physics (MMP) has been jointly organized since 2014 by the International Centre for Theoretical Physics (ICTP) and Trieste University and supported by the IAEA, through the work of the Dosimetry and Medical Radiation Physics Section (DMRP), Division of Human Health (NAHU) and the Technical Cooperation Programme. The Master aims at addressing the scarcity of quality education and training of medical physicists, through an internationally harmonized programme that provides to graduates knowledge and practical skills

that will be brought back to their countries. The Master offers one academic year of theoretical classes followed by one year of structured clinical training that takes place in hospitals. Adequate academic education and structured clinical training of medical physicists play an important role in ensuring the safe and effective use of nuclear technologies in the diagnosis and treatment of patients.
Methods
An online survey was developed with the aim of evaluating the impact of the Master and it was distributed in March 2017 to all graduates through email.
The survey comprised different sections to assess different topics, for example the activity of the graduates before and after the Master and the possibility to achieve recognition of the degree locally. It also included questions about the career plans of the participants and their relationship with local professional associations. Specific feedback was also collected about the Master programme. There are plans for the survey to be repeated after each graduation, to assess and allow follow up actions if needed.
Conclusions
The analysis of the 22 received answers (85% of all graduates at the time of the survey) will be presented in this article.

Contribution ID: 813
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Medical physics practice and training in Ghana

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Medical Physics has greatly supported radiation oncology and medical imaging services in Ghana over the years, with the practice going through a number of phase changes. The country has over a decade established training programme locally which produces human resources to feed into the nation’s radiological health programme. The training programme has grown to receive students from other African countries in addition to local students. Ghana is currently recognized by the IAEA as Regional Designated Centre for Academic Training of Medical Physicists in Africa. The Ghana Society for Medical Physics has also been established as a national Medical Physics body to serve as checks and balances on the professional practice of medical physicists and also makes input into the academic programmes. The Society collaborates with the management of the Medical Physics educational programme to ensure that training offered to medical physicists meet international standards, making them clinically qualified. The Society has also worked together with other allied bodies for the passage of the Health Profession’s Regulatory Bodies Act, giving legal backing to the practice of Medical Physics and other allied health professions in Ghana. The country has participated in a number of IAEA, IOMP and ICTP projects on medical physics and has benefited from its training courses, fellowships and workshops. Ghana’s medical physicists are well placed to practice competently and improve healthcare delivery.

Contribution ID: 900
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

A medical physicist perspective: radiation-therapy in Nepal

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Cancer is one of the most rapidly growing diseases in Nepal. Over half of all cases of cancer in the world arise in people in low and middle-income countries. About 60% of the cancer cases worldwide occurs in low and middle income countries. This proportion will rise to 50% by 2020. In developing country like Nepal, at least 60% of all cancer patient can benefit from radiotherapy. However, the existing infrastructure is far behind to successfully cope with this increasing threat not only to public health but also national economies. Technological advancement in radiation therapy has dramatically increased the reduction of side effects and also increased survival rate in some cases and enhanced the quality of life after recovery. Modern Radiation Therapy treatments require trained and qualified professionals and big investment. However, the developing country like Nepal does not benefit from this advancement due to lack of radiotherapy machines and insufficient number of specialized medical professionals mainly medical physicists. Medical Physicists are one of the key component in Radiation Oncology and plays a vital role in improving cancer cure through technology. Upon pursuing the improvement of the situation, timely training in treatment planning, treatment technique and quality control is significant because the investment on human resource, investment on equipment and facility does not bring out an immediate result. It is necessary to develop human resources in Radiation Therapy by properly responding to the growing demand for cancer treatment and by overcoming the poor situation of limited resources.
The main point to cope with the current situation of radiotherapy service in Nepal is to improve the knowledge, skill and competency of medical physicist to treat the massive increase in cancer patients in particular throughout the country and also to improve cancer treatment by means of strengthening the application of radiation therapy.

Contribution ID: 922
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

The importance of history of Medical Physics in MP education and training

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Few years ago, in 2012, International Labor Association classified internationally Medical Physics (MP) as a profession, being integral part of the Health professionals' workforce. Nevertheless, medical physicists' work dates back to the early 20th century, mainly to apply safely radiations for both diagnosis and treatment purposes. The development of many modern technologies and methods brought the need for high-quality MP education and training in all countries to support their effective and safe use. In the last decades, many graduation and undergraduation courses have emerged aiming the training in MP, with different structures and concepts. In Brazil, for example, since 1990s, more than 10 undergraduation and 12 residency programs in MP area have been created. IAEA, IPEM, AAPM and other international and national organisms developed guides and didactic resources to support and homogenize such initiatives. Besides the discussion of learning methods, this work gathered the available knowledge of MP history and pre-history in order to strengthen and better define the field of Medical Physics, inside Physics history, for students and general people. Thus, one can know, e.g., that ancient Egyptians already utilized physical methods for diagnosis of diseases; that wise men, like Alhazen (11th century), Leonardo da Vinci (15th) and Descartes (17th), contributed to the knowledge of body functioning; that physicists, like Faraday, have assisted in the doctors training, due to the new devices (electrocardiographs, ophthalmoscopes, etc.) developed at that time. They also can know that the first properly called medical physicists became teachers and/or wrote Physics books for medical students in 19th century; and that the discovery and application of X-rays and radioactivity, their problems and victories, made possible the developing of MP field as we have today. With this knowledge, along with the basic concepts, students can build a global view of this odd Physics field.

Contribution ID: 1008
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Do we need undergraduate education in medical physics & biomedical engineering?

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Feedback from local radiotherapy service providers suggested providing a ‘Physicist’ beside a ‘Medical Physicist’ giving the reason that the ‘Medical Physicists’ are not being able to perform the rigorous analysis needed. With a long experience with teaching, I feel the above story has a relevance, particularly to the developing countries. Each treatment planning in Radiotherapy is a research in itself and Medical Physicists need good concepts of Physics and Mathematics, and skills in rigorous analytical work. Now at the undergraduate level a student typically has an age range of 17 to 22. Both the age and the social environment allow them to concentrate and develop analytical prowess in Physics and Mathematics at this level. However, when undergraduate courses in Medical Physics are introduced, some of the topics in Physics and Mathematics have to be curtailed or removed, to make room for biology and medical topics. However, these latter topics, being less mathematical, can be assimilated by a person even when older. Therefore, if such courses are initiated at Masters level rather than at the Undergraduate level, the result would be better in my opinion. Besides, even after Masters, persons have to go through years of residency to become professional Medical Physicists, which also offers the opportunity of learning the relevant biological and medical topics.
A similarity can be drawn to Biomedical Engineering. Persons with rigorous engineering and Physics education at the undergraduate level will do much better if the Biomedical topics are introduced at the Masters level.
Therefore, I would draw the attention of all policymakers to this issue which would be relevant to both the developing and developed countries, but would have more relevance to the latter in view of the prevailing educational system and lack of scientific environment.

Contribution ID: 1080
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Implementation of Project-based Learning in Biomedical Engineering Course in ITB: Opportunities and Challenges

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EL4132 Biomedical Engineering is an elective course for final year undergraduate student in School of Electrical Engineering and Informatics, Institut Teknologi Bandung (ITB), Indonesia. For the last two years (2015 - 2016), the student-centered learning (SCL) was implemented in this

course. In the first meeting, the objectives and learning outcomes for the course was introduced. The course scheme, SCL, was explained to students, including the benefit of SCL. Then, the students divided in (very) small groups, 1 group consist only two students, to conduct some literature reviews from advanced research papers, IEEE Pulse Magazine, IEEE Spectrum: Biomedical.
In 2017, project-based learning (PBL), was applied to the course. There are 30 students in this course, from Electrical Engineering Study Program and Information System & Technology Study Program. The goals is to enable students to take initiative, identify and solve the problems, work and communicate ideas in team, build responsibility and confidence. This paper will focus on implementation of project based learning in Biomedical Engineering, specifically on the opportunities and challenges.
The PBL was conducted in the last three weeks of the course schedule. In this learning scheme, the students need to be active and the instructor act as mentor. The students choose their own topic, identify and explain what is the topic, why they choose that, and how they solve the problem. The most important part is that the students have to review the existing solution and they should propose a new solution according to their review. In the end of the semester, they have to submit a report and a poster, then present their work in class attended by all the students and instructor. Using this learning approach, the students become more active to present their ideas, give some comments and questions.

Contribution ID: 1148
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Medical biophysics as combination of the face-to-face teaching and the remote experiment

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The medical biophysics is a typical multidisciplinary science and this is reflected also in the content of the teaching subject the Medical biophysics at Faculty of Medicine. The main topics are the biophysical principles of some physiological topics and the radiobiology, the physical principles of the medical imaging methods and in the last years something about the new materials used in medicine. Our department traditionally focuses on the use of new technologies in teaching, in addition to our research activities. One of our aims is to apply research results to the teaching. For many years we are interested in the so called smart materials, especially in the metal alloy NiTiNol. This material has a wide use in medicine: stents, osteosynthetic clamp, orthodontic springs … This material has a very unusual combination of properties: hyperelasticity, superelasticity, shape memory and for the medical applications important biocompatibility (useful for the longtime applications). The first three properties are caused by its very special microscopic structure leading to so called austenite-martensite transformation. Mechanical and electrical properties change after a certain temperature is exceeded. We have tried to get this topic more interesting for students. The result of our efforts is one lecture in the traditional form including videos documenting shape memory of the NiTiNol. Next, we have prepared a practical exercise showing how changes occur after the transition temperature is exceeded. And what is the brand new is the remote version of this practical exercise. Students can repeat the very similar practical exercises via internet. This experiment is based on the nitinol spring loaded. After a remotely controlled change of temperature of the spring, its length is shortened and it is measured. The both, shortening and a corresponding force is recorded and may be evaluated. The whole experiment is observed by means of a camera.

Contribution ID: 1187
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Development of a blended and elearning course on anatomy and physiology for engineers in Indonesia: Lessons learned and future developments

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Human anatomy and physiology is an essential part of biomedical engineering (BME) curriculum. This is because while BME consists of diverse subdisciplines such as biomechanics, bioelectronics and biophysics, at the core of it BME is the application of engineering principles to solve problems related to the human body. However, for new BME departments, especially in developing countries like Indonesia, there is often a lack of anatomy and physiology courses tailored for BME students, with students taking courses from other departments such as medicine or pharmacology. This is not ideal, as these courses are designed for different learning outcomes requirements. This paper describes the development and implementation of a course on human anatomy and physiology for engineers that has been implemented both in blended and pure eLearning mode in two universities in Indonesia. It focuses on analogies of the human physiological systems as engineering systems, including tie-in of physiological systems to engineering based quantitative models, as well as BME applications of anatomy and physiology principles. In addition to learning the fundamentals of anatomy and physiology, as a final class project, students are required to conduct a simple design exercise in developing a design applying engineering principles to solve a medical problem. This allows them to start integrating engineering and medical knowledge, which is a key part of BME education. In terms of implementation, the course has been run successfully between the two universities for three semesters, with generally satisfactory learning outcomes. However, there are still some hurdles that merits improvement, notably technical issues related to ICT infrastructure and some pedagogical issues related to higher level learning outcomes in pure eLearning modes. It is hoped that this course and the lessons learned from its development and implementation will contribute to the growth of BME education in Indonesia and beyond.

Contribution ID: 1293
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Medical physics education and training in mefomp countries

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The Education and Training of medical Physics in MEFOMP countries have been evolved since the last decade to better suit the demand and fulfill the market need of physicists in our region. The programs of Medical Physics will be reviled for some countries in our region.
The mission of MEFOMP Educational and Training Committee (ETC) is to promote activities related to education and training of medical physicists for the purpose of improving the quality of medical services for patients in the region through advancement in the practice of physics in medicine. ETC helps and provides support for all medical physics trainee in all member countries to understanding of different levels of learning, and the types of knowledge required for higher level functions such as problem solving, creative innovations, and applied clinical applications.
Medical physics education can be much more effective and efficient when all regional chapters of IOMP share their knowledge and experience to enhance the outcome with coordination of highly qualified experts of medical physics professionals.

Contribution ID: 1297
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Medical physicists certification process and examination in the middle east

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Certifying medical physics is becoming an essential part in recruiting medical physicists in hospitals across the Middle East region. Due to the lack of a comprehensive post graduate programs in MP in most of ME countries; hospitals find it very difficult to hire MP without the proper credentials and clinical experiences. Also, MP in the region find it very difficult to apply and travel for certification in Europe or North America due to visa and other related issues. So, if these certifying bodies are welling to cooperate with MEFOMP and/or similar organizations in the ME region so that certifications will be offered in the region for the region in a way to ease the process and save efforts and resources from the burdens of MP.
Certifying Medical Physicist requires an individual to obtain a university degree at the level of Master degree in Medical Physics, this is followed with at least a one year of clinical residency program in the Medical Physics fields applied in a Hospital.
The existing local/national certifying organization exam models are utilized as reference to design the final exam structure which can be customized for the medical physicists that will be working in the Middle East.
Three Exam Model proposals will be discussed here, all of which aim to evaluate the competencies of the individual medical physicist knowledge and skills by following various examination approaches.

Contribution ID: 1310
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

UDA-µBioLab: teaching microcontrollers with bioinstrumentation

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The Ecuadorian biomedical sector has a major shortcoming in Latin America because the lack of specialization at the undergraduate level and postgraduate level. There is only one university that offers the biomedical engineer degree but it still does not have graduate students. The School of Electronic Engineering at “Universidad del Azuay (UDA)” in Cuenca-Ecuador has been offering the subject of Bioelectronics (6 credits) for more than 10 years, but this is not enough to improve de biomedical sector. This paper presents the development, implementation and assessment of a practice guide designed to support the course of microcontrollers named UDA-µBioLab. This guide allows to consolidate the knowledge about the different peripherals of the microcontroller and introduces the students in the area of Bioinstrumentation through the acquisition of biosignals and actuators for prosthesis. Practices begin with the use of the A/D converter for the acquisition of EMG signals and flashing of a LED, then it is integrated with a DC motor to control the opening and closing of a commercial "Ottobock" prosthesis. To learn the PWM module, the prosthesis must pick up different objects such as a wood cube, a plastic ball and an egg without damage. The final project is the control of a robotic hand with 5 DOF (servomotor) and controlled by the EMG signals of a student and the computer. The outcomes of the course development presented here may be used as a guideline for the creation of multidisciplinary courses.

Contribution ID: 1407
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

KEYNOTE LECTURE: Future Needs of Biomedical Engineering Education

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Healthcare services landscape is changing rapidly due to multiple factors, ie healthcare economics leading to reformation in the healthcare system, major trends in public health, continuing advances in our understanding of human biology that has the potential impact on medical practice and the development of new innovative technologies for effective and precise diagnosis, treatment and monitoring. With advances in technology, how then would future healthcare and medicine look like? Would the approach gravitate towards patient-centered and personalized medicine? Particularly with the development wearables, data analytics, IoT and artificial intelligence etc. The proliferation of health centric devices and digital health will certainly give rise to connected health with increased fitness awareness. Aside from the digital revolution, multi-scale bioengineering approaches are also making impact in healthcare and medicine. In the understanding of cellular and molecular processes in pathology, and integration of computational modeling and in-vivo experimentations to address issues in tissue remodeling, injury risk prediction and device design. As such the field of medical and biological engineering has an important role to constantly attain scientific innovation and translate invention to practice, so as to enhance the healthcare interventions. Therefore, Biomedical Engineering education programme needs to address and respond to the rapid changes in technologies, teaching skills for the real world and ensuring our graduate remain relevant to the industry.

Contribution ID: 1429
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

A global leadership and mentoring programme for medical physicists

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Medical Physics is a relatively small profession and particularly in developing countries many young physicists feel isolated and have limited access to adequate career development opportunities. This mentoring programme is a developmental partnership that brings interested junior physicists together to help them in their studies, career and life in general. It also helps to identify their strengths, needs, values and potential and in order to realise their aspirations.
The initiative brought together four senior physicists from three countries representing both diagnostic and radiation oncology medical physics. We started In 2016 with a pioneer group of 12 mentees from 6 countries (Brazil, Hong Kong, Indonesia, Malaysia, Peru, Vietnam). They are: Vannyat Ath, Samuel Cheng, Chí Đỗ Đức, Louise Giansante, Luiza Goulart, Rachel Yan Hwa Lin, Alejandro Heiner Lopez, Lukmanda Evan Lubis, Aik Hao Ng, Heru Prasetio, Josilene Santos, and Soai Dang Quoc.

The mentees suggested a few topics for discussion, such as professional matters such as academic vs clinical medical physics, career choice, designing and managing research, professional practice, and coping with their studies. In the first year, five Skype meetings were held where one mentor interacted with the mentees for each session. A few talks such as 'Qualifications for the future medical physicist: certification and/or PhD?' and 'A few points on leadership. How to get there?' The talks were typically followed by online discussions and email exchange between mentees and mentor.
We received positive feedbacks, expressing thankfulness for such a unique experience of interacting with their mentors, their peers, and learning to cope with common challenges in their studies and career. We hope to continue to explore various ways to enhance this programme. Furthermore, we would like to encourage more volunteers to join us in mentoring and also to reach out to more mentees globally.

Contribution ID: 1702
5. BME and MP Education, Training and Professional Development
05.01. Education and training in MP and BME

Online training platform applied to imaging education

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One of the biggest problems in the health area is false positive and negative diagnoses, especially in the interpretation of radiological images. Several papers affirm that the experience of the radiologist favors a positive way in the precise diagnosis, reducing the differences in intra and inter expert interpretations. We have as a premise that the training can favor in the decrease of the false positive and false negative diagnosis, and this training must begin at the undergraduate level. Thus, this work aims to present an online training platform applied to the learning of interpretation imaging. The platform was developed using the php language and is hosted on the 000webhost server, consisting of an image base (format, png, jpg, tiff and DICOM), diagnostic imaging tests and user training quiz (students/residents) in the interpretation of radiographic images. The teacher can add the images, assemble diagnostic tests and create questionnaires. The users perform the diagnostic tests and answer the questionnaires, obtaining a score in real time. This platform can be used inside and outside the classroom, where they can train the diagnosis by image with the aim of improving their training. The platform was tested by 20 medical students who, after use, answered usability tests based on the SUS scale. Being that 90% of the users got maximum concept.

Contribution ID: 673
5. BME and MP Education, Training and Professional Development
05.02. Continuous professional development in MP and BME

The training of clinical engineers in Poland

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The professional title of a specialist in medical engineering is granted by the Polish Ministry of Health after completion of the theoretical program, clinical training and the final State Exam according to the present regulations. The same certification process applies for other medical professions like specialization in cardiology, neurology and other health care professions for example a medical physicist. Each trainee has a personal advisor (a specialist in medical engineering) acting as a tutor, providing professional support and evaluating the progress of a

trainee from the beginning up to the final exam. The importance of the tutor position was described in the regulation for acquiring of specializations in the health care professions introduced in 2017. The new law outlines the modifications of the curriculum of training including limiting number of the trainees per tutor to three and restricting the number and volume of stationary theoretical classes. The current medical engineer training program consists of 11 thematic modules implemented during 700 hours of theory classes, labs, seminars and 23 weeks of clinical trainings with total duration of two years. The authors of this paper developed and implemented the new version of that program based on the distance learning. The time of stationary classes was limited to 384 hours. On the other hand the additional 96 hours of consultations were introduced in order to provide more personal contacts between the trainee lecturer. In our opinion the time of classes for the theoretical modules such as basic electronics, automatics, informatics should be decreased even more. The reason for the reduction is that the trainees have already completed such classes during the prior academic education as required the by regulation mentioned above. More over the main purpose of the specialization is to provide the professional training that is directly applied to the health care.

Contribution ID: 1007
5. BME and MP Education, Training and Professional Development
05.02. Continuous professional development in MP and BME

Virtual course for the americas: healthcare technology planning and management over the life cycle

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Clinical engineers apply engineering and management principles to healthcare technology throughout the planning and management life cycle for the betterment of patient care. Clinical engineers are well suited as leaders in this process working with stakeholders from clinical, administrative and other healthcare professions. However, education and training for clinical engineers and others involved in healthcare technology planning and management (HTM) is limited outside the high income, developed countries.
To provide training and education to the low and middle income countries, a virtual course was developed by clinical engineering leadership at the Technical Services Partnership - University of Vermont USA, a WHO Collaborating Center for HTM, to teach students on best practices to follow over the healthcare technology life cycle: assessment, replacement, budgeting, acquisition, deployment, training, patient safety, compliance and maintenance. The current state of medical devices, information systems and the convergence of technologies is part of the learning along with the setup and operation of a clinical engineering department in a healthcare system. The course assessment consists of quizzes/exams, reports, and interactive discussion questions.
Healthcare Technology Planning & Management was first taught on the Pan American Health Organization Virtual Campus for Public Health in 2015. There are English and Spanish versions of the online course which allow participation from students from most of the Caribbean and Latin America countries. Sixty-four students from twenty-six countries successfully completed the 2015 fifteen-week course. The course engagement was exceptionally high as shown by the interactive discussion board with nearly three posts by each student for each question. The course was conducted a second time September – December 2017 with a similarly high turnout of over 100 students taught by four instructors. The presentation will discuss the course goals, content,

delivery, results, and knowledge use in the participant's environments for the 2015 and 2017 courses.

Contribution ID: 1471
5. BME and MP Education, Training and Professional Development
05.02. Continuous professional development in MP and BME

Five Years of International Day of Medical Physics Celebration in Ghana – The Experience

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The celebration of the International Day of Medical Physics (IDMP) was instituted by the International Organization of Medical Physics (IOMP) in 2013. This initiative was aimed at promoting the role of medical physicists in the worldwide medical scene. During the celebration, national and regional member organizations join the mother organization (IOMP) to organize series of events to mark the day. In Ghana, the Ghana Society for Medical Physics which is affiliated to the Federation of African Medical Physics Organizations and the IOMP has actively celebrated the IDMP in Ghana on every 7th November since its inception in 2013. This has given the medical physics profession a huge publicity in the country. Based on IOMP's theme for the year, the society selects appropriate speakers and topics reflecting the given theme. Previous speakers have included medical physicists, radiologists, radiation oncologists, nuclear medicine physicians, radiation protection practitioners and oncology nurses. The background of participants at such events includes medical physicists, radiation protection practitioners, lecturers, radiologist, oncologist, regulators, allied health professionals, students, media and the general public. The IDMP celebrations in Ghana have been very educative and successful. It is vital that the medical physics society continues to keep engaging other health professionals, general public and media, by making them aware of the extremely dynamic and crucial role medical physicists play in the healthcare delivery with respect to diagnostic medical imaging, radiotherapy, nuclear medicine and radiation protection.

Contribution ID: 1358
5. BME and MP Education, Training and Professional Development
05.03. Accreditation and certification

Accreditation of biomedical engineering programmes in universities

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All leading comprehensive universities around the world provide biomedical engineering (BME) education and training. To equip the BME graduates with a professional passport for their career movement across national boundaries, the BME programmes must be professionally accredited. The preparation for and full accreditation of a Bachelor-degree level BME programme are never easy. They require many and constant efforts by all stake-holders of the programme. Under the Washington Accord, for professional accreditation, all programmes must adopt the outcome-based teaching and learning (OBTL) approach. Therefore, right at the outset, the BME curriculum must be designed for OBTL. (Or, for old BME programmes, the curriculum must be re-designed/transformed to be suitable for OBTL.) And a “measurement” structure and process (preferably using a 3-year cycle) must be carefully designed and implemented for measuring the Programme Outcomes (POs, normally 12 POs) using selected courses across all levels (Level 1 to Level 4). Setting the criteria, closing the feedback loop, documentation, etc. are key to the successful accreditation of an engineering programme, including biomedical engineering. At The University of Hong Kong, the Medical Engineering Programme (“MedE”, which is retitled to Biomedical Engineering Programme in 2018) was provisionally accredited in 2014 and fully accredited in 2017 by the Hong Kong Institution of Engineers (HKIE) which is a signatory of the Washington Accord. As the Programme Director of HKU’s MedE Programme, I led the Programme through these two accreditation exercises. As a professional and educator working in the BME field, I also served in HKIE’s Visiting Team for the accreditation of BME programmes in another two universities in Hong Kong. In this talk, I shall share my experience and observations in the accreditation of BME programmes and provide my advice on the preparation for programme accreditation.

Contribution ID: 1905
5. BME and MP Education, Training and Professional Development
05.03. Accreditation and certification

Human-centered surgical robotics with continuum, compliance, collaboration, and cognition

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Representing a major paradigm shift from open surgery, minimally invasive surgery (MIS) assisted by robotics and sensing is emerging by accessing the surgical targets via either keyholes or natural orifices. It is challenging to get delicate and safe manipulations due to the constraints imposed by the mode of robotic access, confined workspace, complicated surgical environments and the limited available dedicated technologies, particularly in terms of endoluminal curvilinear targeting and curvilinear guidance. Addressing the aforementioned challenges and aiming at human-centered flexible minimally invasive robotic systems, we focus on the key biorobotics research in continuum robotic system development, compliant robotic modeling & control, collaborative human-robot interaction, cognitive sensing and intelligent navigation, which are tackling fundamental and technical challenges mostly in the context of MIS applications.

Contribution ID: 440
5. BME and MP Education, Training and Professional Development
05.04. Regional/national experiences of E&T

Status of radiotherapy engineers in Nigeria

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It is without question that of all the professionals in the multidisciplinary radiotherapy team the engineers are the least recognized. A survey of engineers working in radiotherapy centres in Nigeria was carried out to determine the current state of the profession.
In 7 out of 8 radiotherapy centres, the engineers were either exposed to only preliminary training or were not trained at all. During the course of employment, the average equipment training period was 3 weeks which is very inadequate. Of the total number of engineers (n=15) presently working in a radiotherapy centre, 60% have at least an entry qualification of a Bachelors in Engineering (Electrical/Electronics/Mechanical) degree while the remaining 40% have at least an Ordinary National Diploma. The results also show that lack of fulfillment was experienced by 93% of the engineers due to poor remuneration and lack of adequate training.
The current status and limitations faced by the engineers working in the 8 radiotherapy centres in Nigeria is presented with a view of creating more awareness of the profession and its challenges.

Contribution ID: 501
5. BME and MP Education, Training and Professional Development
05.04. Regional/national experiences of E&T

Public-private partnership strategy in acquiring facilities for radiotherapy services and for education and training of medical physicists in southern Philippines

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Mindanao Island is the second largest island of the Philippine archipelago. It is considered the breadbasket of the nation with a population of about 22 M. Although cancer is the third leading cause of mortality, only four hospitals with one linac each offer modern radiotherapy services in the whole island. Four radiation oncologists and seven medical physicists serve the needs of the entire Mindanao. All of the medical physicists are graduates of the single university located in Manila that offers the masters program in medical physics (MP) in the Philippines. Ideally, there is a need is for some 55 linacs and 110 medical physicists to service the entire population of Mindanao.
Significant improvement in radiotherapy services in Mindanao can be effected if an advanced education and training in medical physics program is initiated. An indispensable tool in the implementation of this program is the existence of a linac for the treatment of patients and which can also be used for the training and education of medical physics students . To surmount the huge challenges in present-day Philippines, a private-public partnership (PPP) is proposed with a local private hospital in Iligan City to host the radiotherapy operations of a medical linac. In the PPP, the linac will be acquired through government funds by a university research community which is going to appropriate the linac as an R&D light source also. This is possible since the linac is used for treatment for 8 hours a day and 5 days a week. In addition to education, training , and research and development in medical physics, the linear accelerator can also be used by researchers in material science, nanotechnology, radiobiology, chemistry and agriculture. Public-Private Partnership is an innovative approach which other countries can use for development in education and research, especially in medical physics.

Contribution ID: 826
5. BME and MP Education, Training and Professional Development
05.04. Regional/national experiences of E&T

Role of FAMPO in education, training and professional development of medical physicists in Africa

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Training of medical physicists and recognition of the profession in Africa in the recent past was faced with challenges due to lack of proper structures. Through collaborations between the Federation of African Medical Physics Organizations (FAMPO), International Atomic Energy Agency (IAEA) and the African Regional Agreement (AFRA), four publications on Education and Training of Medical Physicists in Africa have been produced through several task force meetings held under Regional African Radiotherapy Medical Physics (RAF 6/027, RAF 6/031 and RAF 6/044) and Nuclear Medicine Medical Physics (RAF 6/032, RAF 6/038 and RAF6048) projects. These publications, endorsed by the FAMPO, have to a large extent harmonized the standard of medical physics academic education in the region and are being applied towards strengthening clinical training in Africa. FAMPO, being the African Chapter of the International Organization for Medical Physics (IOMP), plays an essential role in the recognition and promotion of medical physics practice, education and training in the continent. FAMPO has undertaken a number of steps aimed at improving education, training and professional development of medical physicists in Africa. The Federation has championed the adoption of the published IAEA/AFRA documents on education and training of medical physicists in Africa. AFRA Regional Designated Centres (RDCs) for the training of medical physicists in the region have been established through collaborations between IAEA and institutions in Member States that have ability to provide multi-national training. Effort geared at implementation of FAMPO accredited clinical training of medical physicists is presently being made through collaboration with IAEA. This would ensure that in the medium term, all interns (trainees or students) who provide evidence of having successfully completed clinical training in an accredited institution will automatically receive registration from FAMPO.

Contribution ID: 1396
5. BME and MP Education, Training and Professional Development
05.04. Regional/national experiences of E&T

What can be expected from a week-long, student visit from Boston University to a developing nation, Peru?

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In September, 2016, Boston University's student chapter of Engineering World Health (EWH) decided to visit Lima Peru as a part of their mission to empower, educate and inspire biomedical engineering community to improve healthcare in developing countries. An applied research plan was designed by the American and Peruvian advisers; a questionnaire was developed to gauge student interest. Six biomedical engineers were chosen to work with the faculty adviser, the Peruvian partner and the Peruvian colleagues to crowdfund money and travel for a week in May 2017. Partial trip’s funding was provided by Boston University's Biomedical Eng. Department and College of Engineering.
To learn about the health care challenges; the applied research plan involved students on technical meetings with two high-level Peruvian-NIH officials, twice each, and interaction with Peruvian

biomedical engineers. The students selected two issues, 1) heavy metal poisoning and 2) mosquito-transmitted diseases. In the course of a week; supervised by the American and Peruvian advisers, the students prepared two plans, one to address each of the identified health issues. Reviewed and critiqued by the NIH officials, the proposals were well received by the NIH officials; Peruvian NIH expects a second group of students, some of the original team members included, back to Peru to implement in May 2018.
Short planned visits by teams of undergraduate and graduate students from developed countries, their immersion in the developing country's culture and having a close interaction with local students, contribute significantly to long-lasting relationships that can bind and support resource poor nations and provide valuable training to developing biomedical engineers.

Contribution ID: 1412
5. BME and MP Education, Training and Professional Development
05.04. Regional/national experiences of E&T

Overseeing the growth of medical physics: the Indonesian case

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As a nation of 261 million people (2015 survey), Indonesia has been in constant need of improvement in healthcare services which includes clinical medical physics services. A growth in number of clinical medical physicists, particularly in the field of radiation therapy, has been observed since the last thirty years. However, it is not until the last decade that a major increase took place owing to three main reasons; (1) the increase in number of radiotherapy facilities, (2) the founding of more medical physics programs in universities, and (3) the fusion of two previously-independent professional societies into one government-acknowledged professional body. All the three main reasons have positive linkage to another, allowing the field to grow even more in the future. This paper discusses the contribution of the three reasons to the growth status in medical physics profession, their relation and two-way impact to the academic aspect, as well as the future opens as consequence of this growth. Immediate plans and ongoing schemes will also be described to elaborate the chances of medical physics to thrive in Indonesia.

Contribution ID: 1646
5. BME and MP Education, Training and Professional Development
05.04. Regional/national experiences of E&T

A Training Program for Radiotherapy Technicians, a Novel Experience

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To reduce patient waiting time, the Brazilian Government decided to install eighty linear accelerators throughout the country. As consequence, it became urgent a need to train professionals in all áreas of radiotherapy. This paper describes a new experience to train Radiotherapy Technicians through a program conceived by the Cancer Foundation, specifically aimed to train 80 technicians, divided into 4 groups,(6 months each), in a program structured in three modules, involving theorethical classes and practical experience.

The Program with a total of 1040 hours of activities, is divided into 3 Modules: Module 1: Basic (345h): mostly theoretical, involving practical work in class and in a radiotherapy center; Module 2: Intermediate level (350h): clinical training in a radiotherapy center with focus on 2D-3D treatments, R&V systems, QA Programs and Safety barriers; Module 3: Advanced (345h): clinical training on advanced teletherapy and brachytherapy techniques. The Modules 2 and 3 are done in 11 carefully selected institutions, supervised by a local Board Certified Medical Physicist and, and followed by weekly reports sent to the Program Coordinator. Local visits to the training institutions are conducted once a month to accompany the students evolution.
As a pre-requisite, the students indicated by their institution must be Certified as Diagnostic Radiology Technician and they should maintain his job upon return. The selection committee evaluates all information, performs interviews by Skype and out of 135 candidates, 80 were selected. The students receive a 6 months scholarship, round-trip ticket, and a Tablet to have access to all the educational material. The students are finishing the course with sufficient technical and physical knowledge to work.

Contribution ID: 1647
5. BME and MP Education, Training and Professional Development
05.04. Regional/national experiences of E&T

The Professional Master Degree on Medical Physics in Brazil, a Novel Experience

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A Medical Physics Master's degree program in progress is a joint effort of the Cancer Foundation and the State University of Rio de Janeiro as part of the National Education Program in Radiotherapy. The purpose of this program is to train, qualify and update professionals, linked to public, philanthropic or private health therapy centers, that treats patients from the Brazilian Health Care System (SUS). This program aims to train 20 medical physicists to work in Radiotherapy during the period 24 months ending in June 2018. It is intended to help to minimize the present gap of qualified medical physicists in Brazil enhanced by installation of 80 new Linac's within the next 2 years. The total workload of the Master of 5410 hours divided in 610 hours of theory and lab work plus 4800 hours of clinical experience plus clinical research project. Each student was awarded a fellowship, and received a laptop with a treatment planning system installed, internet access to the bibliography, lectures and the clinical cases. This innovative paperless Project allows an effective interaction among the students, professors and the coordination team. All lectures, exams, lab reports and homeworks are loaded into the managing plataform developed in-house, called Tandle (Teach and Learning) to be made available to other training programs in the Latin America region. For the clinical training the students are distributed in 15 different carefully selected institutions under the supervision o of Board Certified Medical Physicist.
.This project is financed by the Ministry of Health -PRONON

Contribution ID: 1866
5. BME and MP Education, Training and Professional Development
05.04. Regional/national experiences of E&T

The Swedish Society for Medical Engineering and Physics

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The Swedish Society for Medical Engineering and Physics (MTF) is working in the fields of medical physics, biomedical engineering and biophysics. The society was founded in 1956 and its vision is to be the natural meeting place with a strong voice for medical technology in society. MTF has about 800 members and five sister societies in Denmark, Norway, Finland, Iceland and Estonia. The association arranges an annual event called “The Biomedical Engineering Days” with 350-500 participants from health care, research, industry and a large number of exhibitors. MTF also supports the arrangement of the Nordic Baltic Conference on Biomedical Engineering and Medical Physics. The engagement of MTF in international co-operation is formalised through the International Federation for Medical and Biological Engineering (IFMBE). MTF joined European Alliance for Medical and Biological Engineering & Science (EAMBES) in 2017 as a member representing Swedish biomedical engineering.
One of the association's main goals is to increase knowledge in use of medical devices used at the hospitals by arranging courses like "Medicine for Engineers", "Safety in Biomedical Engineering" and "Medical Device Regulations". Furthermore, as a section of the Swedish Society of Medicine, MTF advises on remittance concerning medical and biomedical technology. MTF’s scientific board supports the society in making strategic decisions regarding research. Other activities of MTF include allocating awards to outstanding contributions to Biomedical Engineering.
Since 1994, the members have the possibility to apply for Certification in Biomedical Engineering that has resulted in nearly 500 medical engineers/MSc engineers certified to date. The Accreditation Panel places considerable emphasis on checking that the candidate has not only the formal education, but also the overall competence to be certified. The purpose of the certification has been to inspire continuous development of skills and to raise the status of the profession of engineers in the healthcare.

Contribution ID: 458
5. BME and MP Education, Training and Professional Development
05.05. Teaching healthcare professionals

Physics education in medical colleges: proposing an extended syllabus

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Physics has indeed revolutionized medical practice since the birth of medicine thousands of years ago. It provided us with better understanding of our health problems through many diagnostic and treatment tools such as X-rays, nuclear medicine, magnetic resonance imaging (MRI), radiotherapy and minimal access surgery. Many medical colleges do not fully implement physics as a core subject in their curricula. This is basically due to the lack of an appropriate course design, references and the poor commissioning of physics in the medical field. The aim of this work is to propose a six-year extended course of physics in medicine that would fulfill the requirements of any medical college. The presented courses will divide the subject into the three academic phases of most medical colleges: premedical, pre-clinical and clinical phases.
Critical analysis of the subject given in some chosen universities will be performed. Medical colleges wishing to test the feasibility of changing a syllabus that had been reviewed by international academic panels need to be included in the study. Questionnaires will be designed to know the extent of implementing the subject at the different levels as well as the possibilities of integrating it with relevant subjects such as Biology, Physiology, Radiology, Surgery, etc.

Constraints including lack of trained staff, well-equipped laboratories, references, etc. will be assessed. Reputable biophysics departments will be contacted and requested to share their experience.
Shifting from classical mathematically-oriented physics to a subject that suits the needs of the developing medical world is a target. It needs hard work to design an integrated syllabus. But most important, it needs dedicated professionals: who believe in the power of physics in conjunction with other relevant health subjects and who wish to join efforts to maximize the benefits of this subject.

Contribution ID: 925
5. BME and MP Education, Training and Professional Development
05.05. Teaching healthcare professionals

Design and implementation of a continuous education program for mammography technicians, preliminary results

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In México, the lack of qualified personnel is one of the causes of the failure of breast screening programs.
In the country, 50% of mammography units are digital systems, and most of them operated by staff with low knowledge in the area.
Since there is not an official training program for the technicians in mammography, many of the experienced staff do not have the adequate knowledge in patient positioning and even less in quality control procedures.
Furthermore, this staff is in charge of teaching new generations.
To standardize the methodology to perform mammography procedures, the INCAN (National Cancer Institute) has developed a training program for technicians who are already working in this area.
Basic concepts of regulations, imaging, breast tissue characteristics, patient positioning and evaluation, are the main concepts.
This training program, taught through a virtual classroom, with recorded and synchronous sessions, lasts 6 weeks, plus 2 additional weeks of residence at the INCAN’s Imaging Department, where routinely quality control procedures, patient positioning, and image evaluation are performed. After 6 months, an evaluation of patient positioning is perform.
Since 2015, 101 technicians have completed the training program.
The main errors detected for patient positioning are: technician stands at the same side of the breast to image, technician does not pull or does not pull enough the breast in the CC projection, using ±45° for all MLO projections instead of the most adequate angle depending on patient constitution, and not including the inframammary angle in the MLO image.
Regarding quality control procedures, none of the technicians has ever performed any.
At the end of the Training Program, the technicians have corrected and standardized the patient positioning procedures and learned to perform quality control tests.
This training program is in process to be implemented as a national official program.

Contribution ID: 348
5. BME and MP Education, Training and Professional Development
05.06. Technology enhanced education

Technology-based educational master program in nuclear medicine

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Nuclear medicine presents a high technology activity and requires highly qualified medical and technical personnel. The last ones includes technologists, producing radiopharmaceuticals, medical physicist, engaging in radiation therapy planning and diagnostic performing, and engineers, whose are responsible for nuclear instrumentation. Technology-based education is crucial for such specialist training. Laboratory exercises and project-based learning allows us to develop students' critical thinking and problem-solving skills. Such educational approach is rather difficult to realize only in laboratory conditions. Therefore, challenging and successful education in nuclear medicine technology implies cooperation with real organizations in this field.
We have developed an educational master program for nuclear medicine technologists training. The program covers various aspects of nuclear medicine and provides technical personnel in this field in Ural region. The program was created in close collaboration with University's radiopharmaceutical production complex, which will be launched in 2018 (Cyclotron Center of Nuclear Medicine, CCNM). The CCNM is intended for production of wide range of radiopharmaceuticals for PET and SPECT studies. The cooperation with CCNM provides performance of various laboratory exercises with real and complex production equipment as well as individual student projects related to the center work. Moreover, the program applies different active learning methods such as problem-based learning, case study, discussion.

Contribution ID: 578
5. BME and MP Education, Training and Professional Development
05.06. Technology enhanced education

Monte Carlo simulation of a linac using PRIMO: user-friendly educational tool which can be taken to the Cloud for free

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The Monte Carlo (MC) method is generally considered as the most accurate tool for dose calculations in radiotherapy. It allows simulating the transport of ionizing radiation in complex configurations such as in the linac. Because of the long computation time required, MC method necessitates heavy computational resources that are not available to many. Additionally, significant training and skill is needed to understand and run the actual codes.
PRIMO is a free, self-contained linac simulator and dose calculation software based on the MC code PENELOPE. Running on Windows OS, it is user-friendly and does not require programming tasks by the end user. PRIMO comes with an intuitive graphical interface which allows any student or user to complete the simulation of a chosen linac in seemingly natural stages: from the primary electron source with an initial energy at the linac head then to the collimators and finally to the water phantom or computerized tomography. Apart from other functionalities, PRIMO provides comparison with experimental values of the percent depth dose and lateral profiles using gamma analysis.
A 6 MV Varian Clinac is simulated to investigate the dose deposition in a water phantom. A typical student desktop of 64-bit 4-core CPU Pentium type is used. It took 56 hours to simulate 25 million histories yielding an average dose uncertainty of 3.7 %. To further reduce the uncertainty to 2%, around 80 million histories are needed. At this point, the simulations can be taken to the Amazon Elastic Compute Cloud where the simulations are faster and steady. Abnormal program termination due to power outages which is a common occurrence in developing countries is no longer a concern. Without the need to invest in expensive hardware upfront, the PRIMO simulations can be deployed faster in the Amazon Cloud and which for some time can be free.

Contribution ID: 897
5. BME and MP Education, Training and Professional Development

05.06. Technology enhanced education

Development of a biomedical engineering e-Encyclopaedia

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Given its vast nature, especially with its multi-disciplinary posture, biomedical engineering as a profession is seen to be well suited to develop and apply e-Learning. The profession also provides excellent background for application of simulations, module design and other e-learning materials. The paper describes the method of developing an e-encyclopaedia for the field of biomedical engineering, emphasizing the necessity of regularly updating the content. The project takes a cue from the project EMITEL e-Encyclopaedia of Medical Physics and Multilingual Dictionary of Terms. When completed, the work will emphasize both the development and delivery of content via all electronic media, including the internet, intranets, extranets, satellite, broadcast, video, interactive TV, and CD ROM.

Contribution ID: 1401
5. BME and MP Education, Training and Professional Development
05.06. Technology enhanced education

Enhance medical education and training using interactive autostereoscopic 3D display by in-situ interaction

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Background: In the traditional medical education scenario, anatomical models or books are utilized to convey the knowledge of anatomical structure. However, the anatomical models are too bulky to carry and too expensive, while the books are not intuitive. In this study, we proposed to combine autostereoscopic 3D display and interactive display to intuitive visualize the 3D display. Objective: Develop an autostereoscopic 3D computer graphics rendering algorithm for medical education and training and evaluate the effectiveness of the interactive 3D display. Method: To meet the image quality and interactivity of the system, we proposed an enhanced rendering algorithm for autostereoscopic 3D displays to achieve higher frame rates and better image quality without pixel resampling. We adopted Octree to manipulate the mesh load and undertake viewport indexing before sending the meshes to GPU. We perform a user study of medical education with a heart phantom, and a human-computer interaction device to capture hand motions, rotations, and gestures. Structure of the heart was labeled and validated by physcian ahead. Furthermore, we devide 40 users (20 woman and 20 man) into two groups: control group and experiments group, to operate a user study on anatomical structures of heart. The controlled group and experimental group operated on CG based 2D display and 3D display, respectively.Result: In this experiment, we achieved rendering rate of approximately 50 FPS and achieved fluent interactivity (grasps and scratches), with the enhanced LBR, while rendering frame rate of the traditional method is 9.8 FPS. In the user study, the experimental group cost 34.7s while the control group used 44.5s in average. Conclusion: Experimental results showed that our algorithm can achieve higher rendering performance and 3D education system promote education experience and reduce education time consuming than CG based 2D display.

Contribution ID: 1734
5. BME and MP Education, Training and Professional Development
05.06. Technology enhanced education

EASIER: Technology-enhanced learning of surgical and interventional technical and nontechnical skills

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As surgical education evolves towards structured, objective and patient-safe training programs, new challenges arise related with the efficient exploitation of technology enhanced learning. The lack of a common pedagogical framework means that it is up to hospitals and training centres to dispose of different technological tools and resources such as VR simulators, online platforms, etc. The choice is usually based in economic criteria rather than pedagogical value. Moreover, the technologies are used in an isolated fashion, their potential diminished by the lack of integrative curricular reports considering technical and nontechnical assessment of skills.
The European Knowledge Alliance for Innovative Education of Surgical and Interventional Skills (EASIER) proposes an innovative approach for surgical and interventional teaching and learning based on TEL. EASIER will develop an innovative pedagogically-supported platform for surgical and interventional multi-skills education. The platform will integrate heterogeneous external TEL assets (VR, augmented video, augmented box trainers, etc.) to provide an engaging learning experience, favouring simulation and interaction. Through the integration, the learner will have access to a comprehensive record of achievements and outcomes linked to any course taken on both technical and nontechnical skills. On the other hand, mentors will be able to use this knowledge to guide residents and suggest learning itineraries and contents.
The platform will be grounded on a validated learning framework for setting learning outcomes and activities in online platforms, the MISTELA pedagogical model. This will set the basis for an EU strategy on a common TEL-based programme offering structured learning and assessment, which will help standard graduate and postgraduate training across the continent, thus favouring mobility of professionals as well as the exchange and co-creation of knowledge. Validation with end-users (learners and mentors) will be carried out in 4 EU countries (Spain, Hungary, The Netherlands and Romania).

Contribution ID: 1845
5. BME and MP Education, Training and Professional Development
05.06. Technology enhanced education

Cultural aspects in technology enhanced education

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Information and communication technologies made our world global already long time ago. Developed global models so influenced education including teaching and mobility. Technology enhanced education became one of possible popular approaches used on different levels of education. For educational institutions technology enhanced education introduce new types of learners and the potential to share resources with other institutions. Learners can be involved in blended learning, with choice when and where they learn. Opportunities for personalized learning where learners find their own way through learning material appears and at last but not least, a wide range of devices and systems between which learners can choose their preferred platform is available. By using mentioned approaches, being virtually involved, we are easily going over geographical borders. Participants are changing continents, countries, regions, cultures and languages easily, without having to step out of the classroom or office even without being aware that they cross the geographical borders. The learners became virtually mobile, but at the same time, participants in the same system can be of different cultural and lingual background. This required new understanding and preparing educational materials as well as educational modules. Needs and expectations of participants from different environments and countries, as well as from different language and culture groups can be different even by some well known and developed topics. Those differences can influence the complete educational process and participants have to be aware of the cultural aspects in the technology enhanced education. Awareness is helping them to avoid communicational misunderstandings and others disappointments during educational process. In the paper, we will introduce some basic cultural aspects and connect them to the technology enhanced education. Through case studies, also our experiences about cultural awareness in different environments will be presented.

Contribution ID: 426
5. BME and MP Education, Training and Professional Development
05.07. Career development in MP and BME

Annals of medical physics and biomedical engineering professionals based on facts from national healthcare, education and science related acts

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According to the latest International Standard Classification of Occupations (ISCO-08) and National Classification of Occupations (NKZ-10) in Croatia, medical physicists and biomedical engineers should be considered as health professionals. The aim of this work is to present unique and very interesting evolution of the legislative framework related to the status of physical and engineering sciences professionals in biomedicine and healthcare work environment since Croatian independence declared in 1991, all in the context of health professionals and allied health professionals classification.
Health protection and health insurance acts, regulations on scientific and artistic areas, fields and branches, acts on academic and professional titles and degrees, lists of academic and professional titles, degrees and abbreviations published and printed by the Official Gazette of the Republic of Croatia from 1991 were analyzed, together with all corresponding amendments and other related documents.
Until 1993 all persons who have gained healthcare-oriented education, together with persons who have gained education of other orientations, but who all participate in the immediate provision of

health care in healthcare institutions were legally considered as health workers. However, after notorious revision of the Health protection act in 1993, medical physicists and biomedical engineers, together with a number of other professions, have been reclassified into allied healthcare professionals group, with a number of negative professional and clinical practice consequences.
After quarter of century of struggling for appropriate professional status and full regulation of profession, medical physicists, molecular and experimental biologists, language and speech therapists, clinical psychologists, phonetician and nutritionists, but discriminatory not clinical biomedical engineers as well, seem to becoming again the workers legally recognized as health professionals, expanding opportunities and challenging new career paths.

Contribution ID: 887
5. BME and MP Education, Training and Professional Development
05.07. Career development in MP and BME

Medical Physics: work force challenges for the Republic of Moldova

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The role of medical physicist and medical physics expert (MPE) in the clinical environment is important due to the last advances in diagnosis and treatment with ionizing radiation. The proposed study is based on the Bonn Call-for-Action statement and was performed in accordance with European recommendations. In the study, the data were collected and evaluated on the installations used in radiotherapy, nuclear medicine, diagnostic and interventional radiology, as well as factors influencing the calculations of the number of the specialists. The authors used methods of the data collection and processing, which were adopted from different systems of classification. From the generic types of institutions and installations, with the evaluated uncertainty, the necessity of the medical physicists, medical physics experts and services was evaluated. The analysis of the availability on well trained medical physicists indicates a large shortfall of qualified professionals. The data are presented in the form of indicators of the whole time equivalents (WTE) of the respective specialists. According to the study there are more than 40 WTE medical physics and about 15 WTE MPEs are necessary to cover medical practices with use of ionizing radiation. The authors through professional society promote the profession of medical physicist and initiated actions to the stakeholders with the proposal for priorities in education, recognition, and place of the work forces occupancy.

Contribution ID: 1557
5. BME and MP Education, Training and Professional Development
05.07. Career development in MP and BME

Medical physics professional development in Nepal: current situation and challenges

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Abstract: The medical physics has become the key player role in radiation medicine after the introduction of ionizing radiation into medicine in early in the 20th century. By the development of modern radiation therapy techniques has improved the quality of RT treatment. So, the importance of medical physics in radiation field is also increasing day by day. The proper implementation of recent advances in radiotherapy is also quite valuable to quality treatment.

In Nepal, Currently thirteen medical physicists are working in five radiotherapy centers with four Linear Accelerators and two tele-cobalt machines and two high dose rate brachytherapy. Medical physicists' importance is negligence in master's radiology and most radiography teaching program and so are not involved. The country need more qualified medical physicist for radiotherapy, diagnostic radiology, nuclear medicine and for education and training. Since there are not university courses in medical physics. So initially, to fulfill the requirement of medical physicist in hospital, radiotherapy centers recruits the physicist with minimum qualification of master degree in physics and clinical training in medical physics. Now days qualified medical physicist number is increasing. IAEA has also supported in human resource development, two has achieved medical physics master from ICTP and two are on progress.
Strengthening the medical physics role and responsibility is main challenge. Absence of National radiation regulatory body is also affecting medical physics profession development. Public health policy for radiation protection need to be review. Medical physics training program, involvement of medical physicists in education, training and research program, establishment of medical physics certification board are challenges of medical physics professional development in Nepal. By addressing above issues brain drain problem can also be reduce.
Keywords- Medical physics, Education and training, regulation, Nepal

Contribution ID: 1718
5. BME and MP Education, Training and Professional Development
05.07. Career development in MP and BME

Healthcare Technology Management Education and the Automation in Healthcare System

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Technolgy has become the key to optimizing health care delivery globally. As the technology advances rapidly so does the need for professionals who understand and speak the language of both the innovators and the practitioners.
With the recent development, artificial intelligence, robotics, augmented and virtual reality have the potential to tranform healthcare provission and service delivery. Many countries have put plans to utilise these technologies and develop more applications with huge budgets allocation.
This paper will deal with the implications of utilizing these technologies on the work force in particular the practitioners in healthcare technology/clinical engineering/biomedical engineering. The paper will further explore venues for curriculum development and changes in qualification system to prepare our work force for the major anticipated changes.

Contribution ID: 919
6. Patient Safety
06.13. Keynote lecture

KEYNOTE LECTURE: Skin injuries in interventional procedures: What the Medical Physicist needs to know

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Various Organizations such as the International Commission on Radiological Protection (ICRP), the International Atomic Energy Agency the European Commission, the Food and Drug Administration and others draw our attention to interventional Radiology (IR) procedures as high radiation dose techniques with elevated risk for various tissue effects. This is due to the use of

either fast multi-detector CT (MDCT) scanners or highly sophisticated fluoroscopic equipment such as angiography machines to best localize the lesion or the treatment site. The machines are used to continuously monitor and record these procedures. The most important tissue injuries affect the skin and the eye lens. They usually appear within 7-14 days of exposure. They may be acute or chronic and a certain threshold is required. The radiation dose threshold can be reached either from a single IR technique or from cumulative radiation doses by successive IR procedures. Several papers reported skin injuries following IR the last 20-30 years, especially after percutaneous coronary interventions, neuroembolisations or other complex techniques. Possible effects include inflammation of skin, presenting as erythema or pain that may later transform into ulceration, atrophy, telangiectasia, sclerosis, discoloration and other effects. Cardiologists, angiosurgeons, interventional radiologists, gastroenterologists or other medical specialties performing these techniques are frequently unaware of the high radiation doses to which a patient's skin may be subjected, even with the use of modern, state of the art equipment. This paper will review current knowledge, techniques and possible regulatory requirements necessary to prevent radiological skin injuries from the medical physicist point of view. Practical advices will be given from the same perspective on how to avoid them by simple steps.

Contribution ID: 1735
6. Patient Safety
06.13. Keynote lecture

KEYNOTE LECTURE: Medical devices safety – still current topic

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Safety is a key factor, next to expected effectiveness, which characterizes quality of a medical device. Safety of medical devices became a big topic after the PIP scandal and as consequence, the authorities started to put more focus on strict and precise compliance with the requirements.
On the other hand, when putting a medical device on the market, the main goal is to safeguard the public health and to offer an effective and no compromizing therapy or diagnose. Therefore, it is crucial that manufacturers are complying with these requirements to highest possible level during the whole lifecycle of the device.
In the presentation, different aspects of safety of medical device will be discussed and also a short overview of safety requirements in the new regulations will be presented.

Contribution ID: 1422
6. Patient Safety
06.01. Reporting systems

Audit of the brachytherapy planning at Genesis Cancer Care Queensland

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This audit was conducted to meet compliance with the Genesis Cancer Care Queensland Radiation Safety and Protection Plan which identifies recommendations for brachytherapy practice. This states that an authorized Radiation Oncology Medical Physicist shall conduct regular independent quality assurance audits of a representative sample of completed brachytherapy treatment plans in order to minimize the risk of undetected systematic errors, which are caused by incorrect assumptions made of treatment planning and delivery systems. These systematic errors introduce potential risk to a large cohort of patients which makes regular independent quality audits necessary.

In the current work the IPEM 81 criteria were used to build a specific structure for the audit.
The audit criteria included global assessment standards, treatment plans related parameters, site specific related parameters, treatment records related parameters and parameters related to treatment delivery.
The assessment criteria included methods and instructions (such as treatment protocols, prescription, treatment plan); tolerances; personnel recording, reporting and training.
Our results were obtained based on the analysis of patients' plans delivered interstitially (such as low dose rate and high dose rate brachytherapy prostate implants), inter cavitarily (such as high dose rate intrauterine and vaginal mould implants), surface skin mould and intraluminal plans.
The audit was taken a random sample from the patient cohort. All treatments have been audited to ensure best practice.

Contribution ID: 1563
6. Patient Safety
06.01. Reporting systems

Evaluation application for tracking and statistical analysis of patient data from hospital real time location system

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In the recent time, an importance of the Real-time Locating systems (RTLS) in the hospital environment is increasingly important. Such systems are essentially utilized for the localization of either unmovable objects, or patients in the hospital environment. It is supposed that patients who underwent some trauma and surgery may have influenced their cognitive functions in a sense of lost concentration, and orientation is space. Such disorders may endanger the patient's health. In cooperation with the Trauma Center of University Hospital we have designed a localization system constituting the patients RF tags which are detected by the RF anchors placed in every hospital room. Data from such system represents the patient's movement and localization completed by sophisticated system of alarms. In this context we have developed the SW application which is connected with the RTLS database where the patient's localization data are stored. This application is fully integrated into the RTLS system. The SW application evaluates time data represents spent time in every room. The patient's data are consecutively refreshed and updated in the SW application to receive current information.

Contribution ID: 30
6. Patient Safety
06.02. Accidents, incidents, and risk management

Off-label use of medical devices in cardiovascular medicine - when the final decision about the safety and effectiveness is needed

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The use of a medical device in cardiovascular medicine according to the instructions provides maximum quality and safety, which has been clinically tested and then clinically evaluated. When you use a medical device and do not follow the instructions for use, you use a medical device off-label. Off-label use of a medical device can be seen not as an extension of the clinical use of a medical device, but also as a way of expanding scientific knowledge. Some off-label uses of a medical device provide positive health effects, and some do not. Two examples of off-label use in cardiovascular medicine are presented. While the off-label use of drug-eluting stents is commonly accepted, the off-label use of continuous left ventricular assist devices as continuous flow total artificial hearts provide very poor clinical results. Medical doctors and their patients should know which off-label use method works and which does not.

Contribution ID: 575
6. Patient Safety
06.02. Accidents, incidents, and risk management

Experience with gamification as part of the Fall Prevention Programme

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Considering the constantly increasing level of fall injuries and consequent hospital treatment costs, there is a great need for support of active ageing, health promotion and fall prevention, especially among elderly people.
One of the current approaches to increase people's engagement and motivation in targeted activities includes various game elements such as scoring points, levels, achievements or "race to the end" dynamic. Gamification as an application of typical gaming components in non-gaming contexts is already proven strategy, implemented also within healthcare industry. It helps in increasing patient activity, self-monitoring, cognitive training, positively supporting therapy follow-ups or even healthcare professionals training. Furthermore, following its current increasing popularity within the field, the global healthcare gamification market is expected to grow at a CAGR of 54.7% from 2017 to 2022 while driven primarily by the growing technological advancements or lifestyle changes(1).
Adopting the method of a systematic literature review within PubMed and Google Scholar databases, the paper primarily aims at providing an in-depth insight into existing patient-oriented gaming solutions in healthcare with the focus on elderly people. Secondarily, according to case studies on gaming solutions for patient follow-ups and rehabilitation exercises, the objective is to provide solid knowledge foundation of successful methods, strategies and device preferences. Such an information base would be used to design a specific gaming solution to help with fall injuries prevention among 65+ people.
Conducted research confirms the above stated premise claiming gamification to be a successful tool for patient rehabilitation and movement disorders treatment. The study also reveals several strategies, design principles and technology recommendations, which should be considered in order to make patient performance more efficient, and thus optimize the treatment process.
(1) REPORTLINKER, Global Healthcare Gamification Market Outlook: 2017-2022. 2017.

Contribution ID: 816
6. Patient Safety
06.02. Accidents, incidents, and risk management

Lean healthcare and its impact on patient safety and process efficiency

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Efficiency in healthcare processes is becoming a main objective in public health because it has an impact on service quality, patient safety and waste reduction. To increase efficiency, Lean Healthcare (LH) has been implemented in many hospitals and laboratories around the world. As

process improvement system, LH has proved that while reducing waste in processes, it has an effect on health risk assessment. Literature of LH including case studies, success factors, tools, techniques and benefits has been increasing. However, the recent scientific literature review addressing the evolution of LH and its impact on healthcare efficiency is scarce. Therefore, this paper is intended to provide insights of the LH phenomenon and its evolution in recent years by: (1) examining critical success factors of LH, (2) examining tools and techniques of LH, (3) outlining LH benefit patterns, and (4) exploring barriers for LH implementation. A total of 218 papers were included in a systematic review of the literature following PRISMA methodology from 2002 to 2016. Ten critical success factors (CSFs) and twenty-seven tools and techniques in LH implementation were identified.

Contribution ID: 1043
6. Patient Safety
06.02. Accidents, incidents, and risk management

Improvement in safety culture with prospective risk management in radiotherapy: evaluation using the AAPM Safety Profile Assessment tool

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Introduction
In 2015 the RABBIT (Risk and Benefit Balance Impact Template) system2 was developed and implemented at St George Cancer Centre. FMEA1 analyses were also carried out for high risk processes.
The RABBIT system guides a multidisciplinary team through four steps for implementing a new technology/technique:
1. Scope: intended use, restrictions and precautions
2. Assessment of project readiness level
3. Risk/benefit assessment using a simple risk matrix or FMEA
4. Decision on clinical release.
The aim of this study was to determine if prospective risk management was perceived to have improved safety culture, which is a critical performance indicator of a department3.
Method
In 2017 relevant radiation oncologists, physicists and radiation therapists were surveyed on safety culture before/after the use of the RABBIT using a subset of relevant questions from the AAPM SPA3 (Safety Profile Assessment) tool.
Results
The survey showed a significant improvement (average score increased from 3.9/5.0 to 4.5/5.0) and exceeded the average performance in SPA (3.5/5.0). This could correlate to (a) risks being formally identified and addressed prior to implementing new technology/techniques, (b) systematic staff training, and (c) structured interdisciplinary team work.
Conclusion
Prospective risk management significantly improved the perceived quality of the safety culture. The RABBIT is a simple and effective method for achieving this, in conjunction with FMEA for high risk processes. The SPA is a valuable tool for assessing the success of quality initiatives and identifying opportunities for further quality improvement.
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Contribution ID: 1253
6. Patient Safety
06.02. Accidents, incidents, and risk management

Taxonomy proposal for the description of accidents and incidents in the operation of Health Devices

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The analysis of accidents and incidents is essential for the study of Human Error and to propose ways of prevention. Documenting accidents and incidents in some clear, precise and unambiguous way is essential to ground the study and to propose error preventing measures. The research on the Human Error is focused on the classification of the error and on identifying the relationship between the error and the human activity that caused it. In turn, companies and institutions use the results of this research in their reports on accidents and incidents. However, there are difficulties regarding the appropriateness of the terms as applied to the company's specific context since taxonomies tend to be generic. In addition, the field of Health Devices has: (i) users from highly trained to lay or inexperienced; and (ii) contexts of use ranging from restricted area to home environments. In addition, another problem comes to be a variety of user profiles documenting the accidents and incidents, once again we can have experienced or even inexperienced users. This paper proposes a taxonomy (supported by a tool) for describing accidents and incidents in the operation of Health Devices. The taxonomy proposed here addresses the concepts and the terms related to the causes of error as well as other concepts related to the cognitive processes that led to the error.

Contribution ID: 1691
6. Patient Safety
06.03. Skin injuries

Clinical and technological evaluation of the hydrocolloid dressing used as nasal protection in newborns submitted to non-invasive ventilation

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Nasal injury resulting from the use of nasal prongs in newborn (NBs) under non-invasive ventilation (NIV) is a common adverse event in Neonatal Intensive Care Units (NICU). To prevent injury, hydrocolloid protections are used on the nasal base, in order to reduce the friction caused by the prong. The evaluation of the composition and the thermal characterization of the hydrocolloid are still little investigated. The present study aimed to evaluate both clinical efficiency and chemical composition of the hydrocolloid, and to achieve thermal characterization of this protection. The study was divided into two phases. In the first one, a control case study was performed with 11 NBs hospitalized at the NICU of a public hospital in the South region of Brazil, and who required NIV with nasal hydrocolloid protection. The evaluation was done before the connection to the NIV and every 24 hours until medical authorization for suspension of the ventilatory support. The level

of injury and the need for exchanging nasal protection were recorded daily. In the second phase, a hydrocolloid sample was submitted to infrared absorption spectroscopy (FTIR) and thermogravimetric analysis (TGA). The incidence of the nasal lesion was 36.36%, all of them being level I. Regarding the number of material changes, the hydrocolloid showed no detachment during the stay in NIV and therefore did not need to be replaced. As for FTIR, the adhesive surface presented bands with predominant characteristics of a thermoplastic elastomer and sodium carboxymethylcellulose. And the non-adhesive surface showed bands with characteristics of a polyether urethane thermoplastic elastomer. In the TGA, the hydrocolloid presented thermal stability up to 100º C. It was possible to conclude that the hydrocolloid is an effective protection to prevent the nasal injury presenting good adhesion to the nasal base of the NB.

Contribution ID: 1705
6. Patient Safety
06.05. Emergency preparedness

Preparation of rice flour bread available at the time of disaster

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Offering dietary and nutritional support at the time of disaster is required for registered dietitians. It is necessary to avoid dieary allergens like wheat, milk and egg for allergic victims. In this study, the bread was prepared from rice flour and the characteristics of rice flour bread were examined as compared to those of ordinary wheat flour bread. Other ingredients of rice flour bread were soybean milk, sugar, canola oil, "Kinako" (roasted and ground soybeans), dry yeast and salt, kept at room temperature with rice flour.The rice flour batter was baked on the frying pan. The wheat flour dough was also baked equally for the comparison. At the time of disaster, the rice flour bread can be preparated using a portable burner, a plastic bag and aluminum foil. The weight of the rice flour bread didn’t change before and after baking. The stress of the rice flour bread increased gently with increased compression strain by compression tests. The stress at 70% strain of the rice flour bread was lower than that of wheat flour bread ($p<0.001$), indicating that the rice flour bread was soft. The sensory evaluation showed that the flavor of the rice flour bread wasn’t better than that of the wheat flour bread ($p<0.05$), the texture of the rice flour bread was better than that of the wheat flour bread ($p<0.05$).The results suggest that tasty rice flour bread can be offered to disaster victims with food allergy.

Contribution ID: 21
6. Patient Safety
06.06. Remote dose monitoring and risk and dose optimization

In vivo dosimetry in total body irradiation

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Total Body Irradiation (TBI) is a radiotherapy technique that consists of irradiating homogeneously the whole patients body and it is characterized by extended source to surface distances and the use of large irradiation fields. The limitations of the available input data and inherent problems with the calculation procedures make it very difficult to accurately determine the dose distributions in

TBI. For these reasons, it is highly recommended to use In Vivo Dosimetry (IVD), to guarantee the quality of TBI treatments as a direct measurement of the delivered dose. An IVD QA system was implemented based on semiconductor diodes and radiochromic films. For the commissioning of the system, both detector types were calibrated independently, using as reference an ionization chamber with a valid certificate in terms of absorbed dose to water (Dw). This guarantees the traceability of the measurements. An assessment was made on the sources of uncertainties. A tolerance level of ±10% was established for the combined contribution of both computational and experimental uncertainties. An experiment was carried out to simulate a clinical TBI procedure to a phantom. In this way, the calibration of the dosimetry system was corroborated. Finally, the IVD system was applied in TBI of three real patients. The discrepancies obtained between the prescribed and measured doses were below the established tolerance level of ±10 %.

Contribution ID: 54
6. Patient Safety
06.07. Diagnostic reference levels

Establishment of CT Diagnostic Reference Levels in Nigeria for Adult CT Examinations

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The study was aimed at proposing national computed tomography (CT) diagnostic reference levels (DRLs) for the six (6) most common adult CT examinations in Nigeria, following a regional study of CT dose in Lagos. This was the first survey for CT doses for head, chest and abdomen examinations carried out across the region. Dose data was collected directly from the scanner console by the researcher in each CT facility. Data was collected for 1132 individual patients, 2196 examinations from 13 CT facilities, representing over 60% of functional CT facilities in Lagos. All scanners were multi-detector CT (MDCT) technology, with 2 to 128 slices and were of four (4) different brands - GE, Toshiba, Siemens and Philips. More than half of which were 16-slice CT scanners. CT dose data was characterised by volume CT dose index (CTDIvol) and dose-length product (DLP). A minimum of 10 samples per examination per facility was required. Mean and median values were calculated for each centre. Median values were used as typical values for each centre, as per ICRP 2016 recommendations. DLPs were set at the 75th percentile of typical dose values across centres. Proposed DRLs for CTDIvol (in mGy) and DLP (in mGy.cm) are head/non-contrast - (49, 935); head/contrast - (48, 941); chest/non-contrast - (10, 369); chest/contrast - (10, 381); abdomen/non-contrast - (10, 478); abdomen/contrast - (9, 456). Wide variations in dose appear across CT scanners. Results were comparable with national DRLs of other countries, and lower for abdomen scans.

Contribution ID: 181
6. Patient Safety
06.07. Diagnostic reference levels

Evaluation of routine paediatric radiological chest imaging procedures for estimation of dose to gonads and DRL

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Evaluation of routine paediatric radiological chest imaging procedures for estimation of dose to gonads and DRL

Arun Chougule, Gurvinder Singh

Introduction:

Routine radiological chest imaging procedures are an integral part of the diagnosis of many paediatric ailments. Since ionising radiation is used for these procedures should be justified and the radiation dose imparted should be kept as low as reasonably achievable. However, use of old machines, an absence of routine calibration, lack of proper training and wrong practices lead to high exposures.

Materials and Methods:

Routine chest X-ray examinations of paediatric patients were performed on DR machine. Prior to the measurements, all QA tests were performed using PTW NOMAX multimeter to ensure the stability, filtration and output consistency. Dose Area Product (DAP) meter readings were noted for each examination. OSLD nanodots were used to measure the gonadal doses of male children. Random sample selection was done and categorised into neonates (0-1yrs) and children (1-5years) categories. DAP meter readings and OSLD measurements were carried out for 28 neonates and 74 children and analysed. The kVp and mAs values used were 52kVp-72kVp and 5mAs-32mAs respectively.

Results and Discussion:

The average DRL values are 0.028 mGy.cm2/projection for neonates (<1yrs) and 0.035mGy.cm2/projection for children between 1-5years. The average dose to gonads of male children measured using OSLD were 0.639cGy for neonates (<1yrs) and 0.307cGy for children (1-5years). Also, there is no correlation (R2=0.33, 0.26) between the DAP measurements and the OSLD readings. The DAP values are well within the limits.

Conclusions:

The measured average DRL values and gonadal dose are very less as compared to the diagnostic reference level of UK/Europe. the reasons can be the introduction of newer technologies and teaching and training of the technical staff.

Contribution ID: 1342

6. Patient Safety

06.07. Diagnostic reference levels

Elaboration of New NDRLs as part of Third National Patient Dose Survey in Diagnostic Radiology in Bulgaria

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Purpose: The aim of this research is to elaborate an update of National Diagnostic Reference Levels (NDRLs) in Bulgaria, as

required by National and International legislation.

Methods and Materials: Special questionnaires and methodology instructions for submission of required data were distributed to all hospitals in the country. Patient dose records and corresponding technical data were delivered from medical institutions via following three methods: by e-mail, by specialized on-line system, or by paper. A national patient dose database build on MS Access was elaborated and employed for storing, processing and analyzing of the collected data.

Results: More than 10500 patient dose records on more than 190 X-ray systems from over 90 health establishments have been collected and analysed. New national DRLs were elaborated and proposed for: Chest-PA, Pelvis-AP, Abdomen-AP, TS-AP, TS-Lat, LS-AP, LS-Lat, Skull-AP, Scull-Lat, IVU, Ba-meal, Ba-enema, CA and PCI - in terms of KAP; for Computed Tomography (CT) of Head, Abdomen and Lumbar Spine - in terms of CTDIw and DLP; for Mammography - in terms of ESAK and AGD.

Conclusion: The new DRL values obtained are proposed as NDRLs for the country. Most are comparable with other European NDRLs with a few exceptions only. Those exceptions are most probably related to actual optimization in existing radiology practices.

Contribution ID: 1333
6. Patient Safety
06.08. Caregivers

Design model of smart bed for bedridden healthcare

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One of the most common health risk for bedridden patient is pressure sore or decubitus ulcers. Pressure sore can develop in a person who is not able to move or lying in the same position for long period of time. To solve this problem, caregiver has to change patient's position every two hours if possible. In addition, caregiver have many kind of care work for assisting the patient such as changing clothes, administering medicine, daily health checking etc. This paper presented a design model of smart bed for bedridden healthcare, including paralysis and elderly. The smart bed consists of mechanism design of bed and patient monitoring system. The bed can change patient's position in left/right tilt by lift left/right side of the bed up automatic. With a graphic user interface for communicate to caregiver or physician. The patient monitoring system measures heart rate, body temperature and body weight which are then sent to home server. All data can then be remotely monitored by caretaker. The proposed smart bed is designed for better assist the daily life of a bedridden person and caregiver.

Contribution ID: 892
6. Patient Safety
06.09. Safety of non–ionizing radiation

Impact of weight value entered into MR system for RF-induced heating of metallic implants

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Radiofrequency (RF)-induced heating in clinical MRI may cause a risk to the patient with metallic implants. Specific absorption rate (SAR) which is a representative index to estimate temperature increase may be influenced by the weight value input to the MR system. The purpose of our investigation is to assess the RF-induced heating for the implants due to the changes of the weight value entered into the MRI. A method for measurement of implant heating conformed to criteria for ASTM F2182-02a.The plastic phantom container was filled with saline and gelling agent to simulate the electrical and thermal properties of the tissue in the body. Two different implants (titanium alloy humerus nail and stainless steel shaft) were selected for testing. The implant was mounted parallel to the static magnetic field and was placed on 2cm from the gel surface and wall of the container. All experiments were performed on a clinical 1.5T MR system. MR imaging were

performed by using a transmit/receive radio-frequency body coil at a whole-body average SAR of 2.0 W/kg for 15 minutes. For scan of each implant, the weight value entered into the system ranged from 10kg to 200kg. Temperature measurements of the tip of implants were obtained by using a fiber optic thermometry system. In the weight value of 60kg, the highest temperature changes recorded for the humerus nail and stainless steel shaft were, respectively, 3.9 and 5.9°C. On the other hand, in the weight value of 200kg, the highest temperature changes of them were 9.9 and 12.4°C. The highest temperature changes were elevated in proportion to increase of the weight value from 10 to 140kg. This study demonstrated that even if SAR is permissible level, the patient have a risk of RF heating for the implant due to the heavy weight value input to MRI.

Contribution ID: 176
6. Patient Safety
06.10. Human factors engineering for medical device and system design

Development of identification system for surgical instruments using UHF band RFID and low-intensity antennae

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Post-op vestigial remnant of surgical instruments in the body is a very serious problem. The current two-dimensional symbol system is being used to help manage this problem. However, the two-dimensional symbols have to be identified one at a time, since the symbols are a sort of printed matter. An HF band passive RFID system was also proposed to help manage surgical instruments. This system also had problems in identifying the signals of a large number of surgical instruments in bulk, since the scope of its identification area was relatively small. To improve the deficiencies of this system, a UHF band passive RFID system was developed to identify the signals of all the surgical instruments, since its identification efficiency was far better than that of the HF band RFID system. The authors have also proposed a new low-intensity antennae for the UHF band passive RFID system. This new system cannot radiate an electrical field strong enough to interfere with medical equipment and should not pose a problem to any electronic equipment in the operating room. From our experimental results using 50 surgical instruments, all the instruments were identified in less than one second with this new RFID system, even when the instruments were covered with water residue. The electrical field intensity was also kept at a low, safe level, maintaining the working integrity of any electronic device within the operating room. These results are very promising and indicate that the proposed RFID system will be an improvement to the surgical instrument management systems currently being used. This new system will also undoubtedly reduce the workload of surgical nurses, while reducing human error in the operating room.

Contribution ID: 195
6. Patient Safety
06.10. Human factors engineering for medical device and system design

An ergonomic evaluation of physical and mental loads in standing-up motion from forward-sloping toilet seats

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We aim to develop a new in-home assistance system to aid in the standing-up motion from toilet seats in assisted bathrooms. The underlying design concept for accessible toilet facilities is to use a novel compact actuation device—a metal hydride actuator with several unique properties such as softness, noiselessness, and being lightweight—for tilting a toilet seat when required, thus helping elderly or frail people to stand-up after excretion. This ergonomic study evaluates the easiness of the standing-up motion using both objective and subjective data from healthy participants, as a prior step before developing the envisaged toilet seat tilting system. In the experiment, the participants were monitored to obtain simultaneous objective data concerning muscle activity, 3D body motion, center of pressure, and seat pressure distribution. Additionally, all participants were requested to provide subjective data (comfort scores) while standing up from a toilet seat under four different conditions—four different forward-tilting angles (0, 5, 10, and 15°). All participants repeated the motion 25 times for each tilting angle, and provided feedback regarding their standing-up experience and feelings under each condition. According to the collected subjective data, a toilet seat tilt angle of approximately 10° increased the easiness and comfort of the standing-up motion. However, according to the measured objective data, the standing-up motion has individual variations in the electromyogram magnitude, center of pressure excursion, and seat pressure pattern, implying that to analyze the standing-up motion both the measured objective data and the perceived subjective data must be considered.

Contribution ID: 536
6. Patient Safety
06.10. Human factors engineering for medical device and system design

Enhancing safe mobility of special needs patients in the operating theatre with I-MOVE- a multi-positional actuator enabled transfer system

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Children with specials needs such as Autistic Spectrum Disorder and Neurodevelopment Disorders are often uncooperative and disruptive during routine hospitalization processes. These patients often cope with either “fight” or “flight” response and not amenable to coaxing, cajoling or distraction. Care during transportation from wards into operating theatre, initiation of anaesthesia, recovery care, maintenance of intravenous lines becomes a challenge. The patients’ disruptive and combative behavior can result in physical and psychological harm to themselves and the healthcare workers. Hospital processes are disrupted with delay in procedures and wastage of theatre time and stressing of manpower resource. The disruptive behavior also results in distress to their parents, healthcare workers and other children.
Currently management is use of sedation before administering of anaesthesia. The routes of sedation include oral, intramuscular and intranasal. The latter routes are unpleasant and noxious. Many patients also refuse to accept oral medication. Physical restrained with human hands is the alternative. These patients are then lifted onto operating table by healthcare staff after they are anaesthetised. When patients become heavier and stronger as they reach adolescence and adulthood, both sedation and physical restraint become difficult or non-feasible.
In this paper, we described an automated second generation prototype, I-MOVE, to intelligently move and transfer patients. I-MOVE facilitates safe perioperative transport, transfer and airway procedures for un-corporative and combative children. It allows multi-position transformation and anticipates the needs of patients in the perioperative period. It is composed of four integrated modules: restraint, multi-positional bed, mobility, power and electronic modules, enabled by a system of actuators. The goal of I-move is to maximize safety for patients and healthcare workers and to enhance operating theatre efficiency and case load throughput. This system takes into

account the functionality, human factor ergonomic as well as general appeal and acceptance by children and their parents.

Contribution ID: 945
6. Patient Safety
06.10. Human factors engineering for medical device and system design

Measurement on the Swallowing Sound of the Thickened Water Using an Acoustic-Emission Microphone

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We aim of this study is to evaluate the swallowing functions of people with dysphagia using an acoustic microphone sensor. This study was carried out to measure the swallowing sounds using an acoustic emissions microphone sensor (AE sensor), then analyzed the frequency range of the measured signals, and we examined the method for obtaining the necessary information to evaluate the swallowing functions. In the experiment, healthy participants were monitored to measure the swallowing function while swallowing of the thickened water. For the measurement, two types of sensors, i.e., a condenser throat microphone and an AE sensor, were employed to measure the swallowing sounds. The results of the wavelet transformation of the acoustic signals acquired with the AE sensor display acoustic signals during swallowing that carry characteristic information between the frequency range of 3 kHz and 40 kHz. In conclusions, the swallowing sound contained information of a wide frequency range. In future works, we plan to conduct experiments with people with dysphagia, to examine its effect, and thus construct a method of evaluating swallowing sounds.

Contribution ID: 29
6. Patient Safety
06.11. Patient safety, medical errors, and adverse event prevention related to health technologies

One pulsatile heart pump size does not fit all patients

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One of the main principles of personalized medicine is to adapt health care to the specific needs of our patients. Based on this principle, medical devices should be tailored to the specific characteristics of the patients and doctors should choose medical devices for patients according to their size. Both pulsatile and continuous flow ventricular assist device help patients with heart failure. Every left ventricular assist device usually contains a pump that a cardiac surgeon connects to the apex of the heart. Pulsatile ventricular assist device systems using volume displacement pulsatile pumps are designed and mainly used for children patients. The first generation ventricular assist devices systems for adult patients relied on volume displacement pumps with one constant stroke volume for all sizes of patients. The concept of one size of the medical device for all patients goes against the principle of personalized medicine. A cardiovascular model in Modelica has confirmed that a pump with one constant pump stroke volume of 65 ml can generate uncontrolled flow and pressure curves oscillating over the normotensive zone for large patients and under the normotensive zone for small patients. The one pulsatile pump size for all patients may cause harm due to non-physiological flow and pressure condition in circulations.

Contribution ID: 37

6. Patient Safety
06.11. Patient safety, medical errors, and adverse event prevention related to health technologies

Legal metrology procedures for increasing safety and performance characteristics with cost benefits analysis: Case study dialysis machines

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The objective of this paper was to increase safety and performance characteristics with cost benefits of medical devices by introducing legal metrology procedures. This should directly improve the quality of patient safety and reliability of treatment.
This study is designed to cover 1100 dialysis machines used in public and private healthcare institutions, during a period of three years. Testing procedures were carried out according to international standards and legal metrology legislative procedures in Bosnia and Herzegovina.
The results show that the average rate of faulty devices during three years testing period is 15,73% and should either have its results be verified, or the device removed from use or scheduled for corrective maintenance. Additionally, cost benefits analysis show yearly savings of 32% if healthcare institutions follow legal metrology procedures compared with unnecessary manufactures attests.
Research emphasizes importance of independent safety and performance inspections, and gives recommendations for the frequency of inspection based on measurements. Results offer implications for adequacy of preventive and corrective maintenance performed in healthcare institutions. Based on collected measurement data, web based application with database of dialysis machines used in healthcare institutions in Bosnia and Herzegovina is created. Thus, legal metrology procedures enabled establishing traceability chain for this type of medical devices.

Contribution ID: 122
6. Patient Safety
06.11. Patient safety, medical errors, and adverse event prevention related to health technologies

Electrical beds: a case study for patient safety in pediatrics

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While electric beds are well established and accepted in all patient care areas to promote patient independence and offer ergonomic benefit to caregivers, bed safety for pediatric patients still remains a debate. In fact, five children in separate incidents have been killed with electrical beds in the 1980s in the United States [1]. Since 2009, Health Canada has reported three deaths and nine injuries of elderly patients in hospital electric beds [2]. The concerns includes patient entrapment from side rails, under bed and other locations of traps. We present a case study of electric beds with the focus on pediatric patient safety. We will provide an overview of risk factors that influence institutional liability, patient safety and risk management. The design criteria cover both patient safety/quality assurance and hospital risk management activities. The population we need to protect are the pediatric patients and visitors (including young family members), as well as hospital staff. Pediatric population is a small percentage compare to overall population, special attention is required. However, pediatric risk management has received little attention in industry standards or in the research literature. The Canadian Council on Health Services Accreditation CCCHSA

environment module notes that the physical environment should have equipment suitable for the client's age and developmental level, it provides no specific guidelines about hazards or concern for the pediatrics [3]. This paper will review the history of bed entrapments incidents and solutions in the market and analyze existing accredited design guidelines in literature. More specifically, studies in geriatric, psychiatric and bariatric wards will be examined to provide potential pediatric solutions. We hope to engage further discussion in electric pediatric bed design that could enhance safety for patients in the future.

Contribution ID: 1121
6. Patient Safety
06.11. Patient safety, medical errors, and adverse event prevention related to health technologies

Effects of flow rate interventions and physical infusion setup properties on blood pressure in neonates receiving inotropic support

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Patients admitted to the neonatal intensive care unit (NICU) often suffer from hypotension, requiring quick intravenous administration of inotropes. These drugs require a continuous, accurate and precise delivery with syringe pumps. In practice, for these neonates, inotropic agents are administered by multiple infusion pumps through a single catheter (multi-infusion). This method is prone to dosing errors because of physical properties of the infusion setup, such as dead volume, resistance and compliance [1]. Deviations from the intended dose, in combination with the underdeveloped cerebral autoregulation in neonates, may result in hemodynamic instability and cause conditions such as periventricular- and intraventricular hemorrhages.
We present our analysis of an in vivo study of flow rate intervention with NICU patients, using two different infusion setups. We investigate the impact of flow rate interventions on mean arterial blood pressure and other vital parameters. Dosing delays and transient effects are connected to physical parameters of the infusion setup. The aim of the study is to provide clinical advice for patient safety in relation to infusion technology.
[1] Timmerman AM, Snijder RA, Lucas P, Lagerweij MC, Radermacher JH, Konings MK. How physical infusion system parameters cause clinically relevant dose deviations after setpoint changes. Biomed Tech 2015;60:365–76.

Contribution ID: 1136
6. Patient Safety
06.11. Patient safety, medical errors, and adverse event prevention related to health technologies

Automatic summary of unstructured patient's medical records

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Patient safety is a crucial point in medical care; but in cases when time is the essence, many guidelines and safety checks are deliberately omitted. The saving of a human life takes precedence. In urgent medicine dealing with a patient of unknown medical history is not a rare event. Even if we are equipped with patient's complete medical records, as humans we are often unable to read them all in time. This article proposes how to automatically extract all life threatening information (e.g. allergies, medications, bleeding disorders, comorbidities, artificial valves and joints) from medical records of different types and origins (e.g. personal medical records, admission notes, ICD-10 codes, laboratories, on service notes, operative reports, discharge summaries, therapies, test results, and so on) in both structured (e. g. HIS databases) and unstructured forms (e.g. narrative records).

Contribution ID: 1235
6. Patient Safety
06.11. Patient safety, medical errors, and adverse event prevention related to health technologies

Metrological procedure for autoclave tests to mitigate adverse events in health care processes

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This paper introduces a metrological procedure for testing of autoclaves for use in basic care. This medical equipment is important in the sterilization activities of surgical materials used in technological processes in health. Through saturated steam, between 3-5% moisture, the autoclave sterilizes the medical instruments by coagulation, transferring a large amount of energy to the microorganisms present, killing them in the process. The test procedure developed is based on current technical standards in Brazil, such as ABNT NBR 16328 and ABNT NBR ISO 17665-1, requiring parameter verification such as, temperature, pressure and time, which depend on the cycle chosen, and some autoclaves have predefined cycles, causing the parameters to differ, according to the chosen one, varying both temperature and pressure, as well as time. In all cases, the parameter attended should be the one that defines the minimum time for the autoclave to deliver, at the end of the process, an instrument with a chance of one in a million of finding a live microorganism, called F0. The tests performed in different brands and models of autoclaves with test equipments, which meet the Brazilian regulation, presented temperatures in the range between 121 and 134ºC, pressures between 1.54 and 2.3 bar and times varying with the brand and the chosen cycle, since there should only be a minimum time, such as 4.65 minutes to 121.1ºC. The problems of failures in sterilization processes compromise the safety of patient care processes, and the metrological procedures allow to mitigate these adverse events. Through metrology, Clinical Engineering can increase the safety, reliability and effectiveness of this technological process in health.

Contribution ID: 1292
6. Patient Safety
06.11. Patient safety, medical errors, and adverse event prevention related to health technologies

Medical devices safety enhancement and performance improvement through a periodic calibration program

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Introduction: Today's have been seen more than 10,000 different types of medical devices in medical centers and hospitals. The medical devices used in medical centers and hospitals for monitoring and treatment of patients require periodic safety and performance checking in order to have confidence in their functioning and operation. Physicians need better accurate medical measurements to better diagnosing diseases, monitoring patients and delivering treatments. The lack of correct and appropriate measurements will certainly have diverse effects in diagnostic and treatment procedures.

Safety and performance testing of medical devices in the medical sector is a one of the key factor in improving public health. Acquiring results of some investigations demonstrate a need for new and severe regulations on periodic performance verifications especially in high-risk equipment.
Material and Methods: The metrological reliability of four high risk medical devices, Electrosurgical unit, Defibrillator, Syringe pump and Infant incubator in use some medical centers and hospitals (privates and publics) according to international and national standards were evaluated.
Results: Quantitative analysis of some parameters that impact the safety and performance represented the amount of the obtained results in some equipment are in critical range with higher values than standard limitations. General electrical safety evaluations for measuring the patient leakage currents and patient auxiliary currents carried out for all of the under test devices, in some cases the amount of leakage currents were over the standard limitations.
Conclusion: Acquiring results represent a need for severe regulations on periodic performance verification and quality control program especially in high-risk equipment. Also it is necessary to provide training courses for operating staff in the field of metrology in medicine. One of the main aim of these training courses is to present what's the critical operation parameters and how the operators can get good accuracy results on each medical devices.

Contribution ID: 1296
6. Patient Safety
06.11. Patient safety, medical errors, and adverse event prevention related to health technologies

Risk evaluation of secondary cancer induced by breast cancer radiotherapy treatment

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The Radiotherapy technologies are one of the most common treatments for cancer, they have been successfully used to damage cancer cells, with as little harm as possible to nearby healthy cells, however Secondary cancer risk following radiotherapy is an increasingly important topic in clinical oncology with impact on treatment decision making and on patient management. The paper aims to investigate and evaluate the current practice in radiotherapy through its different phases and to quantify the risk of secondary primary cancer following radiotherapy in breast cancer by dose calculation and risk estimation of second cancer; to make recommendations for a safer practice in radiotherapy department. The data collected from NBGUH and RHUH with dosimetry calculations on retrospective female patient's files and verifies with dose measurements on RANDO Phantom.
The results showed 85% of compliance in radiotherapy safe practices, calculated Probability of Causation after breast radiotherapy for contralateral and Ipsilateral breast cancer 0.17%, and for lung is 32%, for spinal cord is 24%. While the PC in phantom measurements in Ipsilateral lung 43.22% and PC for contralateral lung 3.099%.

Contribution ID: 1553
6. Patient Safety
06.11. Patient safety, medical errors, and adverse event prevention related to health technologies

Evaluation of the radiation dose in computed tomography examinations using a simulation model and experimental verification

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Abstract
The purpose: This study aims to provide a method for the estimation of the absorbed dose values in the different organs inside a child phantom in a computed tomography (CT) scanner. It includes a Monte Carlo simulation and an experimental method to verify the resulting numerical calculations. Materials & Methods: In this research, we used Thermoluminescent Dosimeters (TLDs) to measure the absorbed dose in several organs inside a child phantom. The phantom was irradiated by using a Siemens CT scanner at suitable parameters (kVp and mA). We also calculated the dose in the same positions inside the phantom by using Monte Carlo simulations and finally made a comparison of the dose results. Results and Discussion: The absorbed doses measured by the TLDs for Left eye, Right eye, Thyroid, Left lung, Right lung, Left pelvic, Right pelvic, and Testes were18:93 1:02, 16:47 0:86, 28:37 1:63, 16:30 1:06, 15:20 1:26, 14:33 0:01, 14:10 1:6 and 17:91 0:16 mGy respectively. The corresponding calculated absorbed doses in these organs by using GEANT4/GATE were 16:961:99, 16:75 1:45, 29:610:77, 16:920:08, 16:260:39, 15:070:01, 14:910:75 and 17:94 0:041 mGy respectively. These results show good agreement for the two methods with percentage differences 11.6%, 1.7%, 4.4%, 3.77%, 6.9%, 5.14%, 5.74% and 0.17% respectively.
Conclusion: The resulting good agreement between the simulation results and measurements will be very useful for the estimation of the absorbed doses in radio-sensitive organs in CT scans.
Keywords: TLD, Ionization Chamber, Monte Carlo Simulation, GEANT4, GATE, Computed Tomography, Phantom.

Contribution ID: 1889

6. Patient Safety

06.11. Patient safety, medical errors, and adverse event prevention related to health technologies

Fault Identification in a Blood Pump using Neural Networks

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This paper compares two fault identification implementations based on a Convolutional Neural Network (CNN) and a model-based approach. Our worked example is the detection of gas bubbles in the pump head of a centrifugal blood pump. We focus on algorithms applicable on minimal sensor data with a reasonable implementation effort. The approaches were restricted to the desired blood flow and the measured rotational speed of the pump. We evaluated both implementations with data from an extracorporeal membrane oxygenation (ECMO) system.
The chosen structure of the CNN consists of one input- and one output-layer. The input layer holds two feature vectors. Each feature vector represents a time-series of sensor data. Both feature-vectors are fed to separate convolutional layers. The CNN was implemented and trained in TENSORFLOW.
For the model-based approach we use a second order model with one zero point for linearization. Input is the target blood
flow and output is the rotational frequency of the blood pump.
The neural network performed well and had a higher detection rate compared to the model-based approach, even though the variation of training data was mostly achieved by augmentation methods.

Contribution ID: 368

6. Patient Safety
06.12. Protocol Optimization

Optimal variable Refocus Flip Angle control method and Echo Train Length for suppressing exposure by Radio Frequency

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The popularization of 3-Tesla Magnetic Resonance Imaging (MRI) has improved the quality of images and shortened typical examination times. However, a side effect of this is an increased exposure to Radio Frequency (RF) radiation. The amount of exposure can be controlled using a technique called variable Refocus Flip Angle (vRFA). A vRFA is one of an important factor in Signal to noise ratio (SNR) and blurring, only a few reports on vRFA control in 2D have been published. In this study, we examined the influence of vRFA control and echo train length (ETL) on these factors, via the acquisition of a T2-weighted image of a brain using the 2D method. We used a device that can arbitrarily control three angles, the fifth RFA, the RFA centered in k-space, and the final RFA. A phantom was used, and adjusted to the T1 and T2 values equivalent to the Gray Matter and White Matter, respectively. The repetition time (TR) was 5000 ms and the echo time (TE), 90 ms. Using ETL of 11–15, and by setting the fifth RFA to 40°, the signal smoothly shifted to a Pseudo Steady State (PSS) and a stable signal was obtained. Further, blurring was suppressed by gently changing the k-space-centered RFA. In the final echo, the PSS was maintained by increasing the final RFA up to 180°, and a high SNR was obtained. This pattern was shown to be a method with reduced exposure. With an ETL of 30, blurring was suppressed through RFA control similar to that used with ETLs of 11–15, but even if the exposure amount was slightly higher, to obtain a high SNR, the fifth RFA was required to be 60°–90°.
In this study, a relationship between vRFA control and ETL is suggested for suppressing exposure by RF.

Contribution ID: 815
6. Patient Safety
06.12. Protocol Optimization

Presentation of Methods of Hospital Equipment Decontamination in United Electronic Documents: Support to the Control of Hospital Infection

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The hospital infections are commonly the more occurred complications in hospitalized patients. It is estimated that in
Brazil from 5% to 15% of patients admitted to the hospital contract some infection coming from a hospital process and increase on
average, 5 to 10 days to the hospitalization. Considering that there is a big variety of hospital equipment in a hospital, and a frequent

incorporation of technology causing it to occur a variety of types and ways to care about the decontamination of its pieces and parts,
it is made necessary to update these methods and make them available in an electronic/digital manner to disseminate information as
well as to facilitate the access to routine consultation. The main purpose of this project is to make available in electronic/digital
document, to the professionals of the Hospital Infection Control Services, to those responsible for the process of decontamination
(CME) and users, the proper instructions from the manufacturers, concerning the decontamination methods of hospital equipment
and their parts. As specific goal we look for Developing and Standardize the evaluation flow of decontamination methods of
equipment and its parts and pieces in the acquisition process, so that all the impact be evaluated in advance, such as: decontamination
method, flow alteration necessity, processes, controls, related costs to new incorporation, budget planning, etc. It was observed the
following orientations from the manufacturer: 7 types of cleaning methods, 15 methods of disinfection and 11
indications of sterilization cycle, to each brand and equipment model in operation in the hospital. It is expected that the
availability of decontamination methods (in one electronic document), revalidation of the infection control commission,
can contribute to update the information (reorientation and updating the professionals responsible for decontamination
activity), as the incorporation of new technology are being made in the hospital.

Contribution ID: 963
6. Patient Safety
06.12. Protocol Optimization

Local dose survey on pediatric multi-detector CT: a preliminary result

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For paediatric patients, where there exists a wide range of patient size, and where radiation risk is two to three times more prevalent than on adults, the need of a more stringent care on dose optimization becomes more crucial and demanding, particularly on computed tomography (CT) procedures. To first investigate the need for optimization, a preliminary dose survey was carried out by recording dose data from head, chest, and abdomen MDCT procedures for pediatric patients. The survey from a total of 590 pediatric patients was conducted on March-September 2017 at Harapan Kita Maternal and Children's Hospital as Indonesia's primary referral hospital for pediatric patients. Results per age group were compared with available works from other regions or countries to first indicate the need for optimization. The preliminary result indicated that head scans for 10-15 years old patients require optimization. The evaluation of protocol selections and scan length determination are proposed as an appropriate action.

Contribution ID: 1183
6. Patient Safety
06.12. Protocol Optimization

CT guided interventional procedures. The effect of radiation safety culture

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Objective: Computed tomography (CT) has evolved into a well-accepted guiding tool for a broad range of diagnostic and therapeutic interventional procedures (IR). The objective was to evaluate radiation doses in these procedures.
Materials and methods: The study was conducted in Konstantopoulio Hospital. The department has 2 multi-detector CTs; one routinely used for IR (Asteion, Toshiba). The patient is placed on CT table in a position that facilitates the pre-interventionally determined access route. A spiral scan is performed, for planning with/without contrast to identify vascular structures, vital organs and/or areas of abnormal contrast enhancement behavior. A radiopaque grid is fixed on patient's skin. The access path can be assessed either on axial images or on multiplanar reformations if procedures are needed to be angulated to the z-direction. Preferably, the intervention is planned in a plane perpendicular to z-axis. If double-angulated punctures are necessary, a tilted gantry can be used for surveillance to provide images parallel to the direction of the intervention or special marking of lesion and entry point. Using the CT images DICOM data, all technical and dosimetric data were collected for analysis.
Results: Forty seven (47) patients were included with a mean age of 70 years. Percentage of male was 64% and female 36%. Median doses in terms of dose length product (DLP) for biopsies, ablations, drainages and nephrostomies were 866.15, 792.4, 1376.55, 899.9 mGy*cm, respectively. Respective ranges were 494.3-1395.0, 215.9-2839.0, 877.7-2565.5 and 328.1-1303.6 mGy*cmData were lower than earlier published values from our hospital. Reasons for this are radiation safety culture and newer CT equipment.
Conclusions: Patient doses were lower than our previous published data due to staff radiation safety culture improvement and newer CT equipment.

Contribution ID: 1242
6. Patient Safety
06.12. Protocol Optimization

Patient dose optimization in computed radiography using the exposure index

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The monitoring and evaluation of exposure index (EI) have been a relevant strategy for patient dose optimization with the advent of digital imaging systems in radiology. In this study, different EI were monitored in chest/planar computed radiography and their effectiveness in optimization of dose and image quality image was evaluated. Large general hospitals from metropolitan region of the Sao Paulo city have participated of the study, in which information from patient representative sample, such as size, area and thickness of the body irradiated, and technique factors (kV, mAs, grid, source-image distance, filtration, beam collimation) were collected. Patients' entrance skin

dose (ESD) were calculated from technique factors registered in each examination. Exposure index used by different manufacturers and more recently proposed by both IEC 62494-1 and AAPM Task Group 116 (standardized exposure index and its associated target exposure index and deviation index values) from clinically accepted images were also recorded. After this, patient dose optimization was implemented using an anthropomorphic phantom based on the relationship between image contrast-to-noise ratio and ESD measured for each exposure setting (Figure of Merit - FoM) in association with the target EI. In all hospitals a large variation of the EI was observed, indicating total disagreement with the recommended ranges. These outcomes were corroborated by the ESD analysis, which reached on average values 3.5 times above the national reference levels in one of the hospitals. Low correlation between ESD and patient thickness was noticed, indicating the need to better adapt the protocols to the patients' body type. In general, the appropriate use of the EI by radiology technician point out that training is required. The patient dose optimization using FoM associated with target EI proved to be efficient in reducing doses without loss quality image.

Contribution ID: 1715
6. Patient Safety
06.12. Protocol Optimization

Assessment of radiation-related cardiac mortality based on breast cancer laterality incidence analysis

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Breast cancer laterality incidence for breast cancer patients were analyzed. The main aim of this study was to explore possible factors for such breast laterality which may eventually influence subsequent treatment option, especially in older patients.
In this study, the results will help assess the impact of tumor laterality on therapeutic outcomes with modern techniques, to indirectly determine whether left-sided treatment remains associated with increased cardiac mortality.
The incidence of left breast cancer occurrence was 64% (N= 288) as compared to right breast of 36% (N=162). Early stage breast cancer (Stage I and Stage IIa) were significantly lower in the studied population recording a 9.2% (N=41), locally advanced breast cancer (Stage IIb and Stage IIIc) were the highest cases of 69.6% (N=314) and metastatic breast cancer (Stage IV) were 21.2% (N=95). The overall stage III cancer incidence was higher in the left than in the right breast. 17.6% (N=79) of patients' data recorded a family history of breast cancer. Lifestyle analysis of data recorded 15.8% (N=71) of patient as alcohol users and 2.2% (N=10) as tobacco users some point in their life. Medical history of hypertension, hypercholesterolemia and diabetes recorded high incidences in younger left sided breast than right breast.
The overall incidence of cancer was higher in the left breast than in the right breast. The excess incidence cancer in the left breast was evident in young pre-menopausal patients in the studied cases. The reason for higher left sided incidence occurrence among women still remains unclear and requires further studies from the medical and scientific communities. Radiation therapy for left sided breast cancer should also be giving a higher priority as it may be associated with elevated risk of cardiac mortality.

Contribution ID: 1776
6. Patient Safety
06.12. Protocol Optimization

Acceptable quality dose (AQD) in CT dose optimization: Croatian multi-center study

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Purpose
Integration of clinical image quality with radiation dose optimization for CT.
Materials and Methods
The study included 951 patients scanned at four tertiary healthcare hospitals in Croatia (from Osijek, Rijeka, and Zagreb) in phase I (baseline, n= 483 CT) and phase 2 (post-optimization, n=563 CT). These included head CT for trauma (237), non-contrast head CT for acute stroke (197), routine chest CT (181), pulmonary nodules follow up CT (24), routine abdomen CT, (273) and kidney stone CT (39). Four radiologists assessed all CTs with a 4-point image quality scoring system (1= Unacceptable quality; 2= Limited quality; 3= Adequate quality; 4= Greater than needed quality). AQD was estimated as described in a previous publication (https://www.ncbi.nlm.nih.gov/pubmed/25430807).
Results
In phase 2, there was a 16% increase in IQS 3 (Phase 1: 48%, 308/640; Phase 2: 64%, 360/563) and a 14% decrease in IQS 4 (Phase 1: 48%, 307/640; Phase 2: 34%, 194/563). This was accompanied by a decrease in median CTDIvol and DLP for routine abdomen CT, routine chest CT, non-contrast head CT for acute stroke, and kidney stone CT protocols in phase 2 compared to phase 1 for images with an IQS of 3. The maximum decrease in dose for images with IQS 3 was noted for kidney stone CT (89%; phase 1, median DLP= 1139.9 mGy.cm; phase 2, median DLP= 116.4 mGy.cm) and the lowest decrease was noted for routine abdomen CT (39.7%; phase 1, median DLP= 854 mGy.cm; phase 2, median DLP= 514.9 mGy.cm).
Significance of the conclusions
Integration of image quality scoring criteria and the concept of AQD resulted in indication based radiation dose and image quality optimization determination of protocols with higher-than-necessary image quality and, awareness and detection of opportunities for optimization.

Contribution ID: 899
7. Accreditation and Certification
07.09. Keynote lecture

KEYNOTE LECTURE: Accreditation and certification in medical physics

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An increasing number of higher education institutions have started to offer courses on Medical Physics in recent years. Moreover, Continuing Professional Development (CPD) for medical physicists is of great professional interest. However, external assessment of the quality of education or training provision is needed. Accreditation is the formal recognition that education and training on medical physics provided by an institution meets acceptable levels of quality.

Accreditation should be based upon standards and guidelines. Requirements for accreditation of a training programme should take into account several aspects including facilities, staff, educational material and teaching methods. The International Organization for Medical Physics (IOMP) Accreditation Board has been set up very recently to ensure that accredited medical physics programs satisfy the highest standards established by IOMP in collaboration with other international organizations. The European Federation of Organizations for Medical Physics (EFOMP) established the European Board for Accreditation in Medical Physics (EBAMP) in 2016. EBAMP accredits medical physics education and training events. In the USA, the Commission on Accreditation of Medical Physics Education Programs (CAMPEP) accredits graduate, residency and CPD programs in Medical Physics.
Certification is the recognition of knowledge of a professional who has completed his/her education or training. EFOMP has established recently its examination board (EFOMP’s Examination Board, EEB) to facilitate the harmonization of Medical Physics education and training standards throughout Europe. EEB has introduced the European Diploma of Medical Physics (EDMP) and the European Attestation Certificate to those Medical Physicists that have reached the Medical Physics Expert level (EACMPE). EEB examinations are designed to assess the knowledge, skills and competences requisite for the delivery of high standard Medical Physics services and are voluntary. The International Medical Physics Certification Board (IMPCB) has also been established to support the practice of medical physics through a certification program in accordance with IOMP guidelines.

Contribution ID: 1901
7. Accreditation and Certification
07.09. Keynote lecture

KEYNOTE LECTURE: Certification of clinical medical physicists - how to uphold the standard globally

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Spearheaded by IOMP and IUPESM since four decades ago, the language was finally placed in the International Labour Office’s list of occupations to define the occupation of Medical Physicist. It was a major milestone marked by IUPESM Past President Keith Boddy (1937-2010). The International Standard Classification of Occupations (ISCO-08) was finalized in 2008 before the publication of the IOMP Policy Statements in 2010. The subsequent monumental harmonizing task of IAEA has made it possible for the medical professionals to harness the highly sophisticated medical technologies in every part of the world with the help of medical physicists, whose job title did not exist in hospitals in many countries, let alone the job descriptions. The International Medical Physics Certification Board (IMPCB), in the middle of the historical development, had to emerge to help the movement in a credible way, by setting up a system to identify qualified medical physicists. The IOMP again was the driving force behind it. Soon after the incorporation of the organization, IOMP became the Principle Supporting Organization when the Memorandum of Understanding was signed during the World Congress 2016. Among the many objectives stated in the bylaws of IMPCB, the tasks of accreditation of national and regional certification boards and direct certification of individual medical physicists are most visible. In this presentation, the speaker will present the process and recent updates of the accreditation efforts, and the preliminary statistics of the examinations. The speaker will acknowledge the current developments in radiation medicine, and explore the challenges faced by medical physicists. With the goal of preparing the qualified medical physicists to face the future, the speaker will summarize with a list of actions for IMPCB to take in order to uphold the standard globally for the not too distant future.

Contribution ID: 943
7. Accreditation and Certification
07.02. Quality systems/quality assurance

Uniforming the route around CE issues in healthcare institutions in the Netherlands

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The new medical device regulation sets additional requirements not only for manufacturers and suppliers but also for healthcare institutions. In the Netherlands, we started from the Dutch Association of Clinical Physics, in consultation with adjoining professional associations, to define a uniform route how to deal with issues related to CE / non-CE status of medical devices or whether it is used within intended use. In this route it is agreed under which circumstances a medical device may be used (regular care, medical research, unique patient, or self-development without alternative). In this route the Medical Device File (MDF) is an essential element to record the design, develop, tests, use and their associated risks. Within this route it is also proposed who or which committee should assess this file at which stage in the route. The CE route is followed by the regular Convenant Medical Technology process. Risks from the CE process should be included or mitigated in this convenant process.
Through this CE route we want to clarify for manufacturers outside a hospital but also for self-developed tools within a healthcare institution how to deal with issues around CE. In this way we hope to maximize both quality and safety without losing too much time in bureaucracy due to lack of clarity of procedures or duplication of information within documents.

Contribution ID: 715
7. Accreditation and Certification
07.03. Clinical audits

External dose audit for high energy radiotherpy photon beams of non-reference conditions using radiophotoluminescent glass dosimeter in Japan

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Purpose
The external dose quality audit (EDQA) for radiotherapy photon beams is implemented by Association for Nuclear Technology in Medicine in Japan (ANTM). In 2010, ANTM expanded the object of EDQA to non-reference conditions of field size changes and wedge filter insertions. In this study, we report the results of EDQA and the present dose delivery status with non-reference beam in radiotherapy in Japan.
Materials
Up to this time, ANTM audited 2205 beams of non-reference conditions. However we restricted the analysis to the data since Dec. 2013, because the Japan Society of Medical Physics issued new standard dosimetry protocol for radiotherapy in the end of 2012. The conditions audited are 5x5, 15x15, 20x20 and 25x25cm for field size changes, and 15, 30, 45 and 60 degrees for wedge filter insertions. The users (radiotherapy facilities) can select any conditions freely from both categories. In the EDQA by ANTM radiophotoluminescent glass dosimeters (RGD) are used as the detector. The doses of RGD irradiated by user are estimated by ANTM and compared to user's stated doses.
Results

Until Aug. 2017, 1440 beams of non-reference conditions have been audited. The number of beams are classified into 471 of wedge filter insertions and 969 of field size changes. The means of the differences between stated and estimated dose were less than 0.5%, and the standard deviations of the differences were around 1% for every field size and wedge angle. These standard deviations are within the values which were estimated by ANTM when starting the non-reference condition audits.
Conclusion
The EDQA for non-reference condition beams of radiotherapy beams has been successfully carried out by ANTM. The results are as expected and it seems that the status of dose delivery to patients in radiotherapy facilities in Japan is also satisfactory.

Contribution ID: 1781
7. Accreditation and Certification
07.03. Clinical audits

Comprehensive audits in nuclear medicine and diagnostic radiology in Thailand

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A comprehensive approach to quality assurance (QA) in the diagnosis or treatment of diseases by radiation, an independent external audit (peer review) is important to ensure adequate quality of practice and delivery of safe and effective diagnosis or treatment. IAEA has developed guidelines for comprehensive audits in radiation oncology, nuclear medicine and diagnostic radiology, with the aim to actual practice and recommend ways to improve quality of patient care. The audits had been carried out only at the request of a hospital and implemented through the IAEA Technical Cooperation programme. The audits are carried out by a team of professionals composed of an experienced medical practitioner, medical physicist and radiographer or technologist, last 5 days and follow the standardized methodologies published by the IAEA. The auditing process include a debriefing, interviews with relevant staff, observations of practice and review of documentation. At the end of the audit, the team of experts brief the local staff on the findings and present the prelimnary recommendations. The full audit report is strictly confidential. In case the auditors identify serious shortcomings in the practice, a follow-up audit mission is usually implemented.
The audits in nuclear medicine and diagnostic radiology have been carried out in Thailand. The process assisted in improving the quality of patient care, promoting the effective use of resources, enhancing the provision and organization of clinical services, developing the awareness of the importance of risk management, developing further professional education and training. Additional efforts are needed to promote the need for quality audits, especially among professionals working in radiology.
Keywords: clinical audits, comprehensive audits, QUATRO, QUANUM, QUAADRIL

Contribution ID: 1384
7. Accreditation and Certification
07.04. Future perspectives (new areas requiring standardization (accreditation/certification)

Quality Index in Oral Radiology

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The methods for the calculation of Potential Risk in medical radiodiagnostics institutions: Evaluation Model for Potential Risk (MARP). These articles present results based on documental evaluation of the institutions, but they suggest that quantitative data from the equipment's quality assurance can be included. This article proposes an evaluation of Oral Radiology institutions with a variation of the Potential Risk model, which considers, besides the administrative factors, quantitative results from equipment's quality assurance: The Quality Index. Results of the application of this proposition in sixty nine institutions are presented, with seventy five evaluated Oral X-Ray equipments, located in the Rio de Janeiro State in Brazil.

Contribution ID: 1490
7. Accreditation and Certification
07.04. Future perspectives (new areas requiring standardization (accreditation/certification)

Quality Indicators for Computed Tomography

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Computed tomography is the primary contributor to the composition of the collective dose due to medical exposures. Implementation of a quality analysis is fundamental for the maintenance of the radiological protection principles. A methodology was developed for the quality analysis with the use of Indicators, which were divided into 3 sectors: Regulation and Management; Equipment; Image Quality and Dosimetry. Technical tests and analyses were carried out to assign integer values for each indicator, ranging from 1 to 5, according to the degree of compliance with the specifications. The score assigned was used to calculate the Quality Index. The model was applied in 110 institutions of the State of Rio de Janeiro, with results distributed amongst 5 ranges of values. About 60% of the institutions received notes belonging to the two highest ranges of values. There was no significant difference between the results of old scanners compared to the younger ones. It is necessary to develop quality assurance programs to promote process optimization. It is also necessary to invest in technical personnel training to avoid underutilization of new technologies.

Contribution ID: 1868
7. Accreditation and Certification
07.05. Role of regulatory bodies

Medical device regulations in Mongolia

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According to the 2013 WHO Baseline Country Survey on Medical Devices, only 69% of 175 responding countries have a national authority responsible for implementing and enforcing medical device regulations. Of this 69%, many governments including Mongolia responded that they have some documents on medical devices and some countries have made little progress in implementing them.
Medical device market in Mongolia is small and limited for any type of major manufacturers to run business in the country. Mongolia does not produce any medical devices except for disposable syringes. Therefore, almost all of our medical devices are imported from many countries made from numerous manufacturers. But medical devices are not registered and the quality of products in the market is unknown. Ministry of Health has some policy documents on medical devices. However, existing documents are not adequate for implementation
With the said problem on controlling the quality and safety of medical devices being used in the country, the researcher aims to understand good regulatory practices in the global context to

ensure safety and quality of medical devices throughout their productive use and to come up with recommendations for the Mongolian government to improve its regulatory systems.
In resource-limited countries such as Mongolia, medical device regulation cannot be developed all at once but requires a risk-based step wise approach. The basic regulations to be introduced include import control on products and registration of vendors.
More advanced controls may be considered at the same time as implementation of the basic regulatory system. These could include classification and conformity assessment of medical devices.
With this project, the researcher hopes to help Mongolia to address issues on weak medical device regulation and protect the population.

Contribution ID: 712
7. Accreditation and Certification
07.06. Standards

Strategic approach to paternity test laboratory accreditation with a compliance of ISO 17025 standard

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Paternity test, also known as Y-STR male lineage test, is DNA examination used to trace the paternal ancestry by common DNA markers. This test found its purpose in examination the court evidence of sexual violence, confirmation of distant relative, or in difficult situations where alleged father is missing. The results of this test can originate results acceptable in the purpose of child support, adoption and/or inheritance, thus it is of crucial importance the proper handling of collected samples. In order to have reliable results with the traceability achieved, the test is accredited in a compliance to ISO 17025. The laboratory accreditation standard, ISO 17025, signifies general requirements for the competence of the testing laboratory. This standard requires specified and challenging approach to testing which includes all activities related to interactions with clients, sample collection, testing, measurement uncertainty and result confidentiality. As a result, we have accredited paternity examination method that is credible, performed by technically competent staff. This paper presents the influence of implementation of ISO 17025 for paternity testing on reliability, confidentiality and accuracy of obtained results.

Contribution ID: 1461
7. Accreditation and Certification
07.06. Standards

Documentation template for the usability engineering process for medical devices

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Introduction: Medical device regulatory processes are currently based on technical (ISO IEC 62366:2015) and regulatory standards (IEC ISO 60601-1-6:2015), which provide an international standard to be applied in evaluating devices and their documentation. However, the lack of standardization in the usability engineering processes used by the manufacturers, and the absence of pre-established metrics for such processes are constant problems in the medical device universe, particularly hindering the evaluation processes. It was verified that the current norms are

insufficient to guarantee good usability engineering processes, even with the existence of good usability practices in the literature.
Objective: This paper presents an analysis of the requirements contained in current standards and proposes a documentation model for usability engineering of medical devices, from the presentation of some techniques that are used in the process of device development.
Method: This work is based on literature reviews in order to identify the state of the art in usability engineering; analysis of current standards, to verify what the regulatory requirements are, and how to comply with them; comparative studies with existing documentation to identify strengths and weaknesses in documentation processes; and elaboration of documentation prototypes.
Results: From these results, it was possible to prepare a template document with all the points required by the current norms. Appropriate techniques were also listed for the accomplishment of some stages of the process, creating greater rigidity in the definition of the parameters of the documentation.

Contribution ID: 1314
8. Health Technology Assessment
08.07. Keynote lecture

KEYNOTE LECTURE: Medical technology assessment in radiation medicine

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Medical equipment assessment is one of the key processes in planning and implementation of healthcare services. The process is important in resources limited public healthcare system in which medical technologies are normally centrally planned and implemented and healthcare policy makers and service planners are accountable for effective and efficient use of resources in meeting service demands. Technology assessment become sophisticated and challenging when complex and high cost equipment such as radiation therapy systems are involved. To achieve optimal use of public funding in healthcare, a strategy of appropriate technologies is often used in service planning and implementation. A key consideration in technology assessment is achieving optimal balance between service demand, service quality, and financial constraints. In the case of national planning and selection of radiation therapy equipment, the scope of assessment should cover more than device functionality and performance standard. Technology appropriateness and cost-effectiveness from the perspective of country specific clinical needs, service compatibility, and financial viability should also be considered. The assessment should be based on a set of country specific criteria which should include (a) technology appropriateness for disease types and staging; (b) compatibility between service capacity and service demand; (c) technology compatibility with local environmental conditions and building and building services infrastructure; (d) compatibility in quality standard and functionality with other radiation therapy and supporting equipment; (e) compatible in service standard and service volume with all relevant supporting clinical services within service clusters; (f) compatibility with the professional competence of the staff members; (g) compatibility with standard of maintenance service; and (h) national resources constraints and service sustainability. A national infrastructure should be established to develop and maintain a set of country specific technology assessment criteria and to conduct the assessment.

Contribution ID: 1858
8. Health Technology Assessment
08.07. Keynote lecture

KEYNOTE LECTURE: Health Technology Assessment of medical devices: challenges, gaps and recent developments

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Health Technology Assessment (HTA) aims to inform healthcare decisions regarding appropriate innovative health technologies. After many years in which HTA community focused mainly on drug assessment, the attention of HTA international community is returning on medical devices, given their growing diffusion, increasing complexity and associated costs.
This talk will report on challenges and gaps met while assessing medical devices suggesting, when relevant, possible solutions.
Since 2014, the Applied Biomedical Signal Processing and Intelligent eHealth (ABSPIeH) Lab at the University of Warwick, directed by Dr Pecchia, focused on peculiar aspects of medical devices, and relevant scientific literature, which affect their assessment. For instance, in a recent study, the ABSPIeH lab demonstrated that even the positioning of a sensor, may affect the significance of a test based on medical devices. In a different study, performing field analysis in Sub-Saharan Africa, ABSPIeH lab tried to quantify the extent of which HTA reports can be reliable when assessing safety or effectiveness of medical devices in low income countries.
This talk will report on those experiences and will conclude presenting the significant effort made by the ABSPIeH, in cooperation with the IFMBE HTAD and the WHO, in order to produce pragmatic teaching material and guidelines on HTA of medical devices, which was designed specifically to meet the needs of medical physicists and biomedical engineers scientific communities.

Contribution ID: 1004
8. Health Technology Assessment
08.01. Technology management programs

Analysis of medical audit data in two dimensional (2D) mammography and observation of dominant radiological features in mammogram

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The present study designed to assess medical audit data in two dimensional (2D) mammography. The present study planned to quantify the efficacy of 2D mammography in breast cancer detection. 50 women (age range, 30–65 years; mean, 45 years) were participated in the study. Participants underwent standard two view 2D mammography on Hitachi Hologic LORAD M-IV at BCDC, SMS Medical College & Hospital, Jaipur. A set of common information were recorded from each of the participants. 90% of participants were came for the diagnosis purposes, 1% for routine screening purpose, rest 9% for disease progression follow ups. 95% of the participants were having education level less than 10th class. None of the participant was aware of breast self examination (BSE). Only 20% of the participants used oral contraceptive pills for at least 2 years in their pre-menopause. All the participants were found to have at least one child. Average compressed breast thickness was observed 4.9±1.0 cm ranging from 3.2 to 7.2 cm. The study noted mean tumor size 3.2 cm with range from 1.0 to 5.0 cm, with favorable biological features. 40% of the mammograms showed to be positive with a suspicious mass. 30% of them also showed at least 3 positive lymph nodes. Further analysis was performed and it was found that 60% of the positives containing circumscribed mass and 20% have asymmetric mass. Mammography plays a central role in diagnostic and screening plans in many low resource settings. Large suspicious masses in mammograms indicator of advanced breast cancer. This probably due to low educational level and unawareness about the BSE among the study population. This recommends need of awareness of BSE in the public. The basic idea of this study is to audit patient demographics and true potential clinical radiologic finding in the mammograms at our institute.

Contribution ID: 1133
8. Health Technology Assessment
08.01. Technology management programs

Wearable sensing of integrated rehabilitation exercise for stroke patient

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Stroke as one of the leading cause of disability for aging population. Regular physical activity is an effective way to help stroke patient in rehabilitation. Baduanjin exercise is a kind of Qigong that combine the breathing adjusting and the physical activity. It can help to stay at a healthy fitness, release the mental pressure and lower blood pressure levels, and also has been shown to improve the respiratory, cardiovascular and immune systems. From the aspect of the stroke patient in rehabilitation, Baduanjin exercise has a suggested as a helpful activity for elders. The benefit of exercise will be more significant if the patient can do the correct posture and breathe in an appropriate rhythm. This study presented a smart evaluation system to monitor the movement and breath of subject during doing the Baduanjin exercise. To simplify the experimental structure and reduce the uncertain movement by the body balance, subjects had been requested only using the upper body with the sitting posture to process the actions of the exercise. Two vital signs and one human motion factor had been measured in this system, the vital signs including breath rate and ECG signal, the breath rate was estimated from the motion of the chest by accelerometer and gyroscope. The accelerometer and gyroscope also using to record shoulder joint movement. All signals collected by the microcontroller and transmit to a software installed on a smartphone for data analysis and display. Base on the pre-installed Baduanjin exercise pattern in the smartphone, the software not only monitoring the movement and vital signs of subjects but also guiding the subject to follow indications to perform correct exercise actions and breath in right rhythm. This study presented an action evaluation and response system for stroke patient rehabilitation purpose by integrating with vital sign analysis and movement characterization.

Contribution ID: 1736
8. Health Technology Assessment
08.01. Technology management programs

Cardiovascular hemodynamic effects of somatosensory 20 Hz mechanical vibrations applied to the right heel during simulated monotonous driving

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The purpose of this study was to investigate the cardiovascular hemodynamic effects of somatosensory 20 Hz mechanical vibration applied to the right heel during prolonged, simulated, monotonous driving. This was a double-blind, within-subjects-design, crossover study. Twelve healthy volunteers (mean age; 21.7 ± 0.8 years) experienced each of three conditions at various times: i) 20 Hz mechanical vibration applied to the right heel; ii) 1.5 Hz mechanical vibration applied to the right heel as a control; and iii) no vibration applied. All subjects undertook 90-min periods of simulated monotonous driving, during which physiological measurements were made.

The parameters recorded were indices of cardiovascular hemodynamic phenomena, i.e., blood pressure, cardiac output, electrocardiogram RR interval, total peripheral-vascular resistance, and normalised pulse volume. Additional parameters were the standard deviation of lateral position, related to the weaving of the car, and subjective rating of sleepiness. All conditions increased the mean blood pressure, and elicited a vascular-dominant reaction pattern typically observed in monotonous driving tasks. However, mean blood pressure, total peripheral-vascular resistance, and normalized pulse volume during the monotonous task were significantly different in those receiving the 20 Hz vibration as compared with those receiving the 1.5 Hz vibration and not receiving any vibration. The observed differences indicate the cardiovascular system being more relieved from monotonous stress with the 20 Hz vibration. The effects of 20 Hz mechanical vibration applied to the right heel were reflected in cardiovascular hemodynamic phenomena, and we conclude that applying 20 Hz mechanical vibration to the right heel during long-distance driving in non-sleepy drivers could facilitate more physiologically appropriate, and possibly safer, driving.

Contribution ID: 1288

8. Health Technology Assessment
08.02. Equipment management systems

Risk-assessment model for medical devices maintenance based on OWA operator

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Medical devices are instruments that are used to diagnosis, monitoring, treatment, or preventing disease. These devices should be work properly according to specified standards of reliability in healthcare services, and the maintenance program of these equipment has a key role to achieve this goal. Disregarding a suitable maintenance program even in the general medical devices such as sphygmomanometer can lead to incorrect diagnosis and prescription of treatment, and even fatal results. Unfortunately, the maintenance program based upon periodic inspection or a preset schedule doesn’t consider many functional parameters such as the type of equipment, operating environment, risk factors, expert opinion, etc. In this way due to constraints in financing capacity, physical infrastructure and human resource capability, prioritize of medical devices, maintenance program based upon the risk has high importance for health centers. This paper proposes a new application of Ordered Weighted Average (OWA) operator for aggregation of different parameters for calculating of Risk Priority Number (RPN). This model is a fuzzy multi-criteria decision making approach based on risk maintenance framework for medical device prioritization. A numerical example presented in this paper shows through the introduced model, clinical engineering departments in healthcare centers could easily classify medical devices for maintenance activities according to their critically scores.

Contribution ID: 27

8. Health Technology Assessment
08.03. Health technology assessment and economics

The first clinic of breast cancer, experience in evaluation of medical equipment: the case mexican institute of social security (IMSS)

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Introduction: To report our initial experience and utility of implementing the evaluation method of technical-economic propositions to biomedical equipment with a clinical engineering approach for creation the first clinic of breast cancer by Mexican Social Security Institute (IMSS)
Materials and Methods: The main arguments referring to the guidelines used in evaluation the biomedical equipment, for this purpose, were create technical notes containing the minimum requirements the biomedical equipment technology considered in the realization of projects; for this case were definition of variables for evaluations fields, clinical (C), technical (T) and economic (E) the equipment proposed using the following algorithm.
$V = 0.45\ T + 0.30\ C + 0.25\ E$
The numerical value V represents the performance level the evaluated equipment, which is represented in a percentage scale 0 to 100%, when V value is > 70%, then equipment is susceptible of being acquired.
Results: The application of this evaluation methodology in each of equipment considered in the project, allowed to obtain a savings of approximately 13% the budget projected total cost.
The clinic has four digital mammography units in which about 45 thousand mastographs will be performed annually and two offices with ultrasound, in which will be granted 12 thousand consultations of diagnostic evaluation.
With the breast clinic, a project is launched that will allow for the benefit of the health of all Mexicans, since it is considered an example to follow in terms of prevention and diagnosis
Conclusions: We show you a methodology for biomedical equipment evaluation, it has it bases over the definition of variables from three evaluations fields, those variables pretend to quantify the physical, technical and functional state of the biomedical equipment, inside of his clinical and economical environment.

Contribution ID: 420
8. Health Technology Assessment
08.03. Health technology assessment and economics

Wireless assistance system during episodes of freezing of gait by means superficial electrical stimulation

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Parkinson's disease in the advanced stage presents the symptom of freezing of gait, approximately 80% of patients may have a freeze after 17 years of illness, provoking falls and injuries in their 60 % of them, the medication is obsolete before this symptom. In search of new methodologies and instruments to help improve the lifestyle of these patients, a non-invasive wireless system is proposed to detect freezing and restart walking by means of superficial electrical stimulation during an episode. A sensor based on a tri-axial accelerometer placed on the posterior secondary nerve was used to acquire and store the data of the right lower extremity during the presence of a freezing episode. The data was processed on the smartphone with Android system using the tool of the discrete wavelet transform developed in Java. The transcutaneous electrical stimulation is applied near the posterior tibial nerve of the lower extremities to continue the walk, which presents better results compared to the vibratory stimulation presented in an earlier version of the authors. The results show feasible diagnostic tests for the validation of the system, such as precision, sensitivity and specificity.

Contribution ID: 459
8. Health Technology Assessment
08.03. Health technology assessment and economics

Economic Evaluation of a Robotic Radiosurgery System for Prostate Cancer Treatments in the Czech Republic

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Purpose: The purpose of this study is to carry out an economic evaluation of the robotic stereotactic body radiation therapy (SBRT) in comparison with the conventional intensity-modulated radiation therapy (IMRT) for localized prostate cancer treatment in the Czech Republic.
Methods: Cost-utility analysis was used for the economic evaluation of the interventions based on their costs and the number of quality-adjusted life years gained (QALYs). The utility of the technologies was identified via a literature search in relevant databases. An estimation of treatment costs for both interventions was obtained from publicly available secondary sources for the Czech Republic. The cost-utility analysis was conducted from the healthcare provider perspective for three scenarios (optimistic, realistic, and pessimistic).
Results: The results of the cost-utility analysis for the realistic scenario were CZK 8 052 per QALY for the robotic SBRT and CZK 5 317 per QALY for the IMRT. In both other scenarios, the IMRT was characterized by a lower cost-utility ratio than the robotic SBRT. The robotic SBRT reaches the same or lower values of the cost-utility ratio as the IMRT in situations, when the acquisition price of the robotic SBRT equipment is lower than CZK 58 million in the realistic scenario.
Conclusions: Under the conditions of the Czech healthcare system, the IMRT is more cost-effective than the robotic SBRT for localized prostate cancer treatment in all analyzed scenarios.

Contribution ID: 593
8. Health Technology Assessment
08.03. Health technology assessment and economics

HTA in the Czech Republic: still behind

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The paper analyses the current state of HTA implementation and organisational initiatives in the Czech Republic. Although there have been some substantial elements of HTA applied in the decision process of pharmaceutical reimbursement since 2008, HTA methods are rather disregarded in other technologies. Since there is practically no demand for HTA studies from payers and state representatives, HTA has been cultivated above all by interested individuals and small academic research groups around them. These groups succeeded to keep pace with the global development both in theoretical and practical issues (among others in HTA methods for medical devices), however, the practical production of country specific HTA studies is quite rare. The main problem is non-existence of a national commonly accepted methodology and a legal framework. At least two attempts to establish a regular HTA process initiated by the Ministry of Health were destined to fail due to frequent personal changes in the Ministry. We discuss topical issues to be solved on the way to a national HTA system, and present our vision of a possible solution. Above all clinicians from research oriented university hospitals seem to be interested more than the national authorities. In the field of medical devices, methods based on the multiple-criteria decision analysis and health economic modelling have been suggested and successfully tested. They find their audience above all in hospital based HTA.

Contribution ID: 665
8. Health Technology Assessment
08.03. Health technology assessment and economics

Applying Artificial Intelligence to the Assessment of Endophthalmitis after Cataract Surgery

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Common in the elderly, cataracts often lead to visual impairment or blindness and rank as the world's leading cause of blindness. Endophthalmitis due to eye trauma or lowered immunity occurs after cataract surgery at a low rate of 0.07%–0.13%, but its occurrence can seriously impair vision or cause vision loss and is a common cause of medical disputes. In Taiwan, the number of cataract operations increased by 55% from 110,000 in 2000 to 171,068 in 2011; the increasing number and increasingly younger age of cataract patients constitute an important epidemiological issue. To examine the risk factors of endophthalmitis after cataract surgery and develop a related clinical decision support tool for health care professionals, we use year 2010 data from Taiwan's National Health Insurance Research Database, employ artificial intelligence methods to construct six predictive models for predicting postoperative endophthalmitis, and then build an assessment system based on the case-based reasoning technology. The back-propagation neural network model performs better than other models, with a mean test accuracy of 91.35% and a mean area under the receiver operating characteristic curve of 0.834. Case-based reasoning combined with weights from particle swarm optimization achieves higher system accuracy, 90.3%, than other combined models using weights computed by other methods. Our prediction and assessment models for endophthalmitis after cataract surgery can be used to support clinical assessment and, when combined with better patient education, may help to improve the quality of care and conserve health care resources.

Contribution ID: 679
8. Health Technology Assessment
08.03. Health technology assessment and economics

Cost-effectiveness analysis of Intrabeam system introduction to the Czech healthcare system environment

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Backround:
Intrabeam system is a technology used in oncology for intraoperative radiotherapy (IORT), a technique of partial delivery of radiation therapy to the tumour bed during surgery. The aim of this study is to evaluate cost effectiveness of the Intrabeam system in early stage breast cancer

treatment in order to reach a decision on a possible introduction of the technology to the Czech healthcare system.
Methods:
In order to determine the clinical effects, a worldwide literature review was conducted. The cost of the Intrabeam system was estimated based on available information about acquisitions of the system worldwide in the last five years. The cost of treatment was calculated from the perspective of a healthcare payer, and all the information gathered was summarized in a Markov model to finalize the cost-effectiveness calculation. A sensitivity analysis was performed.
Results
The input of the model was based on the TARGIT-A pragmatic randomized controlled trial – the largest and most comprehensive study among 26 selected studies from the literature review. The estimated purchase cost of the system for the Czech Republic was determined in the range of CZK 16-20 million without VAT. Based on the findings, three versions (baseline, optimistic, pessimistic) of the calculation for IORT interventions using Intrabeam were determined. In the baseline scenario, the cost of the Intrabeam system intervention was CZK 38 559, the ICER value was CZK 51 795 saved per 1 QALY lost. The results of the sensitive analysis are consistent with the results of the baseline scenario. The ICER value is not above the cost-effectiveness threshold (currently a little above CZK 1.2 million), which is required to consider the technology cost effective.
Conclusion
According to the results of the cost-effectiveness analysis, we do not currently recommend the Intrabeam system to be introduced into the Czech healthcare system.

Contribution ID: 696
8. Health Technology Assessment
08.03. Health technology assessment and economics

Cost utility of administration of 5-fluorouracil in patients with advanced gastric cancer

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Backround:
Dosage of 5-fluorouracil in patients with advanced gastric cancer is usually carried out via an infusion pump during hospitalization or an elastomeric disposable pump in the home environment after outpatient treatment. The aim of this study is to evaluate cost effectiveness of administration of 5-fluorouracil in patients with advanced gastric in Czech healthcare system environment.
Methods:
Clinical effects were obtained from available literature. The cost of administration of 5-fluorouracil was calculate from the perspective healthcare payer perspective, and all the information gathered was summarized in a decision tree to finalize the cost-utility calculation. A sensitivity analysis was performed.
Results
For the first cycle of administration of chemotherapy during hospitalization, the cost was calculated 23 360 CZK with calculated benefit of 0.00556 QALY. Cost of administration of chemotherapy via elastomeric disposable pump in home care was 19 296 CZK with benefit 0.00714 QALY. Administration via elastomeric disposable pump was dominant intervention with ICUR value -2 564 584. For the next cycle of chemotherapy results for administration of chemotherapy during hospitalization was 8 651 CZK and 0.00553 QALY; administration of chemotherapy via elastomeric disposable was 4 678 CZK and 0.00711 QALY. Administration via elastomeric disposable pump

was dominant intervention with ICUR value -2 527 126. The results of the sensitive analysis are consistent with the results of the baseline scenario.
Conclusion
According to the results of the cost utility analysis administration of 5-fluorouracil in patients with advanced gastric cancer via elastomeric disposable pump in the home environment after outpatient treatment was cost effective compared with administration via an infusion pump during hospitalization.

Contribution ID: 699
8. Health Technology Assessment
08.03. Health technology assessment and economics

Implementing Electronic Health Record in a children's Hospital: a HTA process

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Introduction
The adoption of electronic health record (EHR), which contain large volumes of aggregated longitudinal clinical data, guarantees substantial benefits, including a better care, improved safety issue and decreased clinical risks. However, it is also associated with significant costs and large technical and organizational impacts. For these reasons, it is important to conduct a comprehensive evaluation of health care delivery outcomes. The purpose of the study is to gather evidence on safety and overall effectiveness of EHR implementation at Bambino Gesù Children's Hospital.
Methods
Decision-oriented HTA method was applied to assess the technology on clinical, technical, organizational, economic, legal, ethical and safety domains. Itis a new implementation of the EunetHTA CoreModel integrated with the Analytic Hierarchy Process. It allows defining an evaluation structure represented by a hierarchical decision tree filled by indicators of technology's performances, to each of which was attributed a weight proportional to the impact that this criterion provides to achieve the purpose of the decision problem. Finally, the alternatives' ranking was defined. A subgroup of these indicators has been included in a checklist form for the evaluation of six EHR implementation projects. This checklist was used as a tool by each involved professional during demo sessions.
Results
The assessment took into consideration all the recommendations about the benefits and disadvantages of EHR. In particular, EHR seems to offer many benefits in terms of safety and clinical effectiveness such as improved continuity and quality of care and increased accessibility of the data. It's implementation resulted in important organizational outcome such as EHR configuration, learning curve and training; usability was the main technical characteristics of the technology taken into account. Finally, legal aspects on privacy and data security assumed a key role.
Conclusions
A detailed technology's evaluation has permitted hospital's decision-makers to knowingly assess its introduction in the hospital.

Contribution ID: 707
8. Health Technology Assessment
08.03. Health technology assessment and economics

Cost-effectiveness of minimally invasive total hip endoprosthesis implantation as compared with the conventional approach

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OBJECTIVES:
The total hip endoprosthesis implantation is one of the most common surgical procedures of the present day, and surgeons can choose different approaches. The aim of this study is to compare two surgical approaches - the conventional approach and the minimally invasive approach.
METHODS:
Clinical outcomes have been obtained through a literature review of clinical trials. Value engineering methods and multiple-criteria decision methods – namely Saaty's matrix, the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and the Analytic Hierarchy Process (AHP) – were used for setting the scales of criteria and effects, respectively. The total direct costs per patient were carried out by a systematic cost analysis from the healthcare provider's perspective. The cost-effectiveness analysis compared the conventional and the minimally invasive approaches. The calculations were completed by a sensitivity analysis.
RESULTS:
A total of 180 patients were enrolled in the study. The total costs per patient were CZK 57 084 (~EUR 2 173) for the conventional approach, and CZK 54 321 (~EUR 2 068) for the minimally invasive approach. Applying the TOPSIS method, the cost-effectiveness ratio is 7.99*10-6 for the conventional approach, and 11.29*10-6 for the minimally invasive approach. These results were also confirmed using the AHP method, when the C/E ratio is 8.86*10-6 for the conventional approach, and 9.42*10-6 for the minimally invasive approach.
CONCLUSIONS:
The results based on the cost-effectiveness analysis show that the minimally invasive approach to the total hip endoprosthesis implantation is more cost-effective than the conventional approach. On the other hand, the differences of both costs and clinical results under both approaches are insignificant.

Contribution ID: 709
8. Health Technology Assessment
08.03. Health technology assessment and economics

HTA of a pediatric biplanar low-dose X-ray imaging system

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Introduction
Patients with adolescent idiopathic scoliosis frequently receive x-ray imaging at diagnosis and subsequent follow monitoring. To achieve the ALARA concept of radiation dose, a Biplanar Low-Dose X-ray System (BLDS) has been proposed.
The aim of the study is to gather evidence on safety, accuracy and overall effectiveness of a BLDS compared with CT scanning, in a pediatric population, in order to support the final decision on possible acquisition of such innovative diagnostic system.
Methods
The new method Decision-oriented HTA (DoHTA) was applied to carefully assess the diagnostic technology. It was developed starting from the EUnetHTA Core Model® integrated with the Analytic Hierarchy Process in order to identify all the relevant assessment aspects of the

technology involved, identified from scientific literature, experts' judgments and specific context analysis of Bambino Gesù Children's Hospital. A weight was associated to each assessment element and the alternatives' ranking was defined.
Results
This innovative system provides orthopedic images in standing or sitting position, being able to examine the spine and lower limbs under normal weight-bearing conditions. This system is recommended for particular clinical indications as scoliosis and other congenital deformities of the spine. It is able to acquire simultaneous posteroanterior and lateral images in a single scan without vertical distortion and with lower radiation exposure than CT scanning. 2D images acquired can be combined to obtain a 3D reconstruction scanning based on a semi-automated statistical model.
Conclusions
The major advantages of BLDS are the relatively low dose of radiation and the possibility of obtaining a 3D reconstruction of the bones. Our preliminary results show that data on the clinical effectiveness are limited but the technical advancements of BLDS appear promising in terms of patient management and patient health outcomes associated with its use.

Contribution ID: 713
8. Health Technology Assessment
08.03. Health technology assessment and economics

HTA of 3D videolaparoscopy: follow up after 12 months from the introduction into clinical practice

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Introduction
In 2016 a HTA study was conducted in order to gather evidence on safety and overall effectiveness of performing laparoscopic surgery by using 3D videolaparoscopy (3DVL) versus 2D videolaparoscopy (2DVL) display systems in a variety of pediatric surgical procedures in order to efficiently support the final investment decision on video system to be acquired. Results showed that 3DVL might be a good alternative to 2DVL. Moreover, sensitivity analysis has also confirmed that the results associated to the best technology (3DVL) are robust; this has led to a confident decision for recommending it in Bambino Gesù Children's Hospital (OPBG). The objective of this work is to evaluate the impact of 3DVL within the hospital setting after 12 months its introduction in clinical practice.
Metods
Decision Oriented Health Technology Assessment method (DoHTA), developed by HTA unit of OPBG, was applied to conduct the assessment; it provided the definition and numerical evaluation of assessment parameters through which it is possible to evaluate the performances of technologies compared. After 12 months the technology's introduction, a comparison, based on the same assessment parameters, between the previous HTA results and the clinical and management data was carried out. Data from clinical registries concerning duration of intervention, hospital stay, surgery complications and tissue damage, were analyzed. Technical performances were evaluated through users' surgeons' interview (dexterity, video quality, surgeon's comfort). To evaluate the 3DVL impact on waiting lists and operating room productivity, data from hospital management were examined.
Results
Results confirmed previous HTA results, highlighting clinical advantages identified a priori.
Conclusions
This study provided another validation of DoHTA method and confirmed results of HTA process. It highlighted the importance of a HTA process before the acquisition of a technology for which the

investment decision is not obvious, because benefits and drawbacks of the new technology are unclear.

Contribution ID: 719
8. Health Technology Assessment
08.03. Health technology assessment and economics

Grading the quality of evidences in HTA processes

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Introduction
In decision-making processes, HTA plays an important role ensuring the adoption of effective technologies, translating scientific evidence into decisions. Bambino Gesù children’s hospital developed a new method which integrates EunetHTA Core Model with MCDA enabling decision makers to make a more informed decision between different alternatives. This approach is able to quantify the assessment parameters, which were defined by literature evidences, or by expert opinion when lacking evidences. MCDA results (i.e. decision tree of assessment elements, weights’ systems and numerical values of the technologies’ performances) are derive from judgements’ expression by experts. It means that indicators are weighed by the same weight system, either they are supported by strong literature evidences or, on the contrary based only on expert opinion. The objective of this work is to use the GRADE approach to weight the relevance of each indicator starting from its source of information, because different level of evidences should result in different weights.
Methods
A Grade level was associated to each judgement value of performance indicators and a normal probability function was built with the standard deviation inversely proportional to GRADE level to describe the possible dispersion of the judgement due to the different levels of evidence that support each indicator. The higher the GRADE value, the lower the standard deviation associated. A Montecarlo simulation was carried out to evaluate the expected value of technologies’ performances modulated by GRADE level.
Results
Four Gaussian distributions were built and associated to four GRADE levels. .
When an indicator has a low Grade level, its performance value will vary in a broader way according to the linked Gaussian distribution.
Conclusions
This approach showed the importance of applying GRADE system to indicators’ sources of information, because it can modify the overall computation of parameters’ weights and performance, proportionally to their robustness.

Contribution ID: 907
8. Health Technology Assessment
08.03. Health technology assessment and economics

Application of HTA in optometry

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The main objective of the work was to evaluate the possible types of correction of refractive errors for three categories of clients (children from six years with light myopia, teenagers from 15 years

with astigmatism, starting presbyopes) up to the age of 80 using available correction methods (glasses, contact lenses, refractive surgery). The evaluation was performed through the data on the size and frequency of orders in the optics and eye clinic.
The data was gradually processed in the form of a process map and the calculation of the cost of correction for the entire particular category from the perspective of the client. A part of the thesis was the elaboration of the FMEA for individual methods of correction and multi-criterial evaluation by the method TOPSIS. In conclusion, the CEA was developed for individual methods of correction and modeling of sensitivity analysis by reducing / increasing the cost of correction.
From the TOPSIS method, the best glasses correction was evaluated. The CEA was the best lens contact correction.
From the results of the individual analyzes, correction of glasses and contact lenses was best. The best possible combination of correction methods for refractive errors, due to possible health risks, is the combination of correction with glasses and contact lenses.

Contribution ID: 994
8. Health Technology Assessment
08.03. Health technology assessment and economics

Research on Consciousness of the Colorectal Cancer Screening in Japan

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In recent years, the colorectal cancer fatality is increasing in Japan; the first place on female and the third place on male. This study is intended to demonstrate the consciousness of cancer predilection age people on colorectal cancer screening using questionnaire. The subjects were 59 persons who were older than 40 years and agreed to this study. The questionnaire survey on 24 items was conducted and the analyses were carried out using SPSS ver.22.
The average ages of the subjects were 63.43±9.62 years for 23 men and 60.42±9.91 years for 36 women. The responses of questionnaire, “I have the test, because the test is free or aided” and “I have the test, because the test can check some items other than occult blood”, were superior in women than in men. The responses, “I have the test, because my age is in the range easily suffered from any cancer”, “ I think it is difficult to have the test at early time, because self-screening of colorectal cancer is impossible” and “I have the test, because the morbidity of colorectal cancer is increasing”, were superior in the older (≧60) than in the younger (<60). Besides, the family background like single or a member of household and economic condition also influenced on the responses of questionnaire.
At present, the support program for colorectal cancer screening behavior is developed and applied to the subjects. The results of this study will be reported at the congress.

Contribution ID: 1009
8. Health Technology Assessment
08.03. Health technology assessment and economics

The robustness of TOPSIS results using sensitivity analysis based on weight tuning

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The multi-criterial decision analysis (MCDA) are one of the support technics for the Health technology assessment (HTA). The typical method is a Technique for Order of Preference by

Similarity to Ideal Solution (TOPSIS). The outputs of TOPSIS present the order of alternatives. The significant risk originates from inappropriate setup of weights of criterions when a very small deviation from the proper value could change final result substantially. The sensitivity analysis is a method for testing of changes of final order by the modification of original input data or by the little deviation of original weights of criterions. This original approach is very slow and results into many computing in case of change of the value of any attribute. Newly proposed approach is significantly faster allowing the change of values of weight and only few computations inside of TOPSIS. In the first step, TOPSIS will compute values of Positive and Negative Ideal Solutions (PIS and NIS) and the sensitive analysis could compute in next pass only for changed weights. In proposed approach there is a weight tuned (and other weights are recalculated to SUM=1) for range where initial order is equal to modified weights. Is it possible set iteration in counted steps or one pass testing with defined safe range of weight. New approach is fast and simple for implementation, assure robust output of TOPSIS method and points possible wrong set–up of some weight/s.

Contribution ID: 1500
8. Health Technology Assessment
08.03. Health technology assessment and economics

New Methods for Risk Assessment of Medical Devices – Risk Health Technology Assessment

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ntroduction: Risk analysis is an essential part of putting a medical device on the market and also in use of a medical device, whether considering the post-marketing surveillance or the application itself. This study deals with utilizing new methods in the risk analysis application within Health Technology Assessment. Currently, the methods described in the standard ISO EN 14971 are applied. However, the particular methods were adopted from other sectors, and their modification for the very purpose of medical devices risk assessment is missing.
Methods: Based on the state of the art in the field, FMEA , FTA (Fault Tree Analysis), RCA (root cause analysis) and HFMEA were considered. A risk assessment variant using a MCDA was also analysed. The suggested risk assessment methodology within HTA uses some of the principles outlined in these methods, but is explicitly adapted to medical technology.
Results: For the practical verification of the methodology, two specific evaluations were made. The first one concerned the use of the new MRI-TULSA medical device, and the second one was the Risk-HTA when assessing the effectiveness of patient's transfer from a hospital to home care from the point of view of the pulmonary ventilator use. The risk analysis was found to be a useful option for assessing specific outcomes for medical devices market entry. Furthermore, the use of MCDA in conjunction with risk analysis elements taken from already known methods appears to be a suitable alternative in medical devices.
Discussion: The use of risk analysis in the medical device evaluation system appears to be an appropriate and worthy method. The introduction of the so-called Risk HTA has undeniable application. Especially in assessment areas such as entry of a new medical device in the early-stage HTA level and assistive technology.

Contribution ID: 1885
8. Health Technology Assessment
08.03. Health technology assessment and economics

A preliminary cost/efficacy analysis of MIRUS™ system for sedation of critical patients

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Side effects of traditional analgo-sedative agents call the attention to alter-native strategies of sedation for critically ill patients; volatile anaesthetics (VAs) are considered potential substitutes in selected categories of pa-tients. MIRUS™ (Pall Corporation and TIM Germany) is an innovative sys-tem for the administration of VAs to these patients admitted in intensive care unit (ICU).
The aim of this study was to analyse the clinical and economical charac-teristics of MIRUS™, following the Health Technology Assessment princi-ples (HTA); in particular, the study was focused on defining a cost/efficacy ratio of the use of MIRUS™ in an ICU with 8 beds and 80 procedures/year. HTA allows predicting the system impact in the clinical pathway before material introduction.
The assessment showed that MIRUS™ could be innovative, safe and ef-ficient, especially when applied to critically ill patients with compromised organ function. For the purposes of assessment, three classes of ICU treat-ments have been defined: short- (6-24 hours), medium- (24-96 hours) and long-term (>96 hours) sedation (SS, MS, LS). Based on the technical charac-teristics of system, MIRUS™ could be considered unfit for LS. Considering clinical characteristics, effects on patients, sedation times and costs, the HTA shows how the procedure costs are different for each class.
In conclusion, the use of MIRUS™ could be useful and effective for crit-ically ill patients, in which standard sedation may be associated with drug hangover. This assessment seems economically advantageous for SS, where cost/efficacy ratios are positive performing 400 procedures/year, while for MS the cost of drugs impacts on the procedure cost. Therefore, looking at the potential clinical benefits on all potential treatable patients, the best addition strategy of the system in the hospital should be evaluated to opti-mize the cost/efficacy ratio.

Contribution ID: 23
8. Health Technology Assessment
08.04. Productivity and benchmarking

Entry into the european market of medical devices. Two visions: Spain and Cuba

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The work presented is part of an ongoing research project that looks at the same issue from two different perspectives: developed and developing countries. The objective is identify the existence and impact of barriers to entry into the european market for medical devices. An exploratory case study was conducted with spanish companies. At present a descriptive case study is carried out with cuban companies in the sector. The preliminary results show a consensus in the criteria of the spanish participants about the absence of tariff barriers and some discrepancies with respect to non-tariffs barriers, highlighting influence of technical barriers. However, the definitive findings are not yet available. The results of the multiple case study will be contrasted with expert criteria by specific methods.

Contribution ID: 674
8. Health Technology Assessment
08.05. Cost effective technologies for developing countries

Reforming innovative health technologies acquisition process in Tunisian hospitals

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OBJECTIVES: Emerging and innovative medical equipment are continually being produced and flow rapidly into the nation's medical mainstream. Tunisian hospitals are autonomous in their decisions around the incorporation of new medical equipment. Different decisions are taken about a same technology, thus causing increase in practice variability, inequities in the access to health care services and driving up costs. Appropriate procurement of innovative and emerging equipment should be based on evidence of its performance and value improving the quality in healthcare. The National Instance for Assessment and Accreditation in Healthcare was created to inform decision making on most efficient technologies and best practices in healthcare. METHODS: An investigation including SWOT analysis was performed in Tunisia on the way decisions were taken on health technologies and which were the key elements of this decision-making process. Interviews with stakeholders were conducted according to best practices in qualitative research. A flow chart of decisions was built identifying main pitfalls to connect the gap and structure the information around innovations uptake in hospitals. RESULTS: Main weaknesses were lack of standardized procedures for equipment acquisition, inexistence of explicit grids and absence of communication among hospitals around decisions. INASanté represents an opportunity to structure the process of technology approval. Therefore, INASanté has produced and diffused a guideline based on weighted criteria to support decision making. In addition, INASanté conducts upon request robust and systematic evaluation in order to make recommendations regarding new technologies. CONCLUSION: Tunisian hospitals require a structured and informed process on decision making for the acquisition of new and costly equipment with added value. INASanté recommends a standardized manual for proposal submission, prioritization criteria, defined calendar for resolutions, a grid consisting of weighted criteria guiding decision making, a centralized database of proposals and final decisions to avoid duplicates and reduce inefficiencies without compromising hospitals' independency

Contribution ID: 768
8. Health Technology Assessment
08.05. Cost effective technologies for developing countries

Energy management plan in health facilities in Kenya

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This paper outlines recommended Measure, Estimated Implementation plan, Estimated annual energy saving Kwh, Estimated annual CO reduction kg/Kwh, Payback period and Return on Investment.

Energy audit is sometimes called energy survey or energy analysis, to avoid the negative connotation of an audit. Energy Audits form part of key pillars of achieving energy efficiency and effective energy cost control program
It provides opportunities for identification, tracking and reduction of system losses and entails a detailed examination of how a facility uses energy, how much the facility pays for that energy, and finally recommends a program for changes in operating practices or on energy-consuming equipment that will cost-effectively reduce on energy bills.
It is done in levels, Level 0 Bench marking Audit, Level 1 Walk-through audit, Level II Detailed/General energy audit, Level III Investment-Grade audit
Facility Description – service flow, size, construction, facility layout, and hours of operation, equipment list, with specifications, Weather data
Sources of energy generation include Geothermal, Wind and Hydro.
Energy Legislation and Regulations includes Energy Act No. 12 of 2006,The Energy Management regulations 2012, The Energy Solar Photo voltaic systems regulation 2012,The Energy Solar Water heater regulations 2012,Time of Use pricing system, Tiered pricing systems and Solar PV.
Energy conservation measures include Lighting, Motor, belts and drives, Fans and pumps and Water recycling
Biomeds should create awareness of Energy conservation measures, analyse electricity bills, Propose and create awareness of emerging Technologies LED, Solar Water Heaters in Maternity units for hot shower for clients, solar operated Vaccine Refrigerators ,Biogas, Mini Hydro electricity generation and energy Audit.

Contribution ID: 1772
8. Health Technology Assessment
08.05. Cost effective technologies for developing countries

Cobalt-60 radiotherapy units, assessment of the utilization or disinvestment in Latin America

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Objectives: To assess whether the criteria for disinvestment in health technolo-gies -clinical, technological advantage, safety, lifecycle, human factor and costs- are applicable for the withdrawal of cobalt-60 radiotherapy units (Co-60 RTUs) in Latin America, considering health outcomes, and that the economic context, re-placing this technology with linear accelerators (LINACs) is not always feasible. Methods: A systematic review of articles published between 2003 and 2017 in PubMed, Cochrane Library and CRD on the current use of Co-60 RTUs and publications comparing them with LINACs has been made. With a manual search of the references of selected articles. Results: The clinical results indicate that Co-60 RTUs have a significant role in treatment of patients with tumors of head, neck, breast and some types of superficial soft tissue sarcomas of the extremities. The comparison between Co-60 RTUs and LINACs results in advantages for linear accelerators in: the variety of cancer type that can be treated, the delivery of treatment, lifecycle and safety. In terms of acquisition costs, although Co-60 RTUs are comparable to a low-energy LINACs. Considering the number of ex-isting Co-60 RTUs in Latin America, their effectivity and safety in the treatment of some types of cancer and the shortage of skilled professionals, its use can still be beneficial. Conclusions: Whereas in Latin America more than 26% of radio-therapy equipment are Co-60 RTUs, available economic resources and staff are limited. A recommendation is to continue utilizing such equipment in some types of cancer where

they can be used: head, neck, breast and superficial sarcomas ex-tremity soft tissue and allocate the use of existing LINACs for other types of can-cer and in special cases like pediatric patients.
Keywords: Cobalt-60 radiotherapy unit, Co-60 RTUs, linear accelerator, LINAC, Latin America, radiotherapy.

Contribution ID: 783
9. Biosignals Processing
09.07. Keynote lecture

KEYNOTE LECTURE: Dry electrodes for electroencephalography

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Multichannel Electroencephalography (EEG) is widely used in clinical neurology and neuroscientific research. EEG caps with wet Silver/Silver-Chloride (Ag/AgCl) electrodes represent an often-used standard in the field. Reproducible electrode-skin contact for these electrodes is ensured by electrolyte gel or paste. Thus, these electrodes require specific mechanisms to apply and hold the gel at the electrode positions in the caps and require skilled personnel to apply the EEG cap. Dry electrodes allow more degrees of freedom in the design and fabrication of EEG caps and can be self-applied without long preparation times.
This presentation introduces novel multi-channel EEG caps with dry electrodes. The base material of the EEG cap is a light-weight and flexible fabric, which contains small holes (perforation) making it breathable. Polyurethane (PU) based multi-pin electrodes serve as dry contact electrodes. A coating provides electrical conductivity of these polymer based electrodes. The use of silver coating opens the way for dry AgCl electrodes and thus, signal quality similar to wet Ag/AgCl electrodes. Thin coaxial wires are soldered to the bottom of the electrodes enabling active shielding. A second layer of fabrics protects the electrodes and the wires.
Our results demonstrate that resting state EEG, eye movements, alpha activity, and pattern reversal VEP can be recorded with the novel dry multi-channel EEG caps with short preparation time and without significant differences between the novel EEG cap and a conventional cap based on wet Ag/AgCl electrodes.
In conclusion, the proposed novel multi-channel EEG caps with dry electrodes can potentially replace conventional wet multi-channel EEG caps and thus enable new fields of application like brain-computer-interfaces and mobile EEG acquisition.

Contribution ID: 1899
9. Biosignals Processing
09.07. Keynote lecture

KEYNOTE LECTURE: Dynamical analysis of EEG and MEG for localization of the epileptogenic focus, prediction and control of seizures

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Epilepsy is a debilitating brain disorder. It is characterized by epileptic seizures, spontaneously occurring disturbances of brain's normal operation. Of the world's 50 million people with epilepsy, fully 1/3 have seizures uncontrolled by anti-epileptic medication. Understanding the dynamics of generation of seizures (ictogenesis) could provide the foundation for new, more effective, treatment modalities. Currently, the two most promising such modalities are removal of the epileptogenic focus by surgery and control of seizures via neuromodulation. Respectively, what these modalities really need is the accurate localization of the focus and its network, and the understanding of the

dynamics of ictogenesis. Monitoring and quantitative analysis of images and signals from the epileptic brain help neuroengineers towards these directions. In particular, our group has shown that, even from interictal (seizure-free) periods, it is possible to accurately localize the epileptogenic focus by analysis of electroencephalographic (EEG) and magnetoencephalographic (MEG) signals employing measures of directed information flow like the generalized partial directed coherence (GPDC). We have also shown in the past that it is possible to predict seizures with good sensitivity and specificity minutes to hours before their occurrence by employing measures from nonlinear dynamics, and to abate them with a novel feedback control scheme. Examples of focus localization and seizure prediction in humans and closed-loop seizure control in simulations and animal models of epilepsy will be presented. Therefore, the employed platform and measures are promising for identification of the topology of the pathological dynamics of neuronal networks that lead to seizures, development of biomarkers for susceptibility to seizures, timely abatement of seizures by closed-loop neuromodulation, as well as objective evaluation of the efficacy of current and new seizure treatment strategies. Broader application of this framework to other complex systems requiring monitoring, forecasting and control is a natural outgrowth of this analytical platform.

Contribution ID: 208
9. Biosignals Processing
09.01. Linear dynamic analysis of biomedical signals

Research on Respiratory Signal Based on Angular Velocity

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Precise monitoring of human respiration is crucial to the diagnosis of a wide range of respiratory and cardiovascular disorders and (thus) is of great interest to both clinicians and researchers. Existing measurements may include electrocardiography (ECG), nasal cannula and respiratory plethysmography.However, low comfort levels and signal shifts which are often observed in these techniques pose limitations for long-term, accurate monitoring of human respiration.
In this paper, we develop a convenient respiratory signal acquisition method based on angular velocity derived from suprasternal notch. Research has found that waveforms collected from the suprasternal notch display higher robustness, as well as less gender variability. We use the median filter method and intersection detection technique to extract the respiratory waveform, respiratory frequency and respiratory phase parameters. And validated the respiratory signals derived from suprasternal angular velocity in both males and females.The extracted parameters are validated against a carbon dioxide concentration acquisition device, which serves as our golden reference platform.The results demonstrate the potential of suprasternal-derived angular velocity as a simple, low-cost and unobtrusive method for monitoring human respiration.

Contribution ID: 235
9. Biosignals Processing
09.01. Linear dynamic analysis of biomedical signals

RF ultrasound based longitudinal motion estimation of carotid artery wall: feasibility study

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Arteriosclerosis is a chronic, systemic, inflammatory disease of the arteries. Arteriosclerosis reveals itself when complications build up: constricted artery lumen and (or) its thrombosis, enlarged and thinner wall (aneurysm). Nonetheless, it has been proved than significant changes of the mechanical properties of the common carotid (CC) artery wall are present much earlier than the anatomical changes appear.
The aim of this work is to propose and evaluate an algorithm for analysis of longitudinal and radial movements of CC artery from registered radiofrequency (RF) signals. The proposed method uses RF signals, phase correlation and sub-sample algorithms to estimate radial and longitudinal movements of the CC artery which were monitored continuously for 3 – 4 heart cycles. A physical phantom and in vivo tests were employed for testing of the algorithm. The predefined longitudinal movements of 170, 200, 500, 700, 900, 1100 μm double amplitude were generated in the phantom. Common carotid artery intima-media complex longitudinal displacement evaluation was carried out with 24, 45, and 80 years old volunteers. Intima-media complex of CC was selected to determine longitudinal displacement.
Results show that normalized root mean square error (NRMSE) is from 0.28 to 0.58 μm and coefficient of correlation is from 0.88 to 0.96 at any fixed longitudinal motion values when the phase correlation and sub-pixel algorithm was used. If additional filtering is employed, NRMSE was ranging from 0.21 to 0.41 μm, while the correlation coefficient - from 0.95 to 0.98. Implemented phase correlation algorithm was able to register the radial and longitudinal movements of CC artery.
In conclusion, a link between the radial and longitudinal displacements and longitudinal motion decrease with age was observed in vivo. The results from this validation study demonstrate the feasibility of common carotid artery longitudinal and radial movement assessment in-vivo using phase correlation and sub-sample algorithm.

Contribution ID: 371
9. Biosignals Processing
09.01. Linear dynamic analysis of biomedical signals

A novel design of multichannel laser photoplethysmography with lateral incident radiation in the wavelength regions with blood glucose absorption

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For practical noninvasive measurement of blood glucose (BGL) based on pulse glucometry previously reported, it is essential to provide highly accurate and convenient detection of finger photoplethymogram (PPG) with wavelength regions of BGL absorption. This study was to propose a novel but simple geometrical arrangement of a laser based photoplethysmograph through cut and try PPG measurements in various incident laser-beam positions using three representative wavelengths; 808 nm, an isosbestic point of oxy hemoglobin and deoxy hemoglobin, 1160 nm, an alcohol absorption, and 1600 nm, an absorption peak of BGL. Laser beams were applied via an optical fiber flatpack to 8 positions around the fingertip placed on a photodiode. An appropriate position was searched to acquire definite PPG signals using 10 healthy subjects. Although PPGs with 808 nm and 1160 nm were obtained in any positions, those with 1600 nm were acquired only when the laser beam was less than about 3 mm distance upward from the fingertip ball to detect forward- and side-scattered radiation through the tissue. Using this position, a preliminary experiment on multi-wavelength PPG measurements with BGL absorption region were successfully done. We conclude that a lateral incident radiation to the fingertip to detect forward- and side-scattered photons through the tissue is most appropriate for PPG measurements especially in wavelength regions where there is potential for BGL measurement.

Contribution ID: 374
9. Biosignals Processing
09.01. Linear dynamic analysis of biomedical signals

Analysis of biological response to pleasure emotion elicited by video

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To study for the objective evaluation of emotion especially for pleasure emotion, the biological responses of blood circulation and respiration to the emotional videos were investigated. Fifteen healthy young adult men were participated in the experiment. In the experiment, they saw the familiar campus video for 90s followed by an emotional videos for 150s, and saw the campus video again for 60s. After that, the subject self-rated the emotional state by the questionnaire. Five videos which corresponding to “exhilaration”, “happiness”, “soothing”, “aversion” and ”control” were used and presented in random order. As the aim of this study was focused on pleasure emotion, three types of videos corresponding to each pleasure emotions were used.
Impedance prethysmography, electro cardiogram, prethysmograph, continuous blood pressure, respiration wave were measured, and stroke volume, cardiac output, heart rate variability, and its Mayer wave and RSA components, pulse wave amplitude, systolic/diastolic/mean blood pressure, pulse pressure, total peripheral resistance, respiration amplitude/frequency were analyzed.
Self-rated scores of pleasure-displeasure showed adequately in each emotions. A few biological changes were observed in “exhilaration”, such as heart rate, pulse wave amplitude, pulse pressure. However, no bio-changes in common within pleasure emotions were observed.
To find the common bio-responses in pleasure emotions, the precise study of pulse wave were executed. Consequently, a few results were obtained as follows, arterial compliance tend to decrease in each pleasure emotion with no significance. The maximum of differentiated pulse wave named dP changes significantly in “exhilaration” and “happiness”. Moreover, the combined parameter of dP/HR/MBP changed significantly in every pleasure emotions.

Contribution ID: 748
9. Biosignals Processing
09.01. Linear dynamic analysis of biomedical signals

Sparse reconstruction method for decomposition of cardiac and respiratory components from bioimpedance measurements

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Bioimpedance measurements are promising method for medical signal monitoring due to its non-invasiveness and cost-effectiveness. For example, impedance cardiography (ICG) has been used for monitoring the stroke volume. However, the task of estimating parameters from the impedance measurements is complicated by respiratory component and motion artifacts. These components can be considered as noise signals if one is only interested in cardiac component. It is more interesting to try to extract both the cardiac and respiratory signals.

In this work, we investigate the possibility of incorporating sparse reconstruction framework for the separation of cardiac and respiratory signal components from the bioimpedance measurements. The signal decomposition is complicated by non-stationarity of the signal and overlapping of their spectra. The signal has harmonic structure which is sparse in the spectral domain. We approach the problem by considering the dictionary with elements describing spectral components of the considered signal. Parameter estimation task is solved through the means of sparse reconstruction where solving optimization problem returns sparse vector of relevant dictionary atoms. The difference in harmonic structure of the spectra of considered signal components is used to estimate respiratory part of the signal in the first run and then to estimate cardiac component from the residual.

Contribution ID: 929
9. Biosignals Processing
09.01. Linear dynamic analysis of biomedical signals

Cyclostationary analysis of respiratory signals with application of rate determination

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Respiratory signals are periodic-like signals (almost periodic signals) where the noisy periodic pattern repeats itself. Therefore, based on a stationarity assumption, autocorrelation function contains noisy cycles in time-lag with the same rate as the respiration rate. In this work, cyclostationarity test is performed on the respiratory signals in order to determine cyclic characteristics of the time-varying autocorrelation function. Our specific aim is to check whether the cycle period in time corresponds to the respiration rate. Lung simulator was used to generate the respiratory signals. Time-varying autocorrelation variance was computed by using both the modified windowed, and the blocked signal methods. Our simulations resulted that the cycle period was the same as the respiration period. Moreover, we observed that cyclic frequencies corresponded to the respiratory rate and its harmonics.

Contribution ID: 1225
9. Biosignals Processing
09.01. Linear dynamic analysis of biomedical signals

Heart Rate Monitoring for the Detection of Changes in Mental Demands during Computer Work

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The detection of variations in mental demands is a key factor for the optimization of the balance between occupational health and work performance. With the advances in heart rate acquisition technologies, heart rate monitoring is now easily and affordably in access. In this study, we recorded the heart rate of 18 healthy young participants (Six females and 12 males, aged 23±3 years) while they performed three consecutive 5-min tasks with low, medium and high mental demands in two sessions with at least a week apart. The order of the tasks was counterbalanced across participants to avoid carryover effect. Each task was a cyclic computer work, beginning with memorizing a pattern of connected points following by the disappearance of the pattern and then

replicating it using computer mouse clicks on an incomplete version of the pattern. The demand of each task was manipulated by changing the complexity of the displayed patterns. The participants responded to the National Aeronautics and Space Administration Task Load Index (NASA-TLX) questionnaire to rate their perceived mental load after the completion of each task. The mean and range of heart rate, HRM and HRR respectively, along with the performance (an index showing the accuracy and quickness of clicking) for each cycle was calculated and averaged for each task. The repeated measures analysis of variance revealed that the HRR monotonically increased significantly as the mental demands increased ($p<0.001$), whereas the HRM did not change in response to the different task demands, and the responses remained consistent across sessions. As expected, the performance decreased and the perceived mental load increased as the task demands increased. The results suggest that the variations in heart rate would provide useful information regarding the quantification of mental load.

Contribution ID: 1347

9. Biosignals Processing
09.01. Linear dynamic analysis of biomedical signals

Design of linear phase filter by using q-bernstein polynomial

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The aim of this paper presents a design of IIR filter by using q-Bernstein polynomial. There are two parameters for adjusting a characteristic of frequency response. Asymmetry magnitude response is made by parameter q. Stopband and slope of phase are adjusted by varying parameter ε. The advantage is a linear phase and maximally flat more than Butterworth and Chebyshev. The circuit is converted from transfer function by using single amplifier technique and The stability can guarantee with Mihailov's criterion.

Contribution ID: 1418

9. Biosignals Processing
09.01. Linear dynamic analysis of biomedical signals

Assessment of In-Ear Photoplethysmography as a Surrogate for Electrocardiography in Heart Rate Variability Analysis

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The analysis of heart rate variability (HRV) is a well-established method for evaluation of the autonomic nervous system. Generally, HRV is derived from electrocardiograms (ECGs) which requires the fixation of electrodes directly on the skin. This prevents the application of HRV analysis in situations like long-term home monitoring or out-of-hospital acute medical care. In this work, we assess the possibility of employing in-ear photoplethysmography (PPG) as a surrogate modality for the derivation of HRV measurements.
We simultaneously recorded the electrocardiogram, the photoplethysmogram at the fingertip of the left index finger and the in-ear photoplethysmogram in the outer tragus from 14 healthy volunteers. During the 5-minute recordings, the volunteers remained at rest in a sitting position. All measurements were conducted with a measurement system that was developed at our facility. For

the assessment of agreement between the three measurement modalities, we calculated standard time-domain HRV parameters from the derived tachograms. Namely, these were the mean, the standard deviation (SDNN) and the fraction of intervals shorter than 50 ms (pNN50) of the beat-to-beat time series.
The mean differences between the ECG- and in-ear PPG-derived HRV parameters are 0.01 bpm (mean), 2.939 bpm (SDNN) and 0.01 % (pNN50). For comparison, the mean differences to HRV parameters from the fingertip PPG are 0.01 bpm (mean), 3.03 bpm (SDNN) and 0.01 % (pNN50).
The time-domain HRV parameters derived from the in-ear PPGs show a high agreement to the ECG derived features. Furthermore, the results from the in-ear PPG are very comparable to those of the fingertip PPGs. Thus, the in-ear PPG can be regarded as a viable measurement modality for the derivation of HRV parameters. Further studies need to be conducted to extend our analysis to also encompass frequency domain and non-linear HRV parameters.

Contribution ID: 1421
9. Biosignals Processing
09.01. Linear dynamic analysis of biomedical signals

Photoplethysmographic measurements on clinical patients (>65 y) and healthy cohorts between ages of 18-75 y

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Photoplethysmography (PPG) is a promising technique for screening of vascular subjects, especially of various atherosclerotic patients. However, the understanding of the diagnostic value of the PPG features is lacking. PPG waveforms deserve attention for its possible applications beyond pulse oximetry and heart-rate calculation. The PPG waveform is caused by the left ventricular contraction, and it is called the percussion wave (the first wave). This wave is causing blood flow to the proximal aortas. At this time, blood continues to flow out from the proximal aorta. This is causing an accelerated decrease of the intravascular volume and the recoiling of the arterial vessel wall. After a short time, the aortic valve closes, and the blood flow stops against the aortic valve and flows back to the proximal aorta. At this starting time, due to the inertia, the blood that from the adjacent vascular segment continues to flow to the proximal aorta. The PPG pulse waveform that caused by the closure of the aortic valve is called the tidal wave (the second wave). The third wave is a reflection from the periphery and called the dicrotic wave. The PPG pulse waveform contains additional waves called the repercussion and retidal wave. Clinical tests are necessary to quantify the aging effects in relation to the obtained variables and to explore pulse waveform changes with subject age based on the second derivative photoplethysmograph (SDPPG). Based on the amplitude and time relations, the PPG waves reflect arterial stiffness, especially of the SDPPG's b/a ratios increase with age. The SDPPG is related to the arterial healthiness of the peripheral arteries, and suggest that the magnitude of a-a is an index of atherosclerosis and ASO related altered diseases. Beside of the second derivative, the first derivative of the PPG can also be used to calculate the indexes

Contribution ID: 1433
9. Biosignals Processing
09.01. Linear dynamic analysis of biomedical signals

Microwave technology for detecting abdominal bleeding

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Injury accounts for 10 % of global mortality, and tens of millions new victims each year face lifelong disabilities. A significant proportion of traumatic deaths are preventable if detected and treated earlier. Hemorrhage represents a substantial proportion of preventable deaths. Hemoperitoneum (abdominal bleeding) is one injury that is frequently lethal and challenging to detect in the prehospital setting. Ultrasound can be used for detection, but it requires a trained operator and is currently rarely used in prehospital care. In this study, we have evaluated the potential for microwave technology to detect hemoperitoneum. A porcine model of hemoperitoneum using anesthetized pigs was developed. A belt with eight microwave antennas was strapped around the pig's abdomen. Measurements spanning a frequency interval of 0.1–2.0 GHz were performed on ten pigs, and hemoperitoneum of 500 mL and 1000 mL were induced using the pig's own blood and compared to baseline (no bleeding). The blood accumulated predominantly around the midaxillary line on both sides of the body, as confirmed by ultrasound. Therefore, we compared the transmission coefficients for the two outer antennas of the belt, placed close to the midaxillary line. Visual inspection revealed that the bleeding dampened the magnitude of the signal, as was expected due to the high electrical conductivity of blood. An ANOVA test confirmed that the reductions of the magnitude, derived by calculating and comparing the area under the curves, for both the 500 mL and 1000 mL levels were statistically significant for both sides ($p < 0.05$). This shows that microwave technology has potential for detecting and monitoring hemoperitoneum. However, the baseline signals for the different pigs varied substantially, likely due to anatomical differences, which complicates detection. This warrants further studies to explore how the changes in magnitude due to hemoperitoneum can be effectively identified despite baseline variations.

Contribution ID: 157
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Indirect cardiac output and stroke volume assessment during spiroergometric examination

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Cardiac output can be accurately estimated from VO2 during exercise in normal subjects and in patients with heart failure by measuring the LAT (lactate acidosis threshold) or VO2peak (peak oxygen consumption) during bicycle ergometer test (Stringer et at. 1997). Hence, during step-vice increased workload on bicycle ergometer with continuous measurement of oxygen consumption changes in cardiac output and stroke volume can be calculated (Stork et al. 2011). Our measurement documented usefulness of this method in subjects of different performance level, both men and women. Non-invasive evaluation of cardiac output and stroke volume during

spiroergometric stress test enables to extent the information about the health status of the subject and about the functional reserve of his circulatory apparatus.
The examples presented in this study prove the applicability of this method in evaluation of fitness level in healthy male and female subjects of different age. The data of cardiac output and stroke volume will be added into the software program of final protocol of complex sports medical examination. This method can enrich the scale of parameters testifying the functional capacity of the subjects.

Contribution ID: 178
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Wave kurtosis: a novel, specific parameter of TUG-turn quantification

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The Timed Up and Go test (TUG) is widely used in both research and clinical settings. The most common parameter for quantification of functional decline is duration of performed TUG. A part of the TUG is the turn that analysis could provide valuable information about functional decline. Notwithstanding, there is only a few studies deals with the TUG turn processing. This study proposes a novelty parameter wave kurtosis (WK) that provides quantitative metrics for describing and comparing the turn patterns. The WK is designed to evaluate shape of the signal waveform. The WK quantifies peak of the signal, its position and tails. First, responses of WK to different waveforms were shown on artificially generated signals. Then, the biological signals of the turn, namely angular rate, were analysed. Intra-class correlations (ICC) of WK and the strength of a linear association between WK and established turn parameters (turn duration, peak angular rate, and mean angular rate) were calculated. The reliability of WK was in vertical axis poor (ICC=0.26), while reliabilities in frontal axis and sagittal axis were moderate (ICC=0.65, resp. ICC=0.66). The WK about frontal axis is not correlated with turn duration (r=0.18), but is moderately correlated with mean value (r=0.56) and peak value (r=0.69). Further, the WK about sagital-axis is moderately negatively correlated with turn duration (r=-0.56) and moderately positively correlated with turn mean value (r=0.65). There is no correlation between wave kurtosis about sagital axis and peak value (r=0.16). Utilization of waveform parameters opens new area of TUG turn analysis and may allow more sensitive determination of movement disorders or fall risk assessment. Therefore, future studies of turn movement may benefit from the use of the wave kurtosis.

Contribution ID: 242
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Multiscale analysis of microvascular blood flow and oxygenation

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The study of microvascuar perfusion has received much interest and been investigated in a range of pathophysiological states over the previous decade [1]. Recent studies [2], have shown that in many disease states, such as metabolic disease and aging, there appears to be a reduction in adaptive capabilities of the microvascular network and a consequent loss of physiological information content.
Previously [3], we have investigated the time-dependent behaviour of blood flux and oxygenation using time series analysis, power spectral density, and complexity. We found differences in the spectral composition of the signals that were influenced by adaptations to local skin temperature variation such that differences in complexity were observable in different haemodynamic steady states.
In this study, we estimate the regularity and the complexity of the blood flow signals in multiple scales with entropy and complexity measures respectively to assess change in microvascular adaptivity to an imposed stressor (local thermal hyperaemia). The results show that the changes in nonlinear properties of the blood flow signals may be related to the change of the vasodilation caused by local heating. The multiscale methods show good discrimination between the two haemodynamic steady states suggesting that these measures may be valuable in clinical assessment for the discrimination between different pathophysiological groups.

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Contribution ID: 292
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Data-diven quantification of core-limb coordination for patients with knee osteoarthritis

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Quantification assessment of Knee Osteoarthritis (KOA) is crucial for tracking osteoarthritis progression and evaluating outcomes after conservative or surgical treatment. Despite many bio-mechanics-based methods for assessing KOA has been proposed in clinical practice, there are still many limitations .Human gait is a non-linear complex process which contains irregular fluctuations and coupling effects in subsystems. Recently, studies have realized core strength and limb coordination play essential roles in gait and balance control .In this study, we attempt to explore the differences of core-limb coordination among different stages of KOA.
To quantify the coupling extent between core and limbs, we developed an analysis approach termed local manifold structure mapping in phase space, and extracted a novel index Core-Limb Coupling Coefficient (CLCC) from gait pattern inspired by G.Sugihara et al [1]. Furthermore, to verify the feasibly of CLCC, more than 1000 volunteers over 50 years of age with different stages of KOA were recruited, and they were categorized into four different groups according to gold standard Kellgren and Lawrence (KL) ranking score.

With the progression of KOA, CLCC declined along with the rise of KL score between different groups. ANOVA results demonstrated that there existed significant differences in CLCC among those participating groups: controls and KL=1 ($p < 0.001$), KL=1 and KL=2 ($p < 0.01$),KL=2 and KL=3 ($p < 0.05$) . The CLCC has demonstrated sufficient reproducibility (ICC = 0.82). Also, there existed strong relationship between the CLCC and the KL ranking score, with a strong Pearson Correlation coefficient(Left leg: r= 0.68,p<0.05; right leg: r= 0.72,p<0.05). The result suggests that KOA jeopardized the human kinematic chain and made it less effective in coordinating limbs.
As an effective quantitative index, the proposed CLCC could provide valuable tool for tracking osteoarthritis progression, therapeutic decision making and physical therapy evaluation.
[1]G Sugihara Science 338.6106 (2012): 496-500.

Contribution ID: 313
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

To To Implement a Simple Device for Assessing Sleep Disorder

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According to the Taiwan Society of Sleep Medicine reports, one out of every five people has the problem of sleep-disorder in Taiwan. Sleep problems are highly prevalent not only elder and also the youth. Most of sleep apnea occurred in people with obesity. However, most of the people are not aware of their disease. Therefore, to develop a simple device operated at home for sleep disorder detection is needful.
The aim for this study is to implement a simple device for assessing sleep disorder which can be used at home without expensive and complicated equipment. In this study, some signals include snoring signal, oxygen saturation and heart rate variability will record. Those signals are selected to be under American Academy of Sleep Medicine Guidelines type Ⅲ or Ⅳ.
SpO2, photoplethysmography(PPG) and pulse rate were monitored by a pulse oximeter (Nellcor Oximax N-600x). First, the oximetry with a record pulse signal through infrared light and interaction with red light, displayed a non-normalized waveform in real-time signals. Next, SpO2 display showed the hemoglobin oxygen saturation level and continuous recording. Then, pulse rate can be obtained and monitored. AT2020 USB microphone with the features of low-self noise and USB port, is easy to set up and record high quality sound with low power apply are used to acquire the snoring sound.
SpO2 and pulse rate can be recorded directly. Heart rate variability(HRV) is derived from PP interval times series of photoplethysmography(PPG). The spectral analysis method interpolates the PP intervals at a certain rate and transforms these intervals into the frequency domain. Snoring sound with a sample rate 22050 S/s was set and frame by frame signal processing.

Contribution ID: 323
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Using the mode decomposition methods to distinguish vibroarthrographic signals of Knee Joints

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The study aimed to differentiate the osteoarthritis (OA) from the normal knee joints by analyzing the vibroarthrographic signals with both the empirical mode decomposition (EMD) and the ensemble empirical mode decomposition (EEMD). In the study, , one hundred and twenty patients were recruited and divided into Control group (N=26) with healthy knee joints, and osteoarthritis (OA) group (N=94) with degenerative knee joints. All patients were asked to carry out the walking movements. We recorded simultaneously ten-second vibration signals from the medial condyle, mid-patella and lateral condyle of knee joints during the regular walking motion. With the EMD, the intrinsic mode function (IMFs) 8~10 of the vibration signals from the mid-patella, and IMF 8 from the medial condyle were found to have significantly less energy ratios in the OA group than the Control group (all $p<0.05$). Also, with the EEMD adding noise of 100 times, the Control group had significantly greater energy ratios in the IMFs 1 and 13~15 of the vibration signals from the lateral condyle, IMFs 1, 8~12 and 14 from the mid-patella, and IMFs 1, 9, 10 and 13 from the medial condyle, as compared with the OA group (all $p<0.05$). These findings suggest that both EMD and EEMD approaches are promising for distinguishing a degenerative from a normal knee joint. (Supported by MOST 106-2632-E-214-002, Taiwan)

Contribution ID: 324

9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Modeling of the microvascular pulse for tracking the vasoconstriction response to deep inspiratory gasp

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The objective of this work was to demonstrate the suitability of a microvascular pulse modeling method for the evaluation of the physiological vasoconstrictory response to the deep inspiratory gasp (DIG) manoeuvre.
Since the effect is mediated by the sympathetic nervous system, this technique may find application in the assessment of neurovascular deterioration. Synchronous ECG, respiratory, and laser Doppler flowmetry (LDF) signals, acquired from 13 healthy subjects (age: 26±3 years), were analyzed. Reconstruction of the LDF heartbeat waves was performed with a pulse decomposition algorithm based on a multi-Gaussian model. The method's ability to track the transient vasoconstriction following DIG was assessed by comparing goodness-of-fit parameters.
At baseline, the modeling algorithm exhibited a median normalized root-mean-square error of 0.919 (interquartile range (IQR): 0.867 - 0.942), which did not significantly decrease during DIG (0.903, IQR: 0.810 - 0.936, p=0.249). Consistently, no significant difference (p=0.552) emerged between the mean R-squared of the separate waveform models obtained for the DIG (0.973, IQR: 0.953 - 0.980) and baseline phases (0.973, IQR: 0.958 - 0.978). Moreover, during DIG the proposed algorithm achieved a nearly optimal rate of correctly reconstructed pulse waveforms (100%, IQR: 100% - 100%), compared to a median performance at baseline of 98.5% (IQR: 97.3% - 99.4%, p=0.286). To further assess the method's accuracy, the heart rate obtained from the microvascular pulse model was validated with respect to the reference provided by the ECG, and compared against the estimates returned by wavelet transform analysis of the LDF signal. A relative, significant (p=0.001), 46.8% median reduction of the root-mean-square error was thus observed. This superior performance did not appear to decline during DIG (p=0.861).
Collectively, these results indicate that the developed LDF pulse decomposition algorithm has the capability of automatically detecting and evaluating the physiological vasoconstriction induced on the peripheral perfusion by the DIG manoeuvre.

Contribution ID: 386

9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

A complexity analysis strategy to distinguish the essential tremor from early-stage tremor-dominant Parkinson's disease

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Purpose：
Differential diagnosis of tremor disorders, including essential tremor (ET) and Parkinson's disease-tremor dominant type, requires further investigation. Traditional assessments based on tremor characteristics often cause the misdiagnosis of essential tremor (ET) and early-stage tremor-dominant Parkinson's disease (TDPD). Here we introduce the standard aiming target (SAT) test and multiscale entropy (MSE) to record and analyze the patterns of tremor, respectively. We hypothesized that the physiologic complexity of the tremor would be altered by the diseases, which would be able to distinguish the ET from TDPD.
Materials and Methods:
Eight ET patients, fifteen TDPD patients and fourteen healthy participants completed six trials of one-minute SAT. In each trial, participants used a laser gun to aim the target when standing and the time series of the light spot fluctuation were recorded by a camera. The frequency spectrum of the time series were calculated. The complexity was quantified using multiscale entropy.
Results:
The tremor of patients showed higher frequency when compared to the tremor of healthy people ($p<<0.001$) while there was no significance in tremor frequency between ET and TDPD groups($p>0.05$). A significance of physiologic complexity in tremor was observed ($P<<0.01$) and the complexity of healthy participant is greater than the people with disease, within which the complexity is lower in ET patients when compared to TDPD.
Conclusion：
The SAT enables to record the micro fluctuating patterns of tremor. The physiologic complexity of tremor in people with ET and TDPD at early stage is altered by diseases and such complexity might be used as a potential marker to distinguish the ET from TDPD.

Contribution ID: 599
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Pain Correlation Comparison of Extracted Parameters based on Pain-induced Photoplethysmograpic Waveform Change Analysis and Surgical Pleth Index

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The purpose of This research is to compare whether the parameter extracted by the Photoplethysmograpic(PPG) waveform changes is more significant than Surgical Pleth Index (SPI; GE Healthcare, IL, USA). We extracted a PPG value and SPI values for 25 patients performing endotracheal intubation and each values were measured for 6 minutes before and after intubation. Before the analysis, the missed detection and error bits were removed through the PPG peak extraction and Integrity verification process. After these process, the parameter extraction process

was performed. First, parameters were selected based on the physiological implications associated with blood vessels at pain. The single parameters of correlation between each peak, AC variation, pulse area, pulse width, AC amplitude were implemented. To extract better parameters, we further normalized the single parameters in combination. Most of the combined parameters were lower coefficient value than single parameters and it is also lower than SPI. As a results, the parameters proposed in this research showed more pain correlation and accuracy. In this study, we show that the proposed parameters are more suitable for use in pain quantification than SPI and less individual variation.

Contribution ID: 611
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Steady and dynamic assessment of heart rate variability during head-up tilt based on short term measures

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This study is purposed to investigate the changes of short term heart rate variability (HRV) measures responding to slow head-up tilt (HUT) and their ability to follow up the heart rate dynamics during the process of HUT. The data of eight healthy subjects was selected from database Physiologic Response to Changes in Posture (PRCP) published on PhysioNet, providing documentary ECG during slow tilt stimulation (75°HUT over 50 s). Beat-by-beat time series of RRI were extracted from the ECG. Then, short term measuress, such as a geometric measure for HRV (rrHRV), RMSSD, SD1/SD2, were applied to analyze RRI behaviors under steady and dynamic situations. Comparison of steady state was made before and after HUT (S1 and S2). For evaluating the ability in tracking heart rate dynamics caused by HUT, Spearman correlation coefficient (Spearman CC) was used between RRI series and each of the above three measures with the moving window of 10, 30, 60 successive RRIs. The results showed that there existed significant differences between S1 and S2 (S1 vs S2: 4.64(5.40) vs 2.26(1.05) for rrHRV, 31(50) vs 14(13) for RMSSD (ms), 0.500(0.215) vs 0.229(0.073) for SD1/SD2). While for Spearman CC, though there was tendency of decrease with the reduction of the number of successive RRIs, no significant differences were found among them (60 and 10 successive RRIs, Spearman CCs are 0.744±0.070 and 0.695±0.077 for rrHRV, 0.753±0.087 and 0.732±0.073 for RMSSD, 0.666±0.083 and 0.587±0.119 for SD1/SD2) . The selected short term measures are effective from dynamic and steady perspectives. Shorter duration of successive RRIs, such as 10 successive heart beats, is ready for tracking dynamic changes of heart rate, in which the performance of rrHRV and RMSSD is better than that of SD1/SD2.

Contribution ID: 613
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Quantitative EEG in Mild Cognitive Impairment and Alzheimer’s Disease by AR-Spectral and Multi-scale Entropy Analysis

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Precise diagnosis and effective treatment for mild cognitive impairment(MCI) and Alzheimer's disease(AD) is very important, Electroencephalograph(EEG) has been widely used in clinical

research of patients with AD at the MCI stage. To study the linear and nonlinear abnormality of EEG in patients with AD and MCI, multiple characteristics was applied to distinguish AD and MCI patients from the normal controls.
In this paper, EEG signals was recorded from 28 subjects, including 10 AD patient, 8 MCI subjects and 10 healthy elderly people. EEG signals in all channels was computed by auto-regressive(AR) model and multi scale entropy(MSE) to obtain relative PSD value of each frequency band and entropy value in different scale. Receiver operating characteristic (ROC) curve was used to compare the classification ability of the two method in distinguishing the MCI and AD patient from normal controls(NC).
As results the ratio Alpha/theta in left occipito-parietal area can distinguish AD from NC subjects with the area under curve(AUC) of ROC 0.86, and Alpha/theta in left frontal area can distinguish MCI from NC subjects with AUC of 0.76.Moreover, the long scale entropy value in left frontal-central area manifests a better accuracy in distinguish AD and MCI from NC group. In addition, the combined feature from alpha/theta and long scale entropy can discriminate AD from NC group, with higher AUC reaching 0.89, and MCI from NC group with AUC of 0.79.
This indicated that combining PSD and MSE can improve the recognition accuracy of AD and MCI from normal subjects, and rapid EEG examination can be taken as a potential measure to detect AD in early stage.

Contribution ID: 692
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Multi-Gaussian decomposition of the microvascular pulse detects alterations in type 1 diabetes

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Among patients with diabetes mellitus, microangiopathy represents a relevant cause of morbidity and mortality. It is known that diabetes-related hyperglycaemia, oxidative stress, and the consequent build-up of advanced glycation end-products determine a range of structural and functional alterations which affect microvascular pericytes, endothelial, and smooth muscle cells. This pathophysiological process is accompanied by the thickening of the basement membrane, the development of a disordered and inefficient vascularization, and the impairment of the normal NO-dependent vasodilatory pathways, and is in turn reflected by an abnormal vascular stiffness.
Therefore, the aim of this study was to assess the possibility to detect the effect of these structural modifications, through a model-based quantitative analysis of the peripheral perfusion. The microvascular pulse waveform is indeed affected by the biomechanical properties of the vasculature, thus providing valuable hemodynamic information on the circulatory system.
Microvascular perfusion was recorded on the pulp of the hallux with a laser Doppler flowmeter. The measurements were taken in resting conditions from 55 healthy subjects (age: 34±26 years) and 20 type 1 diabetic (T1D) patients without known cardiovascular complications (age: 36±18 years). All involved participants were non-smokers. A multi-Gaussian decomposition algorithm was applied in order to detect the heartbeat-related oscillations, and model their systolic and diastolic profiles. Two sets of 21203 and 4146 pulse models were thus respectively obtained for the control and T1D groups. Their characterization was based on normalized waveform descriptors and physiologically-motivated features translated from recent literature on the decomposition of the digital plethysmographic pulse, such as the stiffness and reflection indices.

The statistical analysis conducted on this dataset highlighted that all the evaluated waveform features significantly differed (p<0.001) between the compared groups. This result indicates that the proposed LDF pulse modeling method has the capability to detect the effects of T1D on the peripheral perfusion.

Contribution ID: 770
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Control of urinary bladder volume in paraplegic and elderly people based on bioimpedance and neural networks

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As is known, bio-impedance is a measurement method that can be used in medicine to know the volume of a person's urinary bladder. However, this method is not entirely reliable due to the multiple factors that influence its measurement, such as the weight of the person, body fat and even the different skin type of each individual. Therefore, this paper proposes a neural network, sufficiently capable of determining when to empty the bladder, so that this muscle is not affected by the time exceeded of urine continence, this work is aimed to people who have suffered injuries to their spine, and therefore do not have the ability of feeling when their bladder needs to be emptied. It is also aimed to those older adults who begin to have problems with their bladder control, allowing them to improve their quality of life.

Contribution ID: 821
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Multifractal analysis used to characterize the physical condition of subjects making exercise

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Multifractal analysis has recently been used to characterize physiological signals, in particular to distinguish between signals from healthy people and people with heart failure. We used the formalism proposed by Chhabra and Jensen to estimate the multifractal spectrum of RR heart interbeat time series obtained from ECG signals with an ambulatory Holter. The subjects are healthy young subjects, which were monitored both at rest and at exercising on a commercial treadmill at various speeds. From these series we obtained subseries when the subjects were at rest and when they were walking at different speeds. We found that at rest usually healthy young people have wide spectrum, but are also asymmetric (right skewed) and the curvature around the maximum of the spectrum is small, i.e. the spectra are not sharp around the maximum of the spectrum. Workout on the treadmill causes that spectra become narrow, nearly symmetrical or left skewed and the curvature of the spectrum around the maximum takes values much higher. When the speed is increased the trend is maintained, it means that spectra are much narrow, still more left skewed and with larger curvature values. However, young people who have good physical condition, shows that the spectra when they area walking remain wide, charged to the right and with small values of curvature, it is required to make tests at great speeds to obtain width, symmetry and curvature values similar to those observed in people that don't do much exercise. It is proposed that the measurement of these parameters of the multifractal spectrum can be used to

monitor the evolution of people who undergo exercise routines to improve its physical condition or to monitor the rehabilitation of patients who had a heart problem.

Contribution ID: 896
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Selection of entropy-measure parameters for force plate-based human balance evaluation

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Balance in humans is affected by age-related disabilities and certain illnesses, compromising their health and quality of life. The most common measurement to characterise human balance is the centre of pressure (COP) displacement. COP is typically measured with a force plate, which produces 2D time-series representing its displacement in the anteroposterior and mediolateral directions.
Entropy measures have been used to investigate the complexity of COP time-series and the differences between normal and pathological conditions. Nevertheless, entropy measures are computed using multiple input parameters, the selection of which has been scarcely investigated within this context.
This study aimed to investigate the behaviour of COP displacement entropy measures using different parameters values, in order to inform their selection. Specifically, we investigated Approximate Entropy (ApEn) and Sample Entropy (SampEn), which are very sensitive to their input parameters: m (embedding dimension), r (tolerance) and N (length of data). A public dataset containing COP time-series for 163 subjects was used. As a case study, subjects were categorised in three groups: young adults (age<60), older adults (age≥60) with and without recent history of falls. ApEn and SampEn were computed for m = 2 to 4 and r = 0.1 to 0.5 with a fixed time-series length (N=3000). ApEn and SampEn values were compared between groups both visually and statistically.
Our results confirm that both ApEn and SampEn are sensitive to input parameter selection and that this selection is essential to observe differences between groups. More specifically, our results suggest that differences between groups are more obvious for lower values of m (e.g. m = 2), particularly for SampEn. As for r, our analysis suggests that the choice of the optimal value is highly dependent on the problem under investigation; therefore, more fine-tuning is required in specific contexts.

Contribution ID: 1014
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Evaluation of Laser Doppler Flowmeter in Capturing Skin Microvascular Blood Flow from high Melanin Skin

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Monitoring skin microvascular blood flow (BF) dynamics using laser Doppler Flowmetry (LDF) and time-frequency analysis methods provides information on the origin and development of diseases [1]. LDF requires propagation of light through skin to reach moving red blood cells in the microvasculature. High melanin concentrations are considered to reduce the backscattered light

detectable by optical systems [2,3]. However, the use of near-infrared wavelengths was demonstrated to improve melanin penetration [4]. Hence, an evaluation of LDF accuracy for the assessment of BF dynamics in skin with high melanin concentration is required, if it is to be used worldwide for the assessment of the pathophysiology of diseases.
To evaluate the effects of melanin, skin BF was measured non-invasively using LDF on the left and right ankles simultaneously with the ECG for 30 min. Subjects (18-27yrs) with both high (n=13) and low (n=10) skin melanin concentrations were included in the study. Time-varying oscillations were assessed using wavelet transform-based methods. No significant differences were observed between groups in the mean blood perfusion (p>0.1), or wavelet power (WP, p>0.6) at any of the recorded sites. The instantaneous heart rates (IHR), extracted from the LDF at both of the recording sites and from the ECG, did not differ significantly between the groups (p>0.8). No differences between the groups were obtained in the WP of the IHR (P>0.2).
These results indicate that high melanin concentration in the skin does not significantly influence the microvascular BF dynamics extracted from LDF signals. The methodology could be applied to the investigation of microvascular pathophysiology and the diagnosis of diseases such as malaria among dark-skinned Africans.
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Contribution ID: 1219
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Application of Empirical Mode Decomposition to Analyse Hemodynamic Response to Static Handgrip

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Empirical mode decomposition (EMD) of biological signals is used to detect reaction to physiological stimuli and identification of global trends in slowly changing variables. We applied EMD to analyse hemodynamic reaction to handgrip in 9 healthy males (aged 21.3±0.3 years) who squeezed the dynamometer at 30% of individually determined maximal force. Each subject was obliged to exercise during 3 minutes. Hemodynamic data were collected using battery powered, ambulatory impedance cardiography device (ReoMonitor) with built-in single ECG channel. Heart rate (HR), length of R-R interval (RR), stroke volume (SV), cardiac output (CO), left ventricular ejection time (ET), pre-ejection period (PEP), the maximum amplitude of the signal dz / dt (Amp), the basic impedance of chest (Z0) were calculated automatically using the dedicated software developed and verified earlier for ReoMonitor. We also developed new computer program (working in MATLAB environment) which allows (among other features) to import hemodynamic parameters for subsequent time periods, and plot the changes of these parameters in time. Also, it enables to calculate and display the dynamics of basic and derivative parameters, describing the impact of systolic time intervals into the length of RR intervals parameters, or relation between them (e.g. ET/RR, PEP/RR, PEP/ET, (ET+PEP)/RR). EMD procedure was applied to identify the components of each basic hemodynamic parameter and all their derivatives. We observed the most pronounced effect of handgrip in second and third intrinsic mode functions (IMF), which were

especially manifested in parameters describing the ratio of systolic time intervals to the length of RR.

Contribution ID: 1240
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Combined phase and magnitude metric for validation of lower limb multibody dynamics muscle action with sEMG

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People walk for lower velocities and run for higher velocities. Under injury or pathology, people adopt modified gait (MG), namely stiff knee gait (SKG) and slow running (SR) as alternative to normal gait (NG).
Despite redundancy of human muscular system, subjects tend to adopt stereotyped lower limb muscle recruitment during gait and running, with an open issue on lower limb muscle action (MA) on modified gait and running, namely SKG and SR in relation to NG.
Developments on multibody dynamics (MBD) have contributed for MA estimation during NG and MG from distribution of joint forces along with personalized musculoskeletal models using inverse methods and external data from kinematics and dynamics.
MBD estimated MA require some validation based on direct measurements of muscle activity. Due to noninvasive nature sEMG is being used for muscle activity detection that can be compared with MBD MA estimation.
Nonetheless, MBD MA estimation and sEMG present different natures with possible magnitude (M) and phase (P) differences requiring appropriate metrics for comparison.
The purpose of this study is to present and apply M and P metrics for comparing MBD MA and corresponding lower limbs sEMG for assessment of MA during SKG and SR in relation to NG for a specific subject.
Subject-specific tests were performed for acquisition of ground reaction forces and kinematic data from joint reflective markers during NG, SKG and SR. Inverse kinematics and dynamics was performed using AnyGait-v.092 with AnyBody musculoskeletal personalized model.
Results from quantitative metrics present better agreement between MDB MA and sEMG on P than on M with combined metric following the same pattern as M. Soleus medialis presented lower P and M error on NG and SKG than at SR with similar P errors for tibialis anterior and higher error on M for TA at NG and SKG than SR.

Contribution ID: 1378
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Ensemble empirical mode decomposition based method for fetal phonocardiogram enhancement

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Nowadays, fetal monitoring standard relies mainly on the analysis of fetal heart rate. However, signals like fetal electrocadiogram (fECG) and fetal phonocardiogram (fPCG) can offer complementary diagnostic information derived from the waveform analysis. The limitations of using, in particular, fPCG are: the signal to noise ratio (SNR) is very low because the recorded signal is a mixture of acoustic components originating not only from the fetus heart but also from the mother (maternal heart sounds (MHS), maternal organ sounds (MOS)) and other sources (power line interference, reverbaration noise, sensor and background noise). Moreover, it is dependent on gestational age, fetal and maternal positions, the data acquisition location.
From the noise components the MHS presents a high correlation in the frequency domain with the fetal heart sounds (FHS). Thus, separation of MHS from acoustic recordings is not straightforward. In addition, the MHS is a narrowband non-stationary signal. Thus, in this paper is proposed a method for fPCG enhancement from the recorded acoustic mixture based on the Esemeble Empirical Mode Decomposition (EEMD). This approach allows to analyze heart sounds into Intrinsic Mode Functions (IMFs) and it is adaptive and data driven.
The performance of the proposed method is evaluated on a database with simulated fPCG signals with different SNRs and is compared with the one obtained by methods based on Wavelet Transform.

Contribution ID: 1444
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Optimum Features Computation Using Genetic Algorithm for Wet/Dry Cough Classification

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The nature of cough has been considered as one of important symptoms in diagnosis. In children, wet cough can be related with lower respiratory track infection. In the absent of trained physician, especially in rural areas, an automated mehod is required to define the types of this cough. Several features extraction methods have been proposed for classifying wet/dry cough of the population with different performances. Using all the features have consequences in computational load. In this work, we recorded cough sound from thirty children younger than forty eight months diagnosed with lower respitatory tract infections. We extracted features from their cough sounds such as mel frequency cepstral coefficients, energy, non-Gausianity index, zero crossing and bispectral index. We proposed the use of genetic algorithm to obtain the optimum features and artificial neural networks to classify wet/dry cough. The results show that our proposed method was able to reduce around thirty percent of the features while keeping the accuracy of 98%, sensitivity and specificity of 93%.

Contribution ID: 1840
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

Oxygen saturation measurement in nasal septum by PPG technique in healthy subjects

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Oxygen saturation measurement in nasal septum by PPG technique in healthy subjects
Matti Huotari
A simple photoplethysmographic (PPG) technique for estimating oxygen saturation in the human nasal septum we studied under the various effects of age and gender. PPG are used in our physiological monitoring, especially for estimation of arterial blood oxygen saturation, and heart rate. The standard site for measurement of PPG and pulse oxymetric (PO) signal is the forefinger. Such a probe is general and works well in a normal case, but nasal septum is possible. The nasal septum was explored as a monitoring site as early as in 1937 /1/ when it was effectively researched.
However, the PPG amplitude changes as a function of temperature that is complicated. The changes in fast PPG amplitude components are caused by the vasoconstriction upon low temperature exposure.
Pulse oximeters and photoplethysmographic devices fundamentally rely upon adequate perfusion of the vascular bed through that it is being monitored.
Anatomically, the nasal septum is a very interesting site. It is the tissue between the left and right sides of the human nose. It contains a rich supply of arteries. The nasal septum probe has been shown to be superior the finger probe in detecting a pulse during hypothermia. However, monitoring at the nasal septum was more reliable than monitoring at the finger in hypothermic patients. The second derivative of the PPG at each site can also both be applied.
It will be often searched multiple fingers, toes, and nasal septum for a site that can provide a accurate saturation value. Additional errors include pigmented skin, nail polish, thermal injuries to fingers and/or toes, and inaccessibility of the extremities.
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Contribution ID: 1939
9. Biosignals Processing
09.02. Nonlinear dynamic analysis of biomedical signals

KEYNOTE LECTURE: Non-invasive assessment of cardioversion drugs through signal processing

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Different types of analysis of the surface electrocardiogram have been proposed for evaluating the effects of antiarrhythmic drugs, such as: heart rate variability, QT-dispersion, ST-segment or QRS-Morphology. A decade or so ago, new research began to appear on atrial antiarrhythmic drug effects, thanks to novel techniques for quantifying parameters related to atrial activity that commonly go overlapped by ventricular activity. Such techniques include analysis in terms of atrial fibrillatory rate and its variability, spectral characterization of fibrillatory waves during AF, P-wave signal averaged ECG during sinus rhythm among others.
This presentation analyzes how these techniques are being applied to a new field of study such as cardioversion drugs, providing knowledge on how they can act non-invasively and analyzing the evolution of atrial dominant frequency together with other parameters in the spectrum (spectral concentration, second peak ratio, harmonics, etc.), observing the different behaviors associated with their effectiveness. In order to validate the information obtained non-invasively, the analysis shows a comparison between the parameters obtained through the ECG analysis and those obtained through a duo-decapolar catheter during an electrophysiology study, in which both recordings are obtained simultaneously. Much of the information can be obtained through advanced analysis of the ECG signal, although asynchrony and heterogeneity continue to be

difficult to obtain. Ultimately, these advances can contribute to overcoming today's challenging clinical questions in AF management.

Contribution ID: 58
9. Biosignals Processing
09.03. Time-frequency analysis

Study on the dynamic vasodilatation of endothelia in peripheral capillaries during the local heating period

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The purpose of this study was to investigate the dynamic endothelial vasodilatation in capillaries on the foot sole during the heating condition. The laser Doppler flowmetry (LDF) was applied to continuously measure the microcirculatory perfusion during a 10-mintue baseline and a 30-minute local heating protocol in 21 healthy participants. The head of the LDF probe was heated from the room temperature of 27℃ to 44℃ and maintained such temperature 44 ℃ through the whole heating period. With the wavelet transform, the spectral power density of 0.0095~0.021 Hz related to the endothelial nitric oxide-dependent activity was found to be significantly greater than that of 0.005~0.0095Hz related to the endothelial nitric oxide-independent activity in the LDF oscillation signals during the entire heating period in the 21 subjects ($p<0.05$). Also, peak values (720±368, 427±223) of the two spectral power densities corresponding to the endothelial nitric oxide-dependent and nitric oxide -independent activities occurred at the second minutes after the heating, respectively. Thus, the vascular endothelium plays an essential role in dynamic regulation of microvascular dilatation during the 30-minute local heating condition, and displays its predominance in the initial heating period. (Supported by MOST 105-2221-E-214 -012 -MY3, Taiwan)

Contribution ID: 210
9. Biosignals Processing
09.03. Time-frequency analysis

Towards non-linear continuous blood pressure estimation: a novel frequency demodulation approach

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The state-of-the-art blood pressure measurement is beside common cuff-based methods the cuff-less estimation of pulse-transit-time, which is the time a blood pressure wave requires to travel from left ventricle of the heart to another peripheral point in the cardiovascular system. Within this work we present a novel method for cuff-less blood pressure measurement by analyzing a single photoplethysmographic signal in the frequency domain and using a frequency demodulation method. The dilatation of the artery and therefore the blood pressure dependent non-linear compliance and non-linear resistance of the artery causes nonlinear signal deformations as the puls wave passes the artery. The signal components of the photoplethysmographic signal with higher amplitudes pass the arterial segment faster than those with smaller amplitudes which results in a harmonic phase-shift. Further the amplitudes are damped according to their height and dilatation of the artery. As a result the phase-shift and amplitude ratio within each period is dependent on the blood pressure.

Both frequency domain based analysis methods, the phase-shift and the amplitude ratio between the fundamental frequency and the first harmonic are analyzed in a beat-to-beat manner using a dataset from PhysioNet database containing 838 periods. The correlation value of the harmonic phase-shifts with the diastolic blood pressure and those for the harmonic amplitude ratio with systolic blood pressure were r=0.9197 and r=0.8851 respectively. To overcome the quasi-continuous phase and amplitude method, the non-linear distortions of the non-linear elastic arterial segment is used by demodulation of the higher harmonics in the signal. In contrast to other approaches, the method leads to a continuous pressure signal with correlation value to the invasive blood pressure of r=0.7578. The novel continuous method thus overcomes several shortcomings of other beat-to-beat methods and is expected to improve current methods considerable.

Contribution ID: 219
9. Biosignals Processing
09.03. Time-frequency analysis

Spectral Analysis of Signal Averaging Electrocardiography in Atrial and Ventricular Tachycardia Arrhythmias

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Targeting complex fractionated atrial electrocardiograms detected by automated algorithms during ablation of persistent atrial fibrillation has produced conflicting outcomes in previous electrophysiological studies and catheter ablation of atrial fibrillation and ventricular tachycardia. The aim of the investigation was to evaluate atrial and ventricular high frequency fractionated electrical signals with signal averaging technique.
Methods: Signal averaging electrocardigraphy allow high resolution ECG technique to eliminate interference noise signals in the recorded ECG. The al-gorithm use automatic ECG trigger function for signal averaged transthoracic, transesophageal and intra-cardiac ECG signals with novel LabVIEW software.
Results: The analysis in the time domain evaluated fractionated atrial signals at the end of the signal averaged P-wave and fractionated ventricular signals at the end of the QRS complex. We evaluated atrial flutter in the time domain with two-to-one atrioventricular conduction, 212.0 ± 4.1ms atrial cycle length, 426.0 ± 8.2ms ventricular cycle length, 58.2 ± 1,8ms P wave duration, 119.6 ± 6.4ms PQ duration, 103.0 ± 2.4ms QRS duration and 296.4 ± 6.8ms QT duration. The analysis in the frequency domain evaluated high frequency fractionated atrial signals during the P-wave and high frequency fractionated ventricular signals during QRS complex.
Conclusions: Spectral analysis of signal averaging electrocardiography with novel LabVIEW software can utilized to evaluate atrial and ventricular conduction delays in patients with atrial fibrillation and ventricular tachycardia. Complex fractionated atrial and ventricular electrocardiograms may be useful parameters to evaluate electrical cardiac bradycardia and tachycardia signals in atrial fibrillation and ventricular tachycardia ablation.

Contribution ID: 256
9. Biosignals Processing
09.03. Time-frequency analysis

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Efficient ultrasonic data collection and analysis for breast cancer detection
Background: High-frequency ultrasound (20-80 MHz) has proven feasibility in differentiating between malignant and benign tissue samples. Traditionally, manually performed waveform data collection, analysis, and storage has proven to be a slow and error-prone process. A software system for improving the speed and accuracy of cancer data collection, analysis, and storage is presented.
Experiments: The main objective of the presented work was to improve the outcome of surgical procedures for soft tissue cancers by developing automated software for pathology analysis inside the operating room. Our software system is responsible for acquiring data from the user, saving and analyzing the data, and providing real-time feedback of the sample's malignancy status. Our software includes an interface for the ultrasonic technology that communicates with an oscilloscope and ultrasonic pulse generator/receiver to acquire breast tissue waveform data. Pioneering data analysis techniques to determine the breast tissue malignancy status and type have been implemented. Results generated by our system have been tested using phantoms and breast tissue specimens collected during surgery at the Huntsman Cancer Institute.
Results: Our software system delivers high-accuracy data collection and analysis results when compared to traditional pathology results. In addition to collection and analysis, our software system automatically saves waveform data quickly and accurately, which has proven to be much faster than the traditional, manual procedure. The developed software allows surgeons to perform tissue analysis on many positions on the tissue margins, and provides them with instantaneous feedback of the malignancy status. The software interface is user-friendly and does not require any knowledge in programming. The system is a prototype for a commercial product that could be used for in vivo tissue examination to assist surgeons for cancer detection in soft tissue organs such as the breast and skin.

Contribution ID: 344
9. Biosignals Processing
09.03. Time-frequency analysis

A time-frequency approach for the assessment of dynamic muscle co-contractions

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Co-contraction is defined as the activity of agonist and antagonist muscles around a joint, enhancing stability and balance. The quantitative assessment of muscle co-contractions would be meaningful for deepening the comprehension of this physiological mechanism. Thus, the purpose of this work is to quantify muscle co-contraction using energy localization in time-frequency domain of sEMG signal during straight walking. To this purpose, sEMG from tibialis anterior (TA) and gastrocnemius lateralis (GL) and basographic signals were acquired in five healthy subjects during walking. The present research was undertaken in compliance with the ethical principles of Helsinki Declaration and approved by institutional expert committee. Basographic signals were analyzed to quantify foot-floor contact. sEMG signals were processed using Wavelet Transform (WT) to identify muscular co-contractions, according to the following steps. Daubechies (order 4 with 6 levels of decomposition) was chosen as mother wavelet. A denoising algorithm based on Daubechies mother wavelet was applied for removing noise from raw signals. Denoised signals were decomposed into WT coefficients with different frequency content, and then recombined to achieve the co-scalogram function, a localized statistical assessment of cross-energy density between signals. The localization of regions with maximum cross-energy density provided the assessment of co-contractions in time-frequency domain. This methodology applied to TA and GL signals was able to detect GL/TA co-contractions in early stance (13.1% - 28.7% GC) and swing (76.9% - 97.0% GC) phase, matching with literature. Moreover, WT approach was able to provide also the frequency band of information content for muscle co-contractions: 48 - 142 Hz. In conclusion, this study proposed WT cross-energy density as a reliable estimation of muscle co-contraction in time-frequency domain.

Contribution ID: 392
9. Biosignals Processing
09.03. Time-frequency analysis

Wavelet phase coherence between the microvascular pulse contour and the respiratory activity

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Oscillations in the microvascular blood flow originate from both central mechanisms (cardiac and respiratory activities) and local physiological processes (myogenic response to intravascular pressure changes, metabolic and neurogenic control mechanisms), which have been associated with six specific frequency ranges. In this work a Wavelet Phase Coherence (WPC) analysis was conducted in order to study the time-phase relationship between morphological features of the peripheral pulse and the breathing activity. It is in fact established that the microvascular pulse contour relates to the biomechanical properties of the vascular tree, and carries valuable hemodynamic information on the state of the circulatory system.
The analysis involved a group of 21 healthy young subjects, aged from 20 to 30 years. Skin perfusion was recorded on the pulp of the right index finger by laser Doppler flowmetry, while respiration was simultaneously monitored with a wearable chest band. A multi-Gaussian modeling algorithm was used to decompose the pulse waveform, with the aim of separately reconstructing and characterizing the forward travelling systolic wave and the diastolic, reflection components arising from vascular impedance mismatch. The WPC between breathing and model-derived parameters of the pulse contour was estimated, so as to determine whether their characteristic individual oscillations were somehow mutually related. The reliability of the obtained WPC values was assessed with the method of Amplitude-Adjusted Fourier Transform surrogates.
In 17 subjects, a significant degree of phase coherence was thus identified for the total area beneath the diastolic part of the cardiac pulse, in the respiratory frequency band [0.145 - 0.6 Hz]. The corresponding median WPC found in this interval was 0.779 (interquartile range: 0.634 - 0.825). These results indicate that the microvascular reflection waves exhibit a marked periodicity linked to the breathing activity.

Contribution ID: 569
9. Biosignals Processing
09.03. Time-frequency analysis

Investigation of the feasibility of postoperative pain assessment using frequency analysis of photoplethysmogram variability

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Quantification of pain is necessary for optimal dose of anesthetic drug. In pain quantification, there have been many attempts to analyze the photoplethysmography(PPG) waveform as an promising marker of cardiovascular dynamics.
PPG variability(PPGV) is an approach for quantifying amplitude variation of each heart beat. In this research, we derived 8 parameters of PPGV on frequency domain and investigated the feasibility of postoperative pain assessment.
Derived parameters were defined as the amplitude from baseline to systolic peak (ACA), the amplitude from diastolic peak to systolic peak (HPH), the amplitude difference of adjacent systolic peaks(ACVsys), the amplitude difference of adjacent diastolic peaks(ACVdia), the ratio of ACVsys to ACA (ACVsys/ACA), the ratio of ACVsys to HPH (ACVsys/HPH), the ratio of ACVdia to ACA (ACVdia/ACA), and the ratio of ACVdia to HPH (ACVdia/HPH). All these parameters are related to the PPG amplitude. Thus, using these parameters, we calculated representative frequency domain variables: TP, VLF, LF, HF, nLF, nHF and LF/HF. Every parameter was derived in clinical dataset obtained before and after surgery, and it was verified whether there is significant different using paired t-test. Consequently, significant difference($p<0.05$) was found in every derived variable except on the nLF of ACA, VLF, nLF of HPH, TP, nHF of ACVsys, TP, VLF, HF, nLF, nHF of ACVdia, nHF of ACVsys/ACA, nLF, nHF of ACVdia/ACA, nHF of ACVsys/HPH and nLF, nHF of ACVdia/HPH. This result suggests that the frequency domain variables of PPGV are promising in pain quantification and that the significant changes were more frequencly observed in normalized variables.

Contribution ID: 847
9. Biosignals Processing
09.03. Time-frequency analysis

Classification of children with SLI through their speech utterances

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Many young children have speech disorders. The research focused on one such disorder, known as specific language impairment (SLI) or developmental dysphasia in Czech (DD). A major problem in treating this disorder is the fact that specific language impairment is detected in children at a relatively late age. For successful speech therapy, early diagnosis is critical. This paper provides the issue of identifying SLI in children on the basis of their speech and presents two different approaches to this issue using. The First access is a new method for detecting specific language impairment based on the number of pronunciation errors in utterances. The success rate of detection of children with SLI is higher than 93%. An advantage of this method is its simplicity in the form of a simple test. This test is used in a mobile application SLIt Tool which is designed for iPad. The second method is based on the acoustic features of the speech signal. The feature set used to analyze speech data contains 1582 acoustic features and the success rate is almost 97%. An advantages of these different methods is that they could be used together to develop of the robustness automatic detection system.

Contribution ID: 865
9. Biosignals Processing
09.03. Time-frequency analysis

Development of the new audiological test - speech intelligibility in noise in the Czech language

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An effort to use a speech signal for classifying hearing disorders is older than 200 years. Up to the present approximately 100 tests have been published, which bear their title either according to the author of the test or the place of the origin of the test. In the Czech language the "Czech Speech Audiometry" was published in 1960 by Seeman, this test is used in our country up to now and it consists of single words. Evaluation of speech recognition is also possible by presenting testing material in sentence form with presence of competitive noise.

Our paper shows a preparation of such test from a technical point of view – an acoustic analysis of signals, choosing a competitive noise (speech noise, babble noise, cocktail party noise), testing of speech test on normal hearing subjects. The time characteristics of the babble noise are similar to the human voice and therefore it masks more expressively on the central level than the random stable noises (speech noise, pink noise, white noise, ...).

We evaluated the influence of the babble noise on sentence intelligibility in hearing impaired listeners with presbycusis. A group of more than 400 persons was divided into younger group (age from 40 to 65 years) and older group (age from 66 to 85 years). For these two age groups, we compared the test performance in the subgroups stratified by the speech audiometry in silence. We demonstrated a statistically significant worse understanding of sentences in the older group against the younger group listening to sentences at level 65 dB SPL in competitive noise at level 65 dB SPL (p=0.05). The development of the sentence intelligibility in noise test increased our possibilities of audiological examinations by another test, which was up to now missing in the Czech language.

Contribution ID: 1124

9. Biosignals Processing

09.03. Time-frequency analysis

The evaluation of the tremor: signal database of healthy control subjects

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A tremor – an involuntary rhythmic oscillatory movement of a part of the body – belongs to one of the most disabling features of multiple sclerosis (MS). In clinical practice, the tremor is currently classified according to clinical scales. Unfortunately, this approach is fully subjective in principle, and the objective classification is still missing.

As is shown in the literature, the tremor can be investigated by accelerometers and gyroscopes. This approach opens the possibilities for objective classification. Based on the frequency analysis and other advanced methods of signal processing the tremor signals could be classified. A condition of the successful development of these methods is an existence of a signal database of healthy subjects. This paper concerns with the collecting of the signal database of healthy control subjects, the part of a wide research which aims with the evaluation and classification of tremor on patients with MS and also with the first initial processing of the data.

The signals were acquired on the group of healthy subjects aged from 18 to 50 years (more than 20 subjects). For each patient, one-minute records of postural and intention tremor (with and without closed eyes; 4 records together) have been acquired, and also several clinical tests have been passed (pinch strength a handgrip strength (JAMAR) tests, nine-hole peg test, coin rotation task test and plate tapping test). All records have been supplemented by anamnestic data.

An initial classification of the data has been done and will also be presented in the paper, especially the study of a dependency of the accelerometry signals on the left/right dominance and also on the gender.

Contribution ID: 1224
9. Biosignals Processing
09.03. Time-frequency analysis

Usability of Volume Pulse Wave Biosignal

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As arteries lost its elasticity, the velocity of pulse wave and the amplitude of the reflected wave both increase. These cause the changes in the pulse wave form, especially in the diastolic, dicrotic part. The aim of this study is to show the usability of the pulse wave measurement on surface arteries.
The method is based on experience of pulse wave palpation. The volume changes, influencing the membrane, transfer themselves into the pressure changes and move towards the positive input of a sensitive differential pressure transducer. The differential pressure transmitter converts the pressure differences into electrical voltage. This system offers high sensitivity to volume changes of artery diameter. The output of the transducer is connected to the measuring PC. The evaluation parameters can be assessed from the time domain, derivations, velocity or frequency domain. In the time domain, a number of parameters can be measured: crest time, dicrotic wave time, total pulse duration, interwave time, systolic amplitude, dicrotic wave amplitude, waveform derivation. From these proportions, next relative parameters can be derived.
Mean variation coefficients in [%] of parameters in one pulse wave run were: crest time 11,8; systolic amplitude 8,45; relative crest time 11,38; interwave distance 12,97; relative dicrotic amplitude 23,1; relative dicrotic time 7,15; augmentation index 13,23; PWV 6,76. Mean variation coefficients in [%] of parameters in long term measurement were: crest time 9,17; systolic amplitude 10,79; relative crest time 6,91; interwave distance 3,77; relative dicrotic amplitude 11,37; relative dicrotic time 1,87; augmentation index 4,58; PWV 5,87. Some parameters show significant differences between specific groups of volunteers, some parameters are interdependent.
The results show, that volume pulse wave biosignal parameters variability can grow up to double digit values. Some of these variabilities are physiological due to respiratory, but some parameters are apparently not usable for further evaluation.

Contribution ID: 1697
9. Biosignals Processing
09.03. Time-frequency analysis

Simulation of required CPAP usage to normalize AHI in obstructive sleep apnea patients

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Obstructive sleep apnea (OSA) is a highly prevalent disease with severe health consequences. The severity of OSA is estimated with apnea-hypopnea-index (AHI). OSA is often treated with continuous positive airway pressure (CPAP). The aim of the current work was to create a simulator showing benefits of different levels of usage of CPAP treatment.
226 male OSA patients were evaluated. CPAP treatment was simulated in 5 minute intervals starting from the beginning of the night and continuing until the end. The cutoff point where AHI reached normal level of < 5 events/h were determined for mild, moderate and severe OSA categories.
We found a trend of increasing AHI towards the end of the night. The median values of the required simulated CPAP usage times to normalize the AHI values (AHI < 5 events/h) were 3.9h, 5.3h and 6.2h in the mild, moderate and severe OSA severity categories, respectively.
CPAP treatment adherence can be limited in OSA patients due to several reasons. The presented CPAP treatment simulation tool could aid the clinicians to give recommendation to the OSA patients for required CPAP treatment times and to motivate the patients to higher adherence levels of the treatment. This could possibly better prevent the harmful health consequences related to OSA.

Contribution ID: 1737
9. Biosignals Processing
09.03. Time-frequency analysis

Tissue oxygen saturation estimation of human webbing using six-band LEDs

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Near-infrared spectroscopy is a non-invasive method of monitoring tissue oxygen saturation (StO2). Many commercial NIRS devices are presently available. However, the precision of those devices is relatively poor because they are using the reflectance-model with which it is difficult to obtain the blood volume and other unchanged components of the tissue. Human webbing is a thin part of the hand and suitable to measure spectral transmittance. In the previous research, we proposed a method for measuring StO2 of human webbing from a transmissive continuous-wave near infrared spectroscopy data. We used a halogen lamp as light source and a spectrometer for detection. We developed a probe for human webbing. We also proposed a two-step algorithm for calculating the StO2. In the first step, by providing proper pressure on the arm by a cuff and measuring spectral transmittance during the application of pressure, we extract the static spectral components. In the second step, by subtracting the static components, we estimate the components of oxy- deoxyhemoglobin. Although the method was evaluated on an arterial occlusion test (AOT) and a venous occlusion test (VOT), the device had the problems of the weight, the simplicity, and the cost.
In this paper, we present a new device for measuring StO2 of human webbing to solve the above-mentioned problems. This device consists of six light emitting diodes (LED) and a photodiode and a controller. Six wavelength bands were optimally selected using spectral transmittance data collected with the previous device. The LEDs are alternately turned on and off based on a pulse width modulation (PWM). We evaluated the new device through an AOT and a VOT. As a result, the measured signals changed during pressurization and the release like the previous device and reasonable relative change of StO2 was observed by the proposed method.

Contribution ID: 241
9. Biosignals Processing

09.04. Connectivity and causality

Multisignal analysis for assessment of relationship between neuronal activity, vascular responses and systemic blood supply in Mayer wave frequency range

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Mayer waves (MW) were first identified as oscillations of arterial blood pressure (BP) of frequency around 0.1 Hz but they were also observed in other physiological signals. The purpose of our work was estimation of coupling between BP, heart rate variability signal (HRV), changes of concentrations of oxygenated and deoxygenated hemoglobin HbO/HbR and evolution of amplitudes of EEG rhythms related to appearance of MW with the aim of better understanding of neurovascular coupling and generation mechanisms of MW.
For 10 healthy subjects (mean age 28 years) near infrared spectroscopy signals (NIRS), EEG, ECG and BP were recorded during 4 minutes of spontaneous activity. Resulting signals: diastolic and systolic BP (diaBP/sysBP), HRV, HbO, HbR and alpha (8-13Hz) and beta (13-25Hz) amplitudes evolutions sampled at 2 Hz were simultaneously fitted to the Multivariate Autoregressive Model and then Directed Transfer Functions (DTF)s were calculated. DTF is a multivariate directional measure of coupling based on Granger causality principle. Contrary to bivariate measures (e.g.: coherence) DTF allows to detect causal reciprocal connections. DTFs were integrated in the 0.07-0.13Hz frequency range and based on the found integrals full scheme of coupling between considered signals was constructed.
Results reported in literature correspond well with ours in respect of directionality of interactions, however they concerned only fragmentary relations between signals, moreover the methods applied in them were unable to identify reciprocal connections.
We found strong influences of diaBP and sysBP on all the other variables. The prominent feature of interactions were strong reciprocal couplings between sysBP and diaBP and between sysBP/diaBP and HRV. This kind of interactions are likely to generate oscillations. Our results do not support the theory of the central pacemaker of MW, but they suggest the existence of local cardiovascular control system connected with baroreflex loop.
Acknowledgment.
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Contribution ID: 364
9. Biosignals Processing
09.04. Connectivity and causality

EEG functional connectivity detects seasonal changes

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Seasonal alterations in human health, mood, and basal cortisol level have been reported in several studies. Despite the interest in these factors, seasonal changes in brain functional connectivity as a possible base of these phenomena have not been studied before. The aim of the current study is to analyse seasonal effects using two resting electroencephalogram (EEG) functional connectivity measures: magnitude-squared coherence (MSC) and imaginary coherence (iCOH). Recordings from 78 healthy estonians were used: 25 recordings from spring, 8 from summer, 10 from autumn and 37 from winter months. Eyes-closed resting EEG was recorded from 30 channels using Neuroscan Synamps2 acquisition system and five frequency bands were analysed: delta (1-4 Hz), theta (4-8 Hz), alpha (8-12 Hz), beta (12-30 Hz) and gamma (30-45 Hz). Results of the study

revealed increased beta MSC in spring and winter months compared to summer and autumn months, increased beta iCOH in spring, autumn and winter months compared to summer months and increased gamma MSC in spring and summer months compared to autumn months. The increase in beta MSC and iCOH in spring and winter months compared to summer months may be the result of increased stress or deficiency in Vitamin D. Current study is the first to bring out seasonal changes in brain functional connectivity, but the shortcoming of the study is the limited number of recordings in summer and autumn months. Therefore, further studies are required for more reliable results.

Contribution ID: 395
9. Biosignals Processing
09.04. Connectivity and causality

Analysis of electroencephalographic dynamic functional connectivity in Alzheimer’s disease

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The aim of this study was to characterize the dynamic functional connectivity of resting-state electroencephalographic (EEG) activity in Alzheimer's disease (AD). The magnitude squared coherence (MSCOH) of 62 patients with dementia due to AD and 36 cognitively healthy controls was computed. MSCOH was estimated in epochs of 60 seconds subdivided in overlapping windows of different lengths (1, 2, 3, 5 and 10 seconds; 50% overlap). The effect of epoch length was tested on MSCOH and it was found that MSCOH stabilized at a window length of 3 seconds. We tested whether the MSCOH fluctuations observed reflected actual changes in functional connectivity by means of surrogate data testing, with the standard deviation of MSCOH chosen as the test statistic. The results showed that the variability of the measure could be due to dynamic functional connectivity. Furthermore, a significant reduction in the dynamic MSCOH connectivity of AD patients compared to controls was found in the delta (0-4 Hz) and beta-1 (13-30 Hz) bands. This indicates that AD patients show lesser variation in neural connectivity during resting state. Finally, a correlation between relative power and standard deviation was found for MSCOH, suggesting that an increase/peak in power spectrum could be a pre-requisite for dynamic functional connectivity in a specific frequency band.

Contribution ID: 515
9. Biosignals Processing
09.04. Connectivity and causality

Scalp level connectivity for representative channels in emotional status

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Emotion can be regarded as a special brain status and it can be captured by Electroencephalography (EEG) via deploying significant number of channels all over the scalp. To

find out its characteristics, the scalp level connectivity is one of the interests that widely considered so far. However, to distinguish the most significant channels, which indicate the special regions, has not yet been studied properly. Therefore, in this work, we aimed to identify the most representative channels towards different emotional status based on coherence and correlation among different channels. The most representative channels have been determined by studying the connectivity which relies on the corresponding coherence and correlation values. In this purpose, the DEAP, an online EEG emotional database has been considered. Certainly, the emotional status can be evaluated on the valence-arousal space. The results and analysis show that the AF4, P4. Fz and CP6 have higher percentages of connectivity than others for different emotional status. Thus, such findings could be useful to understand the scalp level responses during elicitation of emotion.

Contribution ID: 1465
9. Biosignals Processing
09.04. Connectivity and causality

Stimulus-response patterns in ADHD

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Background: The paper describes the application of the traditional Event-Related Potential (ERP) methods in comparison with quantitative dense-array EEG recording analysis called the Brain Activation Sequences (BAS) to find state-based differences between Attention Deficit Hyperactivity Disorder (ADHD) patients and healthy controls. Patients were examined twice, first time as drug-naive and then as medicated.
Methods: A group of 13 outpatients from the Psychiatric hospital and seven healthy controls participated in two experiments based on auditory stimuli presentation (based on mismatch negativity schema) while reading a pictorial magazine. The EEG recordings were processed as ERP and concurrently passed through the source localization technique followed by the method called the BAS. Recordings were made using 128-channel EEG machine with hydrocel-based nets.
Results: Event-related technique revealed results opposite to common findings when patients' averaged potentials in left frontal and central regions exhibit higher values than healthy controls, but the method was applied to drug-naive patients and controls only. The Brain Activation Patterns technique identified brain regions involved in stimuli processing that differ significantly between both study groups. Differences exist in standard and target stimuli. Both participating groups utilize left orbital and right lingual gyrus, while right cuneus and inferior occipital gyrus are typical for controls but right temporalis transversus is activated exclusively in patients. Moreover, target stimuli processing in patients utilize Extra-nuclear (TALg) and temporalis transversus gyri.
Conclusion: Significant differences between patients and controls exist in processing auditory stimuli based on standard and target tones. Most active gyri in controls seem to indicate attention divided equally to reading and stimuli, in patients attention mechanisms seems to wonder as expected.

Contribution ID: 1473
9. Biosignals Processing
09.04. Connectivity and causality

Analysis of cortical sensorimotor networks formed during different motor task categories in spinal cord injury

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Spinal Cord Injury (SCI) is a devastating condition that affects the whole Central Nervous System due to disconnection of afferent and efferent neural pathways. Brain reorganization occurs at structural and functional levels, including connectivity. Electroencephalography (EEG) has been used to study brain network dynamics following SCI, mainly in complete lesions. We recorded high-resolution EEG from 10 subjects with incomplete SCI and 10 healthy controls during 32 different classes of upper limbs visual motor imagery (VMI). We estimated Current Cortical Density distributions and we defined 24 nodes over the sensorimotor cortex at the source space. We used Directed Transfer Function to compute weighted directed adjacency matrices (networks) at full density for alpha and beta rhythm. We compared characteristic path length (CPL) and mean clustering coefficient (CC) properties for alpha and beta networks formed during left, right, proximal, distal, rotational, linear and total upper limb imagery classes between SCI and healthy groups. We also studied properties within groups comparing left to right, proximal to distal and rotational to linear classes, as well as alpha to beta networks. While CPL and CC were mostly stable across all networks between and within groups, the main effect of rhythm showed a statistically significant difference in mean CC. Beta networks showed greater clustering in most VMI categories. Furthermore, we calculated and visualized in-strength (IS) and out-strength (OS) of each node for each VMI category. Cingulate motor areas (CMAs) bilaterally had consistently much higher OS than any other node in every category, while a consistent third OS peak (albeit much smaller) was also recognized at right dorsal premotor area. CMAs also had the least IS in every network, while other nodes received almost equal inputs. Graph analysis is a promising tool to investigate functional sensorimotor brain networks following SCI during multiple motor imagery tasks.

Contribution ID: 1523
9. Biosignals Processing
09.04. Connectivity and causality

Functional neuroimaging evaluation of dance interventions for senior citizens at risk of dementia

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Recent neuroscientific advances provide a plethora of contemporary tools for robustly analyzing functional, brain interactions in order to identify pathological deviations due to neurodegeneration. Current research hypothesizes that inducing neuroplasticity of the mature human brain would prevent dementia onset. Among the proposed solutions, dancing programs seem to be promising since they combine cognitive and physical training in a pleasant manner. The latter improves adherence to the intervention. Aiming to promote active and healthy ageing we investigated whether traditional Greek dances may and improve cognitive, physical and functional status of elderly. So, we recruited 44 participants who were randomly assigned either to the training group or to an active control group. The training duration was 6 months. All the participants were scanned through a resting-state (eyes-closed condition) electroencephalographic (EEG) examination. The

EEG testing was performed 1-14 days before (pre) and after (post) the training. Cortical network analysis was applied by modelling the cortex through a generic anatomical model of 20000 fixed dipoles. These were grouped into 512 cortical Regions of Interest (ROIs). High quality, artifact-free data resulting from an elaborate pre-processing pipeline were segmented into multiple, 30 seconds of continuous epochs. Then, functional connectivity among ROIs was performed for each epoch. Synchronization matrices were computed and then thresholded in order to provide binary, directed cortical networks of various density ranges. The analysis results demonstrated that the dance training improved optimal network performance as estimated by the small-world property. This was mainly due to better information flow and re-organization of network connectedness on local level. These results imply the applicability of dance training as a potential, non-pharmacological intervention for delaying dementia onset. Ongoing research activities would further investigate the training's efficacy in comparison with a combination of a neuroplasticity-based cognitive and physical training system (LLM Care).

Contribution ID: 1759
9. Biosignals Processing
09.04. Connectivity and causality

Inadequate cardiac support at peak exercise in patients with a left ventricular assist device

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Left ventricular assist devices (LVAD) implanted increase perfusion, restore hemodynamics at rest and improve submaximal physical capacity as well as quality of life of end-stage heart failure patients. Aim of this work was to compare patients' LVAD response recorded with enhanced monitoring during different types of physical exercises.
Estimated LVAD pump flow and it's derived parameters characterizing the assisted cardiac system (such as heart rate, aortic valve opening, contractility, etc.) were continuously recorded from patients (n=16) during maximal bicycle ergometer stress-tests (MBEST) (n=24), sub-maximal 6-minute walk tests (n=16) and medical training sessions (bicycle ergometry (n=100), walking (n=137), strength training (n=71) and mobilization training (n=134)). A hemodynamic lumped parameter model was used to reproduce the different individual responses in LVAD parameters during MBESTs and explain the underlying hemodynamic mechanisms.
At a constant LVAD impeller speed, exercise responses during MBESTs showed an LVAD flow increase of 0.9±0.5 L/min and increase in heartrate of 20.4±15.4 bpm at a peak workload of 0.61±0.34 W/kg. Mobilization training was the only medical training resulting in a significantly reduced ($p<0.05$) pump flow response compared to MBEST. Heartrate and aortic valve opening were significantly reduced ($p<0.05$) during all trainings compared to MBEST. A stepwise regression analysis showed that the response in LVAD pump flow provided insufficient evidence to estimate patients' exercise capacity. The hemodynamic model was able to reproduce and explain 3 depicted pump flow responses from the MBESTs ranging from +0.17 to +1.86 L/min.
In summary, with current constant-speed pump management, the flow increase during MBESTs in LVAD-patients is inadequate. The combination of continuous pump monitoring and the hemodynamic model provides improved understanding of the LVAD-hemodynamic interaction to develop individual automatic control strategies and improve cardiac support during exercise.

Contribution ID: 34
9. Biosignals Processing
09.05. Signal pattern classification

Canonical Correlational Empirical Data Analysis of Intramuscular EMG Writer`s Cramp Signals Multidimensional Scaling—A study With Indigenously Built Automated Intelligent-ARTEMG-system

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In this study, we have investigated 23 hand muscles of dystonia Writer`s cramp (WC) diseased conditions (subjects who are patients affected with dystonia-WC-neurological-syndrome which comes under other movement-disorders) using innocuous intramuscular micro-wire-electrodes(100µ) embedded into five muscles of right-hand(RH) and signals/wave-forms data gathered parallelly—simultaneously from five-muscles using indigenously built developed advanced real-time multi-channel ARTEMG automated-system while writing with right-hand(RH), and left-hand(LH) for mirror-movements and to see mirror-objects of RH. A canonical correlation-analysis between right-hand writing-signal (RHWS) and left-hand writing-signals (LHWS) for each subject was carried out; giving squared-canonical-correlations. Correlations, for each subject between the signals when inscribing firstly with RH (in which innocuous-intramuscular-microelectrodes 100µdiameter were implanted) and then with LH are specified (to see mirror-movements and/or mirror-objects). Though correlations are mostly-negligible, albeit, some correlations are quite significant and distinctly-high. These are presented as a Table of significant correlations, i.e., correlations which are greater than >0.50 in absolute value. It is found that often, same muscle-pairs will have significant-correlation with same-sign, in both ‘hand-signals’ (i.e.,RHWSandLHWS). Muscle-pairs (ECR1,FCR3), (ECR1,5th-muscle) and (ECU2,FCR3) have only positive +Ve significant correlation, in both hands, if at all correlated. Similarly, muscle-pairs (ECR1,FCR4), (ECU2,FCU4), (ECU2,5th-muscle), (FCR3,FCU4), (FCR3,5th-muscle) and (FCU4,5th-muscle) if at all have significant correlation do not show any distinguishable-patterns among the Concordant© and Discordant(D) groups-of-subjects (WC-patients). Our study showed significant quantifiable EMG differences in the signals seen while writing with the right and left hands between those WC subjects with concordant mirror movements (C group) versus those with discordant mirror movements (D group). This study was conducted at Nizam’s Institute of Medical Sciences (NIMS) a tertiary care centre in south India with a dedicated movement disorders and biomedical engineering team. Ethical clearance was approved from the institute and medical council of India (MCI) and Indian council for medical research (ICMR). Study period was from August 2010 to 2012.

Contribution ID: 49
9. Biosignals Processing
09.05. Signal pattern classification

A Clinico-statistical Analysis of Intramuscular EMG Writer`s Cramp Signals Multidimensional Scaling—Study With Indigenously Built Advanced Automated Intelligent-ARTEMG-System

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We investigated 23hand muscles-of-dystonia Writer`s cramp(WC) diseased-conditions (subjects affected by dystonia-WC-neurological-syndrome other movement-disorders due to DYT1-gene mutations in the brain) using innocuous-intramuscular micro-wire-electrodes(100μ) embedded into five-muscles of right-hand(RH) and signals—waveforms data gathered parallelly from five-muscles using indigenously built advanced real-time multi-channelARTEMGautomated-system while writing with right-hand(RH), and left-hand(LH for mirror-movements and to see mirror-objects of RH). A canonical correlation-analysis between right-hand-writing-signal (RHWS) and left-hand writing-signals (LHWS) for each subject was carried out; giving squared-canonical-correlations. Correlations, for each subject between the signals when inscribing firstly-with-RH (in which innocuous-intramuscular-microelectrodes 100μ-in-diameter were implanted) and then with LH are specified (to see mirror-movements and/or mirror-objects). Though correlations mostly negligible, albeit, some correlations are quite-significant and distinctly-high. These are presented as a Table of significant-correlations, i.e., correlations which are greater-than >0.50 in absolute-value. It is found that often, the same muscle-pairs will have significant-correlation with same-sign, in both 'hand-signals' (i.e., RHWS,LHWS). Muscle-pairs (ECR1,FCR3),(ECR1,5th-muscle) and (ECU2,FCR3) have only positive(+Ve) significant-correlation, in both hands, if at all correlated. Similarly, muscle-pairs (ECR1,FCR4),(ECU2,FCU4),(ECU2,5th-muscle), (FCR3,FCU4),(FCR3,5th-muscle) and (FCU4,5th-muscle) if at all have significant correlation do not show any distinguishable-patterns among the Concordant© and Discordant (D) groups-of-subjects(WC-patients). Our study showed significant-quantifiable-EMG-differences in the signals seen while writing with the right and left-hands between those WC`s subjects with concordant-mirror-movements(C-group) versus those with discordant-mirror-movements(D-group). The canonical-variates defined for 2 sets-of-variates observed on the same "individuals" are pairs of linear-combinations of the two-sets, which are maximally correlated with each other, but uncorrelated with other such sets. In the present case one can construct a combination of RH-and-LH signals, which have a maximum-possible-correlation. If the correlation is high-enough, it would mean that two-signal-sets are somehow interrelated–possibly the same causal-mechanism being responsible for the signal-patterns in the right and left-hand-signals. Otherwise, the two sets of signals appear to be independent of each other on the whole.

Contribution ID: 262
9. Biosignals Processing
09.05. Signal pattern classification

Automated neurons recognition and sorting for diamond based microelectrode arrays recording: feasibility study

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Introduction: Microelectrode arrays (MEA) are extensively used for recording and stimulating neural activity in vitro and in vivo. Deposition of nanostructured boron doped diamond (BDD) to the neuroelectrodes enables obtaining of dual mode low-noise neuroelectrical and neurochemical information simultaneously. The signal processing procedure requires to find and to distinguish

individual neurons spikes in recordings. The spikes identification is usually done manually that is inaccurate and not appropriate for complex datasets. Therefore, we define methodology and algorithms for neurons recognition and evaluation based on the unsupervised learning.
Methods: Forty-five extracellular randomly selected signals from 26 unique measurements of embryonal hippocampal rat neurons (20kHz, 6 min) were recorded on the commercial 60 TiN channels MEA. Signals were filtered in the 300-3000 Hz band and the amplitude detector (4x std of the background noise) was used for spikes detection. The WaveClus features were computed and its 2 PCA components were extracted for every spike. The optimal number of clusters were evaluated by an expert rater. K-means + gap criterion (alg. 1) and the Gaussian Mixture Model + Bayes Information Criterion (alg. 2) were implemented and compared.
Results: As the real number of neurons in the vicinity of the each microelectrode is not known during data analysis, we can only consider the similarity among the scores. The total IntraClass Correlation showed a significant inter-rater agreement for all 3 rater procedures (ICC=0.69, $p<0.001$), when post-hoc weighted Cohen's Kappas for 2 raters were 0.85 (expert vs. alg. 1; $p<0.001$) and 0.62 (expert vs. alg. 2; $p<0.001$).
Conclusion: A substantial agreement of algorithms and expertise in detecting the number of neurons has been achieved. This will contribute to the objective definition of the dual mode BDD MEA performance criteria and for comparison with the current system.
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Contribution ID: 284
9. Biosignals Processing
09.05. Signal pattern classification

Automatic sleep stage scoring with single-channel EEG via CNN-CRF

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Introduction
Sleep staging is a crucial component of the diagnostic evaluation for sleep disorders,such as sleep apnea, parasomnias, and hypersomnia. Polysomnography (PSG) is conventionally performed by trained technologists in clinical practice, while the cost and discomfort of PSG limit the potential for long term sleep studies.Additionally,many previous sleep stage classification methods used hand-crafted signal features to train a classifier and the contextual information was often ignored.In this study,we proposed a novel method that automatic sleep stage scoring with single-channel EEG via deep convolutional neural network and conditional random fields (CNN-CRF).
Methods
To verify the feasibility of CNN-CRF, the widely-used publicly Physionet Sleep-EDF Database was used.In particular, a subset of data that include healthy subjects (20 subjects, aged 25-34),a total of 39 single-lead ECG signals from electrodes Fpz-Cz.The sleep stages are scored as wake (W), REM (R), light sleep, and deep sleep according to the standardized rule of American Academy of Sleep Medicine (AASM). The method adapts a convolutional neural network (CNN) to extract stage-specific features from single-channel EEG, and couples it with conditional random fields (CRF) to capture the contextual information of sleep stages.
Results
Testing is performed by the leave-one-out method.CNN-CRF achieved superior performance with an average accuracy of 85.7% and epoch-by-epoch Cohen’s kappa of 0.767, comparable to expert-expert.
Conclusion

Our method is truly end-to-end,which avoids hand-crafted features.Further,our method only needs a single-channel EEG,which could provide valuable tool for sleep management,such as tracking the progression of sleep disorders and physical therapy evaluation.

Contribution ID: 379
9. Biosignals Processing
09.05. Signal pattern classification

Pulse rate variability analysis to enhance oximetry as at-home alternative for sleep apnea diagnosing

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This study focuses on the at-home Sleep Apnea-Hypopnea Syndrome (SAHS) severity estimation. Three percent oxygen desaturation index (ODI3) from nocturnal oximetry has been commonly evaluated as simplified alternative to polysomnography (PSG), the standard in-hospital diagnostic test. However, ODI3 has shown limited ability to detect SAHS as it only sums up information from desaturation events. Other physiological signs of SAHS can be found in respiratory and cardiac signals, providing additional helpful data to establish SAHS and its severity. Pulse rate variability time series (PRV), also derived from nocturnal oximetry, is considered a surrogate for heart rate variability, which provides both cardiac and respiratory information. In this study, 200 oximetric recordings acquired at patients' home were involved, divided into training (50%) and test (50%) groups. ODI3 and PRV were obtained from them, the latter being characterized by the extraction of statistical features in time domain, as well as the spectral entropy from the commonly used very low (0-0.04 Hz.), low (0.04-0.15 Hz.), and high (0.15-0.40 Hz.) frequency bands. The ODI3 and PRV features were joined in a multi-layer perceptron artificial neural network (MLP), trained to estimate the apnea-hypopnea index (AHI), which is the PSG-derived parameter used to diagnose SAHS. Our results showed that single ODI3 rightly assigned 52.0% of the subjects from the test group into one out the four SAHS severity degrees, reaching 0.470 Cohen's kappa, and 0.840 intra-class correlation coefficient (ICC) with the actual AHI (accuracies of 90.0%, 88.0%, and 82.0% in the increasing AHI cutoffs used to define SAHS severity). By contrast, our MLP model rightly assigned 75.0% of the subjects into their corresponding SAHS severity level, reaching 0.614 kappa and 0.904 ICC (accuracies of 93.0%, 88.0%, and 90.0%). These results suggest that SAHS diagnosis could be accurately conducted at-patients' home by combining ODI3 and PRV from nocturnal oximetry.

Contribution ID: 450
9. Biosignals Processing
09.05. Signal pattern classification

Classification of cardiovascular pathologies in artificial signals of a lumped parameter model using a naive Bayes algorithm

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Pathological bulges of the blood vessels, especially aneurysms in the abdominal (abdominal aortic aneurysm, AAA) or thoracic aorta (thoracic aortic aneurysm, TAA) are a highly underestimated problem. According to Criqui et. al. these diseases affect 12 – 14 % of the population. However the asymptomatic course of the diseases in most patients and the misinterpretation of the initial

symptoms in about one third of the symptomatic patients lead to a categorical underdiagnosed clinically situation. A supplementary non-invasive method, which is independent of the examiners experience, would be highly desirable for early diagnosis at the family physician level. The aim of this study is the development and validation of a methodology to classify the above mentioned vascular pathologies using non-invasive cardiovascular pressure and flow measurements.
For this purpose, we studied the classification performance of a naive Bayes classifier, based on pressure and flow signal intervals and amplitudes. These features were extracted from 3.000 artificial pressure-flow signals generated by the numerical cardiovascular modelling tool SISCA, that describes the blood flow in the cardiovascular network based on Westerhofs theory in a zero dimensional lumped parameter approach. Besides the control group of normal patients, the variational scenario is based on two pathological conditions of the AAA and TAA with different extension and location. The nominal cross sectional areas were enlarged between 200 % and 600 %, while the length of the aneurisms were modified within a range of 30 and 90 mm. The model parameters were varied randomly within their uncertainty ranges using the Monte-Carlo method. Finally the pressure and flow waveforms were collected at sensitive locations in left leg/ arm.
The classification performance was evaluated using sensitivity, specificity, classification accuracy, mean squared error (MSE) and receiver-operating characteristics (ROC). Depending on disease severity, the procedure achieved a global testing classification accuracy of over 80%.

Contribution ID: 490
9. Biosignals Processing
09.05. Signal pattern classification

Visual image search of spatial frequencies using convolutional neural network

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Improving the design of displays requires clarifying the subconscious role that visual image searches controlled by spatial frequencies play. In our previous study, we applied support vector machines (SVMs) to scan path data to discriminate the ability of subjects to subconsciously search for targets, finding that the conclusions drawn depended on the features derived from the data. In this study, we introduce a convolutional neural network (CNN) technique that lacks a priori features in an attempt to improve the accuracy of subconscious discrimination. A target stimulus was embedded in a 6 × 5 region of a background image, while changing the spatial frequency parameter β in the target stimuli. The scan path during eye movement in response to a target stimulus was measured in addition to the detection time and accuracy rate based on the subject's oral answer for the position of the target stimuli. Eight healthy men with normal vision participated in the experiment. All participants provided written, informed consent, and the study design was approved by the ethics committee of Tohoku Gakuin University. The CNN employed in this study was composed of convolution and fully connected layers. The scan path raw data were used as training data, with β = 0.7–1.0 denoting that subjects were able to subjectively search, and β = 0.0–0.3, indicating otherwise. Values of β = 0.4–0.6 corresponding to the threshold of subjective visual search were used as test data. Using the CNN, the presence of the search was indicated for each β from 0.4 to 0.6 for each subject, which was occasionally inconsistent with the subjective discrimination. From these results, we suggest that the use of CNNs may be capable of indicating subconscious visual search. This study was supported in part by the research grant from JSPS KAKENHI Grant Number JP17K00385.

Contribution ID: 512
9. Biosignals Processing
09.05. Signal pattern classification

Discrimination between day and night ECG recordings based on the morphology of P and T waves

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The morphology of P and T waves hides valuable information. Measurements on the morphology like the width and the height of the wave or the area under the curve are influenced by various factors, thus revealing diagnostic, prognostic or other kind of information. Considering a larger number of such measurements allows the problem to be examined in a higher dimensional space, employing machine learning based classifiers. The aim of this paper is to show that the discrimination between day and night periods is possible even when information extracted exclusively from P or T waves is used. Thirty four features are employed and examined for this purpose, extracted from ECG recordings during diametrically opposed periods: 1.00 to 3.00 in the night and 13.00 to 15.00 in the afternoon. The waves were detected both in a manual and automatic way to ensure stability and coherence of results, as well as independence from the possible limitations of the detection method. Totally, 2700 P and 2700 T waves were selected manually, using an auxiliary visual inspection tool implemented to assist fast and accurate selection With the automatic detection method we selected approximately 100,000 P and 100,000 T waves. The correlation coefficient was used to give us an indication of the most important features and also serve as a feature selection criterion. Four classifiers (K-Nearest Neighbor, Decision Tree, Naive-Bayes and Support Vector Machines) were employed in our experiments. Experimental results showed that the discrimination between day and night periods is feasible even when we are based exclusively on the morphology of P or of T waves. The accuracy achieved using machine learning based methods is remarkable, ranging from 82% to 95%. The percentage 95% was achieved for SVM and kNN classifiers and manual detection, when automatic detection presented accuracy 93% with kNN.

Contribution ID: 666
9. Biosignals Processing
09.05. Signal pattern classification

An alternative method for SAHS patients classification based on oximetry and respiratory effort signals

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The “Gold Standard” for Sleep Apnea/Hypopnea Syndrome (SAHS) diagnosis is based on the Polysomnography (PSG) study in a sleep laboratory. It consist of connect to patient´s body several sensors, mainly oronasal airflow (OA) and pulse oximeter (SpO2) sensors while Respiratory Inductance Plethysmography sensor (RIP) is alternative. The OA signal can be estimated from RIP signal (RIPFlow). The signals sent by such sensors are analyzed to get the Apnea/Hypopnea Index (AHI) and to classify the patients into three groups: Normal (N), Moderate (M) and Severe (S).
In this study, an alternative method for scoring apnea/hypopnea events based on thorax and abdomen RIP sensor and for analyzing the %SpO2 values variations using Median Absolute Deviation (MAD) is proposed. Also, the automatic algorithms from standard and proposed methods were implemented to estimate AHI. In order to test the proposed method’s performance, PSG recordings acquired in 23 patients (21M, 4F, 50 ± 18 yrs.) from St. Vincent's University Hospital /

University College Dublin Sleep Apnea Database were analyzed. The Sensitivity (Se) and Specificity (Sp) values were calculated considering patients classification (N, M and S) and considering the standard method and well as the one proposed.
The results obtained for each group (N, M y S) in proposed method are: Se (75%, 92.86% and 100%), Sp (94.74%, 88.89% and 88.89%) respectively while the standard method, the values are Se (25%, 78.6% and 100%) and Sp (84,2%, 66.7% and 66.7%), respectively.
We conclude that the proposed method show an improvement in patient classification using RIPFlow and SpO2-MAD. Besides, it has a low computational cost and it can be implemented in portable devices.

Contribution ID: 671
9. Biosignals Processing
09.05. Signal pattern classification

Optimization of algorithms for real-time ECG beats classification

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Beats classification is an essential step in the ECG signal analysis for cardiac arrhythmias detection. There are multiple alternatives to solve this problem, but these are considerably reduced when real-time restrictions are added to the analysis. The goal of this work is to expose an optimal solution based mainly on the use of voltage values of the signal in the time domain and compare it with other based on Daubechies' Wavelets analisys. Several measures are used in both feature spaces to determine the similarity of every beat to a patient's specific patterns and, after that, a method similar to clustering's algorithms is used to assign a class to each. To evaluate the performance of the proposed algorithms, ECG signal records extracted from the MIT-BIH database are used. With the method used in the analysis, we obtained 92.68 % of sensitivity and 92.65 % on premature ventricular contractions predictivity, which allow us to conclude that it is very feasible for their application in real time systems, due to their low computational cost.

Contribution ID: 779
9. Biosignals Processing
09.05. Signal pattern classification

Artificial Neural Network applied like qualifier of symptoms in patients with Parkinson's disease by evaluating the movement of upper-limbs activities

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The Movement Disorder Society (MDS-UPDRS) defines characteristics to qualify various symptoms of PD, the present works propose to apply an Artificial Neural Network ANN to qualify symptoms based upon movement of upper-limbs activities. In this way, a system based on Arduino and Android mobile app were developed, where accelerometers are used to acquire and store the acceleration data from upper-limbs while PD patients were doing three activities: rest sitting, eating and brushing teeth, meanwhile their symptoms were classified by doctor between 0(normal) to 4 (most severe impairment). After that, store data were processed and estimation on Power Spectral Density (PSD) was done, then this information and doctor's diagnosis were used into the ANN

training to evaluate the symptoms in PD patients. For the ANN training was used back-propagation model and many ANN configurations, until get the best fit between inputs (processed data) and output (doctor's diagnosis). The results showed that trained ANN can be used like qualifier with a high degree of accuracy over the 90%, for the tests performed. Moreover, even though MSD-UPDRS allows to get an accurate diagnosis, there is not objective, so ANN could be fixed to be completely objective, being a great advantage with manual evaluation

Contribution ID: 812
9. Biosignals Processing
09.05. Signal pattern classification

Detection of sleep stages in temporal profiles in neonatal EEG: k-NN with semi-automated etalons extraction by k-means compared to k-means

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The aim of this study is to improve detection of changes in sleep stages from temporal profiles created from EEG recordings of newborns.
Our semi-automatic approach uses k-NN for classification that is trained on etalons (prototypes) that are created by a semi-automated approach consisting of k-means for etalons suggestion and an expert-in-the-loop for verification of the etalons. This approach will be analyzed together with a simple k-means cluster analyses used for classification.
The data were acquired in the Institute for the Care of Mother and Child in Prague and the study protocol and patient informed consent have been approved by the ethical committee of this institute.
The EEG recordings are of full-term and preterm neonates (20 records in total) and their length vary from 20 to 120 minutes. Each EEG recording was recorded polygraphically from eight electrodes positioned in the standard „10-20“ system. The EEG recordings were scored with labels: quiet sleep, active sleep, awake and transfer to quiet sleep, by an experienced physician Dr. K. Paul.
Each EEG recording is digitally preprocessed by the mean removal filter (no other filters are applied) and segmented adaptively. For each segment 24 features are extracted and used in different classification processes: k-means and semi-automated approach with k-NN and k-means together. The resulting temporal profile (the class membership in time) is analyzed for neonatal sleep stages using our method that creates a single detection curve from all channels and a threshold that detects the sleep stages.
The combined semi-automated method of k-NN and k-means combined is more suitable due to the fact that the resulting classes are already sorted by the level of amplitude which is better for temporal profile analysis. Each method is compared to doctors labelling.

Contribution ID: 932
9. Biosignals Processing
09.05. Signal pattern classification

Determination of lung sound as normal or abnormal, using a computerized statistical methodology

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Lung sounds are generated either by rapid fluctuations of gas pressure or by oscillations of solid tissues while abnormal lung sounds occur due to deformation or obstruction of the respiratory track. In this study the authors investigate a possibility of objectively determine a lung sound as normal or abnormal using a computerized statistical methodology. For the study, breath sounds were recorded from nonsmoking, healthy subjects and subjects with respiratory disorders whose external physical symptoms were not and other body sounds from the recorded sound to obtain only the lung sound. After amplifying a lung sound signal up to the initial recorded amplitude, signal was compared with a standard normal and standard abnormal lung sound. The comparison was done by calculating Mahalanobis Distance mean values which gives measurements for the deviation in recorded lung sounds, with the standard; normal and abnormal lung sounds. The Mahalanobis distance mean values obtained from subjects with respiratory disorders showed considerable deviations from the specific range of values obtained by subjects with normal lung sounds concluding this method is capable of distinguishing between normal and abnormal lung sounds. However the limitation of the study is the low sample size and few types of respiratory disorders of test objects. This method can be further developed to noninvasively determine the progress of patients with respiratory disorders using statistical data, as a database.

Contribution ID: 946
9. Biosignals Processing
09.05. Signal pattern classification

Conduction Velocity Mapping: A new method to analyze and visualize multichannel atrial electrograms

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Atrial fibrillation (AFib) and atrial flutter (AFlut) are the most frequent arrhythmia of the human heart. They lead to a reduced quality of life and an increased risk of stroke. A therapy option of increasing importance is RF-ablation. The right strategy for the placement of RF-ablation lesions is still not clear, but in any case, a precise characterization of the electrophysiological properties of the atria is mandatory.
Today often multichannel catheters with up to 64 channels are employed and the local activation time (LAT) is depicted. Some cardiologists also want to see a “voltage map” showing the local maximum voltage of a depolarization front or the “dominant frequency” of depolarization fronts passing by.
We are convinced that also the local conduction velocity (CV) is an important electrophysiological property. The speed of the depolarization front is significantly reduced in fibrotic areas and the depolarization can even be stopped by lines of blocking scar. Both scar and fibrotic tissue can support the formation of local or global reentry circuits.
We tested various algorithms to calculate the local CV from multichannel electrograms, evaluated their performance and created CV-maps. New high-density mapping techniques enable the fast acquisition of CV maps for the whole right or left atrium. AFib patients have to be converted to sinus rhythm beforehand.
In patients with AFib or AFlut CV maps show regions of slow and fast conduction and lines of block. Also, collisions and splitting of the depolarisation wavefront can be observed.
CV maps might be important to identify the best personalized ablation strategy.

Contribution ID: 949
9. Biosignals Processing
09.05. Signal pattern classification

Analysis of kinematic parameters relationships in normal and dysgraphic children

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Kinematic analysis of handwriting, using digital tablet together with appropriate tests and processing software, allows the evaluation of the level of graphomotor abilities acquired by a subject. Several studies focused on the kinematic parameters extracted from the writing of both normal subjects and subjects presenting specific disorders, such as dysgraphia, recorded during simple tasks. However, the relationships between these parameters have not yet been analyzed. The aim of this study was to examine and identify possible relationships between kinematic parameters like Amplitude (SA), Duration (SD) and Peak Velocity (PkVS) of Strokes extracted from handwriting and their changes between normal and dysgraphic children. Fifty normal and eighteen dysgraphic children, attending classes from 2nd to 5th grade of primary school, were involved in the study. A series of three cursive tests (sequence of “lelele” and copy of a sentence as accurately as possible and as fast as possible) was administered and analyzed by means of a suitable proprietary software written in MATLAB. Results showed a linear relation between SA and PkVS parameters with similar slope in both groups but different intercept values due to reduced peak velocities, at the same stroke amplitude, in dysgraphic children. Linear relationship was also present between SA and SD parameters in “lelele” test while in the other two tasks a less clear relation was found particularly in children with writing difficulties in which longer stroke durations, at the same amplitude, were observed. In all tasks, dysgraphic children showed reduced peak velocities of strokes with longer duration and slightly greater amplitudes than in normal subjects, as expected in case of poor fluency. The differences found in the relationships among some kinematic parameters could be useful for an early identification of children with dysgraphia. These findings did not depend on the specific task used.

Contribution ID: 950
9. Biosignals Processing
09.05. Signal pattern classification

Influence of dysgraphia on kinematic characteristics of handwriting in Italian primary school children

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Handwriting is a complex skill that improves with schooling and it is accomplished after the child has achieved and integrated underlying perceptual-motor performance components. Even though nowadays children are expected to acquire a level of handwriting proficiency even on the first day of school, at least 27% of the school population has difficulty with handwriting and needs to be screened for an intervention program. As a first step towards finding a test able to early identify handwriting difficulties, in this paper we examined the influence of dysgraphia on kinematic characteristics of children of primary school. Fifty normal and eighteen dysgraphic Italian children from 2nd to 5th grade of primary school were considered. Three cursive tasks (sequence of “lelele”

and the copy in the Accurate and Fast mode of a sentence) were proposed and several kinematic parameters (curvilinear velocity, pen lift duration, total length, length and duration of components and strokes, number of strokes and letter per second) were evaluated. Since differences were present among grades both in normal and dysgraphic children, each parameter was compared between children coming from corresponding grades by means of the Wilcoxon rank sum test. Results showed significant differences between the two groups of children within each grade for curvilinear velocity, total length and number of letters per second. Pen-lift durations were significantly different only in the Accurate and Fast tasks (involving linguistic competences) while number of strokes per second as well as stroke duration and length showed significant differences depending on the task and grade. These differences support the hypothesis of a lower fluency as well as an increased fragmentation and a different motor planning in dysgraphic subjects. In conclusion, our study found a series of kinematic parameters able to discriminate dysgraphia from normal handwriting that could be useful for starting an early rehabilitation treatment.

Contribution ID: 1002
9. Biosignals Processing
09.05. Signal pattern classification

Estimation of heart rate variability features via convolutional neural network

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Over the last decades HRV (Heart rate variability) analysis has become a popular method for the assessment of the autonomous nervous system in diverse fields of research. In particular, depressed HRV can be used as a predictor of risk after acute myocardial infarction, as an early warning sign of diabetic neuropathy, stress and risk of accidental falls. The extensive application of HRV analysis is due to the fact that it is noninvasive, easy to perform and relatively cheap. However, the conventional HRV analysis is performed on 5 minutes ECG recordings (i.e., short term) which in e-health monitoring might be unsuitable, due to real-time requirements. Recent studies investigated the correlation between short term and ultra-short term HRV features (i.e., below 5 minutes). It has been demonstrated that for certain case studies ultra-short term HRV (i.e., 1 min) is informative enough and can be used for the detection of certain clinical outcomes. However, there is still the need to assess ultra-short HRV features below 1 min to allow real time detection. Therefore, the main aim of this study is to evaluate the association between the heart beat morphology and the HRV features to further reduce the number of heart beats required for the HRV estimation, in order to allow real time monitoring. The proposed system for the heart beat analysis employs deep learning methodologies, specifically a convolutional neural network (CNN). The CNN is able to extract a hierarchy of abstract features that describe the heart beat morphology. These abstract features can be used to infer the values of the HRV features. The proposed framework will be evaluated on a dataset comprising 480 subjects, for each having around 8 hours of ECG recordings available. This analysis will be presented in this paper.

Contribution ID: 1050
9. Biosignals Processing
09.05. Signal pattern classification

Pre-diagnosis of cardiac diseases by dynamic neural networks

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In this research, an algorithm based on dynamic neural networks was designed to pre-diagnose cardiac diseases using virtual reality therapies. People who receive this type of therapy may manifest a likelihood of heart disease depending on the virtual world to which they are exposed. The neural network learns from a database of signals with cardiac conditions (fibrillations, arrhythmias) and through real-time monitoring, the patterns are searched to identify whether the test subject is healthy or suffers from heart disease. The dynamic neural network functions as an estimator of states, over the time this learns the dynamics of the cardiac suffering signal, thus assimilating its behavior. Applying the mean square error (LMS), we can compare signals and know if they are identical.
The experiment was applied to a group of 62 people of different ages, complexions, and heart conditions, from the Tecnológico de Estudios Superiores de Ixtapaluca. The test subject underwent virtual reality therapy while monitoring his heart signal with a self-designed electrocardiograph. The signal obtained from the electrocardiograph was compared with the signal obtained from the neural network, giving as a final result the prediction of heart disease.

Contribution ID: 1054
9. Biosignals Processing
09.05. Signal pattern classification

A Rapid Assessment Method on Fistula Stenosis Staging for Hemodialysis Patients

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The AV access is usually evaluated by feeling thrill and pulsation through palpation, listening for the bruit by using a stethoscope, Doppler ultrasound imaging, or angiography, etc. However, these techniques require specific equipment and operator. Phonoangiography is a noninvasive tool for identifying vascular diameter change. In this study, a mock model has been set up to simplify the simulation of blood flow condition. Phonographic signal is recorded by electronic stethoscope and further signal processed. The relationship of phonographic signals and stenotic lesions is studied. Early detection of hemodialysis access problems such as stenosis and thrombosis is very important issue. The purpose of this study is to develop a phonographic system to evaluate arteriovenous shunt(AVS) stenosis of hemodialysis patients. The degree of stenosis(DOS) is used as an index to classify the AV access condition, and is determined by the narrowing percentage of normal vessels. In this mock model, the DOS is set to be varied from 0%, 50%, 70%, 80%, 85%, 90%, 92.5% to 95%. The empirical mode decomposition(EMD) method is applied to analyze the relationship between DOS and spectrogram. Verification is based on Doppler ultrasound which is the golden standard in clinical application. From the experimental results, the proposed method is demonstrated to be feasible for charactering the staging of DOS conditions. The spectrogram from bruit signal shows that the power in high frequency is increasing when the DOS is gradually increased. There is a great correlation between the phonoangiography and the severity of DOS in AV access. This noninvasive method may be useful and potential for early detection in home-care use.

Contribution ID: 1120
9. Biosignals Processing
09.05. Signal pattern classification

PCA-QDA models selection for detecting NS1 related diseases from SERS spectra of salivary mixtures

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Non-structural protein (NS1) in saliva has recently turned out to be engaging, as it is potential to prompt a method for diseases related to NS1 at febrile stage. Furthermore, non-invasive detection of NS1 in saliva, free from risk of blood infection, will make the approach preferable to current serum based ones. Our work here intends to define an optimum model for Quadratic Discriminant Analysis Classifier (QDA) optimized with Principal Component Analysis (PCA), to distinct between positive and negative NS1 adulterated samples from salivary SERS spectra, which, to the best of our knowledge, has never been explored. The adulterated samples are acquired from our UiTM-NMRR-12-1278-12868-NS1-DENV database. The PCA extracts significant features from database after pre-processing, based on three stopping criteria which are Scree test, Cumulative Percent of Variance (CPV) and Eigenvalues-One-Criteria (EOC), which then are served as inputs to the QDA classifier. The performance is compared to our previous works, since others is unavailable. It is found that the PCA-QDA model is defined by 5, 70 and 115 principal components (PCs) from Scree, CPV and EOC criterion, with accuracy performance of 100%, 84.2%, 55.3% respectively.

Contribution ID: 1126
9. Biosignals Processing
09.05. Signal pattern classification

Classification of myopotentials of hand's motions to control applications

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Realization of the system for classification of hand's gestures is described in this master's thesis. The first goal was to create hardware that would be able to measure signal of myopotentials for computer analysis without external noise and with right amplification. The second goal was to program an algorithm which could classify specific gestures of hand. Hardware prototype of four measuring channels was created by combination of 2nd order filters and right amount amplification. The user is isolated from the power source using galvanic isolation because of usage of active electrodes. For digitizing the data, the Arduino Nano microcontroller was selected and programed using defined communication protocol. The computer software is programed in C# programming language. Signal processing and drawing to user interface is in real time. The one of five possible gestures that user made is chosen using fuzzy logic and designed system of scaling.

Contribution ID: 1270
9. Biosignals Processing
09.05. Signal pattern classification

Accuracy comparison of ML-based fall detection algorithms using two different acceleration derived feature vectors

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Falls among the elderly are an important health issue which can lead to serious consequences. Unintentional falls in elderly are the most common cause of nonfatal injuries. Different fall detection algorithms have been proposed for fall detection using vision based, ambient or inertial sensors. In this experiment, we used data collected from 16 subjects performing 15 tasks: 12 activities of daily living and 3 simulated falls. Subjects were equipped with a waist-mounted IMU to collect tri-axial accelerometer data during the activities. We derived features from accelerometer data on time-windowed identified activities and divided them into 2 different feature vectors that are used for fall detection algorithm. The selection was made based on the computational complexity of the features. We used different machine learning (ML) techniques to distinguish fall events from non-fall events (i.e. activities of daily living). In this paper, we compared and analyzed the accuracy of fall detection for different ML-based algorithms using the two acceleration-derived feature vectors for potential real-time implementation.

Contribution ID: 1363
9. Biosignals Processing
09.05. Signal pattern classification

Feature extraction and visualization of mi-eeg with l-mvu algorithm

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The feature extraction of Motor Imagery Electroencephalography (MI-EEG), as a key technique of brain computer interface system, has attracted increasing attention in recent years. Because of the high temporal resolution of MI-EEG, researchers are usually bedeviled by the curse of dimensionality. Some manifold learning approaches, such as Isometric Mapping (ISOMAP) and Local Linear Embedding (LLE) etc., have been applied to dimension reduction of MI-EEG by modeling the nonlinear intrinsic structure embedded in the original high-dimensional data. However, these methods are difficulty to exactly represent the nonlinear manifold, affecting the classification accuracy. The Maximum Variance Unfolding (MVU) can solve this problem, but it is unsuitable for online application due to the computation complexity. In this paper, a novel feature extraction approach is proposed based on the Landmark version of Maximum Variance Unfolding (L-MVU). First, the MI-EEG signals are preprocessed according to the event-related desynchronization and event-related synchronization. Then, L-MVU is used to extract the nonlinear features, and a joint optimization of parameters is performed by using the traversing method. Finally, a back-propagation neural network is selected to classify the features. Based on a public dataset, some experiments are conducted, and the experiment results show that L-MVU can preserve more information and perfectly extract the nonlinear nature of original MI-EEG, and reduce the redundant and irrelevant information by introducing the landmark points as well, yielding a higher classification accuracy and a lower computation cost. Furthermore, the proposed method has a better effect on feature visualization with an obvious clustering distribution, illustrating the great potential in processing of EEG signals.

Contribution ID: 1423
9. Biosignals Processing
09.05. Signal pattern classification

Ultraviolet–Visible spectroscopy assessment of liver condition

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Liver is a multifunctional and important organ. It is also one of the biggest organs in human body, where its malfunction may lead to severe deterioration of whole organism health or death. The liver is a target to both primary and secondary tumors. More than 700 000 people are diagnosed with liver cancer each year throughout the world, where it is also leading cause of cancer deaths, estimated as 600 000 deaths each year. In most cases, it is necessary to perform biopsy in order to find and analyze pathological changes. During biopsy, there are often necrotic tissue found. Liver necrosis may happen by both cancer occurrence and treatment. Moreover, identification of necrotic tissue clinically are not available or are expensive.
This creates opportunity for applying optical methods for necrosis detection such as Spectroscopy. Spectroscopy benefits from being well-known technique already applied in medical purposes. It is powerful tool allowing quick and reliable analysis. Relatively low-cost of single measurement and possibly small size of setup are additional benefits. Another strength are potential in vivo measurements.
USB4000 UV-VIS-ES portable spectrometer was used to investigate spectral properties of beef liver. Fiber optics table was built, it allowed for precisely choosing certain spots on each sample. Reflectance was measured using 200 μm core optical fibers, where total range of 200 – 850 [nm] was covered. Furthermore, in order to simulate necrosis in tissues, samples were boiled for fixed amount of time, ensuring cells' death. Measurement results were processed with Matlab environment in order to create classification algorithm based on spectral properties. Obtained spectra allowed for creating classifier, which automatically allocate unknown spectra as either raw or boiled liver. Sensitivity of classifier was equal to 99,7 % from 1000 independent spectra (points).

Contribution ID: 1457
9. Biosignals Processing
09.05. Signal pattern classification

Atrial fibrillation detection from wrist photoplethysmography data using artificial neural networks

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Atrial fibrillation (AF) is one of the most common types of cardiac arrhythmia leading to increased risk of heart failure and stroke. Therefore, early screening and diagnosis can reduce the AF impact. The development of photoplethysmography (PPG) technology has enabled comfortable and unobtrusive physiological monitoring of heart rate with a wrist-worn device. Therefore, it is important to examine the possibility of using PPG signal to diagnose AF in real-world situations.
There are several recent studies classifying arrhythmias with artificial neural networks (ANN) based on ECG RR intervals, but to the best of our knowledge, none from PPG wrist devices. The aim of this paper is to present an ANN classifier to detect AF episodes from PPG data. This

classifier is able to distinguish between AF and non-AF rhythms on a beat-by-beat basis. The input feature of the ANN is based on the information obtained from an inter-beat interval (IBI) sequence of 30 consecutive PPG pulses and the transition probability matrix between IBI states.
The PPG dataset was acquired with the PulseOn wearable optical heart rate monitoring device and the recordings were performed in the post-anesthesia care unit of the Tampere University Hospital. The study was approved by the local ethical committee. The guidelines of the Declaration of Helsinki were followed. In total 29 subjects participated to the study: 15 subjects had normal sinus rhythm (NSR) and 14 had AF during the recording. The average duration of each recording was 1.5 hours.
As IBI extracted from PPG signals are highly sensitive to motion noise, IBI reliability was automatically evaluated beforehand. Only beats considered reliable were used by the AF detection algorithm. The achieved sensitivity was 98.73% and the specificity 97.48%. Based on these results, the ANN algorithm demonstrated excellent performance at recognizing AF from NSR, using wrist PPG data.

Contribution ID: 1487
9. Biosignals Processing
09.05. Signal pattern classification

Segmentation methods for biomedical multimodal long-time data acquired in real-live environment

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Continuous long-time acquisition of various biological parameters such as heartrate, movement, temperature and electro-dermal activity has become strongly facilitated by the rapid evolution of wearable devices. This development has led to the uninterrupted acquisition of data sets covering whole days, weeks or even months. Since the test subjects cannot be kept under controlled conditions for these extended time periods, such data is considered to be collected under real-life conditions. In consequence, there are no means to control the factors that might negatively affect the sensor quality and reliability. Diverse existing pipelines for time series analysis, e.g. pattern mining, rely on detection of segments belonging to similar context. Therefore, time series segmentation and change point detection techniques must be considered as a crucial component of the analysis pipelines designed to investigate real-world biomedical multimodal long time data sets. Such techniques have already been applied to other issues in various scientific fields and many of them have been adjusted to or specially developed for sets of different data types. In this paper we present the tests and the adaption of existing methods to meet the requirements of the analysis of long-duration time-series of biological parameters. We investigate new approaches and assess their performance on such data and evaluate the suitability of various combinations of bio-parameters as well as different segmentation or change point detection techniques. Finally we present recommendations for an optimal segmentation of various bio-parameter combinations.

Contribution ID: 1862
9. Biosignals Processing
09.05. Signal pattern classification

THEPHY - A Thermal Imaging and Peripheral Physiology Dataset for Deception Detection

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The fight or flight response is a mechanism of the autonomous nervous system which modulates the blood flow distribution all around the body and is especially visible in the facial subcutaneous vasculatures. These modulations lead to temperature fluctuations that can be measured by thermal imagers. In this paper, we address a deception detection framework with both physiological signals and thermal videos. Since the accuracy of thermal imaging data is challenging and in some studies, it is quite low, we collect a new database. We employ simple statistical features with various pattern recognition algorithms to evaluate our dataset which was collected from 32 subjects in two different scenarios. The result of classifications shows the overall accuracies of 61.1% and 60% for thermal signals in the 'Best Friend' and 'Mock Crime' scenarios, respectively.

Contribution ID: 32
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Canonical correlational analysis of invasive EMG writer`s cramp signals multidimensional scaling for multidimensionality—a study with advanced multichannel ARTEMG system

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Clinico-statistical analysis yield significant-results in neuro-electro-physiological-medical diagnostics. In this direction, a detailed empirical data-analysis is more profitable, and may lead to a deeper-understanding of the phenomena involved in dystonia-Writer's cramp. In this study we have investigated 23 hand-muscles signals of both right and left hands gathered using innocuous-micro-electrodes(100μ-diameter) implanted(invasive) in right-hand and EMG-waveforms/signals acquired/recorded with indigenously built ARTEMG-system while writing with two hands. EMG is a complex signal. Its characteristics are affected by many factors including diseases. Such as Writer`s, Musician`s cramp.
A canonical correlation analysis between right-hand-writing-signal(RHWS) and left-hand-writing-signals(LHWS) for each subject(patient) was carried out; giving squared-canonical-correlations.
Correlations, for each subject, between the signals when inscribing firstly with right-hand(RH) (in which invasive-microelectrodes were implanted) and then with left-hand(LH, to see mirror-movements) are specified. Though correlations are mostly negligible, some correlations are quite significant and markedly—distinctly-high. These are presented below as a Table of significant correlations (i.e., correlations which are greater than >0.50 in absolute value). It is found that often, the same muscle pairs will have significant correlation with same sign, in both 'hand-signals'(i.e.,RHWS and LHWS).
Muscle pairs (1, 3), (1, 5) and (2, 3) have only positive +Ve significant correlation(Table), in both hands, if at all correlated. Similarly, pairs (1,4), (2,4), (2,5), (3,4), (3,5) and (4,5) if at all have significant correlation do not show any distinguishable patterns among the Concordant© and Discordant(D) groups of patients(subjects).

ECR(1) ECU(2) FCR(3) FCU(4) 5th-Muscle
ECR(1) + + -Ve +
ECU(2) ∗ + -Ve -Ve
FCR(3) + + -Ve -Ve
FCU(4) -Ve -Ve -Ve ∗ -Ve

5-th Muscle + -Ve -Ve -Ve ∗

Conclusion:
This study showed significant quantifiable EMG differences in the signals seen while writing with the right and left hands between those writer's cramp subjects (patients) with concordant mirror movements (C-group) versus those with discordant mirror movements (D group).

Contribution ID: 47
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Design and development of advanced multi-channel EMG micro electrode recording system

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The input impedance offered by one Op-Amp differential amplifier is far too less for high resistance sources like the human-body. Here it is essential that the body does not source any kind of current because it is required to drive the circuit. The requirement is of an amplifier-circuit that has high-end input-impedance so-as-to faithfully effectively reproduce the signal fed to it. This kind of requirement is perfectly provided by the Three-Op-Amp instrumentation amplifier. In addition to high input impedance, the amplifier configuration also has a very high common-mode rejection ratio (CMRR), which effectively removes the 50 Hz line frequency inherent in most of the signals.
Our setup consists of envisages mainly four stages: 1. Instrumentation amplifier with a driver circuit, 2. Gain-set amplifier, 3.Low-pass filter, 4. High-pass filter. The EMG signals are acquired with fine innocuous intramuscular wire 50 micron diameter and flat surface electrodes placed on the skin of the muscle under investigation. The signals picked up by the electrodes are applied to the body of the subject are passed to the amplifier circuitry through coaxial cables.
In our study, we have constructed an EMG amplifier setup for multi channel capturing of EMG signal with special reference to Writer's cramp from the subject having input impedance greater than 200 MΩ, CMRR of 65 dB and variable gain 1000-10000. Ag electrodes used. Good differential amplifiers with CMRR should have rejection ratio close to 100,000. In other words, the signals are amplified 100,000 times more than unwanted potentials appearing as a common mode voltage. The input impedances of the most amplifiers range from 100 kΩ to hundreds of MegaΩs. This study will explain the design of multi-channel EMG with a special reference to dystonia Writer`s cramp Signal-acquisition—recording and signal analysis.
Innocuous microelectrode development and EMG-WC`s is a specialty of this work.

Contribution ID: 86
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Research on Autism Spectrum Disorder of Preschool Children with Hand-related Auditory and Visual Stimulation Event-related EEG

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The mechanism and locations of the pathological changes are becoming an exceedingly common problem in preschool children of Autism Spectrum Disorder (ASD). According to the previous references and our research team's basic work, we put forward the hypothesis that the sound

stimulation from body language representing people's feelings and attitudes may fire the mirror neurons' disorder.
Electroencephalograph (EEG) was applied with hand-related auditory and visual stimulation event-related experiment for 10 c-ASD and age-matched 21 NC. All subjects were scanned with 32 electrodes to analyze u rythum power of the motor-sensory are.
Thus, by using u rhythm depression of electroencephalogram (EEG) with hand-related auditory stimulation, we found the healthy adult's sensory motor responses.
Based on these findings, to the goal of this project is to localize the brain abnormality in preschool ASD children, uncover the molecular imaging mechanism of their stereotyped behaviors, and delineate the importance of the fMRI navigation in the treatment. We will create new stimulation for ASD auditory comprehension and apply Fourier-ICA in lager samples' research. These lines of research are expected to expand our knowledge in the early diagnosis and early treatment of ASD, and potentially lead to the discovery of the pathological mechanism for psychiatric developmental disorders.

Contribution ID: 120
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Microstate analysis of aging-related brain connectivity alterations using EEG data

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Numerous studies have shown age-related alterations in functional connectivity of brain regions using fMRI data, while evaluating task-based performance; ensuing from a decline in cognitive processes, as well as during rest. The patterns of these alterations in functional connectivity are relatively complex i.e. both increases and decreases has been found. Despite advancements, diversity in the aging-related resting-state functional connectivity alterations is still unclear since fMRI indirectly measures neuronal changes. In the present study, microstates, i.e. timepoint-wise calculated topographic configurations, representing short-lived functional states, are investigated using resting-state EEG data, a direct measure of neuronal potential, of 18 young (age: 23.2±4.1) and 18 old (age: 71.8±5.6) subjects to unveil the electrophysiological signatures of aging-related alterations. Microstates are referred to as 'atoms of thought' and possible electrophysiological representatives of global integrative process. Four microstate templates, explaining 73.55% global variance for old and 79.68% for young data, are extracted from both groups, and EEG data are segmented into a temporal sequence of these spatial topographies. For quantitative analysis, temporal parameters which include mean-duration, occurrence-per-second, and coverage for each microstate are calculated. Topographic configurations are altered in old subjects especially microstates A and D ensuing from age-related network reorganization due to dedifferentiation and compensation processes. Increased mean-duration for asymmetric while decreased for symmetric microstates, is observed. A similar trend is found for frequency-of-occurrence, and coverage is decreased for C only while increased for other microstates in old subjects group. The differences are statistically significant ($p<0.05$) for mean duration and coverage (repeated-measures ANOVA). It is observed that age-related changes give rise to neural activities which are more localized, asymmetric and have reduced temporal stability in global synchronicity compared to young. This study provides evidence that age-related reorganization of networks can be measured using scalp potentials and its dynamics can be captured at fine temporal resolution.

Contribution ID: 158

9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Evaluating alpha relative power of EEG signal during psychophysiological activities in salat

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In order to investigate human brain activities during psychophysiological activities in salat (Muslim prayer), several facts are analyzed in this study. This research work investigates relaxed condition with eyes open and eyes closed and compared with 2 rakat (a single unit of Muslim prayer) salat. Consequently, we have proposed and numerically shown that salat provides more relaxed state of mind than that of relaxing with either eyes opened or closed. Several subjects are participated to record Electroencephalography (EEG) signal through the B-Alert system in this study. The effects of the alpha band are determined by using spectral analysis of EEG signal. By using Welch's method, power spectral density was analyzed and in consequence relative power of alpha-band was calculated. Through Student's t-Distribution, the p-value was evaluated to determine the difference between the alpha relative-power of salat and another relaxed state. As a result, during psychophysiological activities in salat, a significant increase in alpha relative power has been observed in the frontal and parietal regions than other two relaxed sessions. This result reflects the relaxed condition of the human body which raises parasympathetic activity and lessens the sympathetic activity. Therefore, salat can support proper relaxation, reduce anxiety than other two (predefined) relaxed situations.

Contribution ID: 177
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

MEG Frequency tagging to track auditory neural processing during dichotic listening task

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In dichotic listening test, two different auditory stimuli are presented simultaneously to the participant, one to each ear. When speech stimuli are used, typical finding for the dichotic listening is the so-called right ear-advantage which means that more stimuli are correctly reported from the right ear than from the left ear. Right ear-advantage is commonly explained as the left temporal cortex being dominant for perception of elementary speech units and that the dichotic mode of presentation gates the contralateral input from the ear to the auditory cortex. However, so far, the relationship between right ear-advantage and neurophysiological auditory processing is not clear. We used a frequency tagging approach to explore auditory neural processing during dichotic listening. To get such information, we labeled the input at each ear by tagging the speech stimuli with amplitude modulation of different frequencies at each ear and by discriminating cortical responses at the modulation frequencies. The MEG was recorded while participants listened to a pair of dichotic stimulus sounds, chosen from 48 kinds of Japanese two syllable sounds ("A-ka", "I-nu", etc.), which were amplitude-modulated at 35Hz and 45Hz. Experiments were carried out for both Active and Passive conditions. In the Active condition, participants were instructed to describe, between trials, the two syllable sounds that they heard in the left and right ears. In the

Passive condition, participants just watched a silent movie during the dichotic stimulation. Behaviorally, the accuracy of reports to stimulation from the right ear was higher than from the left ear, i.e., right ear-advantage, for most participants. The amplitude of the auditory steady state response measured with MEG for the right ear input was significantly greater than the left ear input. This result suggests that the frequency tagging method is a useful tool for exploring auditory neural processing during binaural interaction.

Contribution ID: 217
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Electrical Right and Left Cardiac Atrioventricular and Left Atrial Delay in Cardiac Resynchronization Therapy Responder and Non-Responder with Sinus Rhythm

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Cardiac resynchronization therapy (CRT) with hemodynamic optimized biventricular ventricular pacing is an established therapy for heart failure patients with sinus rhythm, reduced left ventricular ejection fraction and wide QRS complex. The aim of the study was to evaluate electrical right and left cardiac atrioventricular delay and left atrial delay in CRT responder and non-responder with sinus rhythm.
Methods: Heart failure patients with New York Heart Association class 3.0 ± 0.3, sinus rhythm and 27.7 ± 6.1 % left ventricular ejection fraction were meas-ured by surface ECG and transesophageal bipolar left atrial and left ventricular ECG before implantation of CRT devices. Electrical right cardiac atrioventricular delay was measured between onset of P wave and onset of QRS complex in the surface ECG, left cardiac atrioventricular delay between onset of left atrial signal and onset of left ventricular signal in the transesophageal ECG and left atrial delay between onset and offset of left atrial signal in the transesophageal ECG.
Results: Electrical atrioventricular and left atrial desynchronization were 196.9 ± 38.7ms right and 194.5 ± 44.9ms left cardiac atrioventricular delay, and 47.7 ± 13.9ms left atrial delay. There were positive correlation between right and left cardiac atrioventricular delay (r= 0.803 P<0,001) and negative correlation be-tween left atrial delay and left ventricular ejection fraction (r= -0.694 P=0,026) with 67 % CRT responder.
Conclusions: Transesophageal electrical left cardiac atrioventricular delay and left atrial delay may be useful preoperative atrial desynchronization parameters to improve CRT optimization.

Contribution ID: 234
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Assessment of ECG signal quality after compression

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Highly efficient lossy compression algorithms for ECG signals are connected with distortion of the signals; lossy compression is always a compromise between compression efficiency and signal quality. It is recommended to express this relation using rate-distortion (R-D) curve. To decide

whether the signal is suitable for further analysis, it is necessary to assess its quality after reconstruction. Although there exist many methods for quality assessment, neither of them is standardized or unified. The methods usually do not offer any information about their acceptable values (informing about signal suitability for analysis). This paper introduces 10 new methods for signal quality assessment as well as their limits. Four methods are very simple (entropy, mean, median, and spectra similarity), two are based on delineation of ECG (SiP and SiPA) and the last four combine dynamic time warping, delineation, and calculation of distance (DTWdist, DTWpmfp1, DTWpmfp2, and pmfp). These methods are tested on 1,875 (125 records, 15 leads) ECG signals of standard CSE database using compression algorithm based on wavelet transform and set partitioning in hierarchical trees.
The signals were compressed with various efficiency. To express the efficiency, we used average value length (avL) – 33 levels from 0.1 bps to 9 bps were used. Two ECG experts divided the compressed signals into three quality groups: a) perfect quality, evaluable without restrictions; b) good quality, some parts of ECG (such as P wave, ST segment) are distorted; c) not evaluable ECG, only the rhythm can be approximately evaluated. Owing to the experts' ECG classification, we set the range of avL for each quality group. On the basis of this, we determined corresponding ranges of 10 new methods values.
Based on the trend of R-D curve and computational demand of the methods, we recommend four methods: median, spectra similarity, SiPA, and DTWdist for further use.

Contribution ID: 263
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

An algorithm to detect atrial fibrillation on lead II

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The aim of this paper is to discuss an algorithm for Atrial Fibrillation (AF) detection based on the study of fifteen-second ECG strips from lead II; a peak to peak ECG voltage greater than 0.5 mV and a 250 Hz sampling rate were requirements. A FIR moving-average filter was applied to improve the signal quality and remove the signal baseline fluctuations. QRS complexes were detected using an energy function based on the Teager operator. To measure the QRS complex width, a nine-point derivative function was computed to identify the onset and offset of each complex. The absolute maximum voltage inside each complex was the fiducial point to calculate the duration of RR intervals between successive QRS complexes. A 15-second ECG strip was classified as arrhythmic if more than 10% of RR intervals measured were shorter than 85% of its mean value. When an ECG strip was classified as arrhythmic, the segment delimited by the T wave offset and the onset of the next QRS complex was analyzed, excluding 160 ms previous to the QRS complex. The kurtosis coefficient was computed for these samples and a moving energy window was computed across this segment; the moving average width was 60 ms. An AF event was identified if the energy reached significant values and the kurtosis coefficient was less than or equal to zero; the energy threshold to define significant values was set experimentally. The proposed algorithm was tested with twenty 15-second ECG strips extracted from MIT-BIH AF database and the complete MIT-BIH Arrhythmia database. All the AF events present in the studied sample were identified, but five 15-seconds ECG of sinus rhythm were misclassified as arrhythmic, although these errors did not affect the algorithm performance. These results are promising and could be improved with a better signal to noise ratio.

Contribution ID: 280
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

MEG ASSR's to AM-modulated ambiguous musical segment reflecting the listener's induced state of illusory hearing

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We previously reported behavioral and neurophysiological (evoked MEG) responses to ambiguous music and showed response differences depending on which of the possible melodies the listener heard. The ambiguous musical configuration was formed by two sustained notes (A4 and E5) and short (0.25 s) C5 notes presented 4 times with 0.25 s rests between consecutive presentations. Illusory melody, C5-A4-... (Down) or C5-E5..(Up) can be perceived although some participants more often heard the stimulus itself without illusion. In the present study, the sustained E5 and A4 tones were amplitude modulated by 42.5 and 37.5 Hz sinusoidal waves and the auditory stationary state responses (ASSRs) to these envelopes were measured. Each stimulus, 5 s in duration, consisted of three segments and the sustained tones continued throughout the whole length. The first 2 s segment contained only the sustained tones, the next 1 s segment was used to present one of the two suggested melodies C5-A4-C5-A4 or C5-E5-C5-E5 for inducing the listener, and in the last 2 s segment either the repeated C5 tones or nothing but the continuous tones were presented. The blank 2 s segments were used for control with the preceding melodies. Therefore, there were altogether 4 kinds of stimuli; Dn-Amb (down-ambiguous), Dn-Cnt (down-control), Up-Amb, and Up-Cont presented in random order and the responses were averaged for each category. The averaged signals were peak filtered at 42.5 and 37.5 Hz and hilbert-transformed to obtain the envelopes of the ASSRs to the two modulated tones. Eleven of the total of thirteen subjects were tested for the difference between the responses to Up and Dn stimuli normalized with respect to the control. There was a significant difference indicating that the ASSR to the tone involved in the illusory melody heard by the subject is more suppressed than to the tone not involved.

Contribution ID: 308
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Event-related synchronization/desynchronization in neural oscillatory changes caused by implicit biases of spatial frequency in electroencephalography

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Spatial frequency may elicit characteristic mental and neural activity in humans, exhibiting a 1/f fluctuation. However, a visual pattern consisting only of spatial frequency itself will not necessarily effect any reaction explicitly, but it may implicitly. We adopted an implicit association test (IAT), which is in widespread use in the research of implicit biases, to answer that question. At the same time, we attempted to characterize the neural activities associated with implicit biases of spatial frequency by using electroencephalography (EEG). We used two types of checkered-pattern stimuli, with high and low density, as targets. The high and low densities correspond to high and low spatial frequencies. There are two evaluative categories, with associated nouns and adjectives carrying a range of positive and negative meanings. EEG data were recorded, and the event-related synchronization (ERS) or desynchronization (ERD) for each event were analyzed based on the intertrial variances for the theta (4-7 Hz) and alpha (8-13 Hz) bands for each strong and weak associative strength comparison between the targets. All participants provided written, informed consent, and the study design was approved by the ethics committee of Tohoku Gakuin University.

The category (e.g. high spatial frequency - positive or low - negative) was then obtained from the reaction times of the IAT for each subject. The ERS and ERD characteristics differed between strong and weak associative strengths, measured at the front and central areas at around 1,000 ms for the alpha band, and at the prefrontal area at around 500 ms for the theta band. This difference suggests that spatial frequency characteristics affect neural oscillatory activity associated with implicit biases of spatial frequency. This study was supported in part by the research grant from JSPS KAKENHI Grant Number JP17K00385.

Contribution ID: 321
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

A decision-making fusion method for heart rate estimation based on the multiple QRS detectors

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Accurate heart beat detection for ECG signal plays a fundamental role in monitoring cardiovascular diseases (CVD). QRS serves as the basis for the automated determination of heart rate, as well as the benchmark point for classifying the cardiac cycle and identifying any abnormality. QRS detection has been extensively studied for over 40 years. Lots of QRS detection algorithms exist and most of them are verified with high sensitivity and positive predictivity on the standard (or clean) ECG databases. Recent progress in mobile ECG and portable battery-operated systems rises the challenge of accurate QRS detection for real-time dynamic ECG recordings since the variety of noises.
In this study, a decision-making fusion method for heart rate estimation based on up to nine QRS detectors were proposed. First, the ECG signals were detected by these nine detectors. Then, the voting fusion rule had been established that a heartbeat was determined when more than five detectors showed their detections in a 150 ms time window respectively. Considering it is almost impossible that all detectors showed their detections at the same time, time window was introduced. And the mean value of the middle three detections' positions in the window was served as a corrected heartbeat. Moreover 270 ms blind-eye window was employed to avoid the oversized T waves to be taken as detections. The new proposed method was tested on 100 ECG records with poor signal quality from the PhysioNet/CinC Challenge 2014. For comparison, the best detection accuracy for the single algorithm was only 75.35% while the new proposed fusion method reported a detection accuracy of 80.42%.
The proposed fusion method can significantly improve the heart rate estimation accuracy for the ECG signals with poor signal quality. Thus it has a potential usefulness in the real-time dynamic ECG monitoring situations.

Contribution ID: 331
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Gait asymmetry in Winters group I hemiplegic children: role of tibialis anterior

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Hemiplegia is a neurological disorder that occurs quite often in children, affecting up to one child in one thousand. Typically, only one side of the body is affected by hemiplegia, while the other side is maintaining an apparently normal behavior. Purpose of present analysis was assessing gait asymmetry in group I (W1) hemiplegic children according to Winters classification, where W1 is characterized by presence of drop foot in swing in the hemiplegic side. Asymmetry was quantified by differences between hemiplegic and non-hemiplegic side in terms of foot-floor contact and electromyographic (EMG) activity. Surface EMG from tibialis anterior (TA) and foot-floor contact data were acquired in ten hemiplegic W1 children during walking to fulfill this aim. An exceptional number of strides was analyzed to consider the data variability, expected in W1 (mean ± SD = 287 ± 62 strides for each child, more than 3000 in total). Statistical gait analysis, a recent methodology performing a statistical characterization of gait, was applied to process EMG data. The research was undertaken in compliance with ethical principles of Helsinki Declaration and approved by institutional expert committee. Results showed that asymmetries were detected in basographic data: W1 children showed a significant decrease ($p < 0.05$) of strides with normal foot-floor contact (HFPS sequence: heel contact, flat-foot contact, push-off, swing) in hemiplegic side with respect to non-hemiplegic side. Also TA recruitment presented asymmetries during walking, characterized by a curtailed, less frequent activity ($p < 0.05$) during terminal swing and a lack of activity at heel strike in hemiplegic side, with respect to non-hemiplegic side. In conclusion, present study suggested that walking in W1 children is characterized by asymmetries in both foot-floor contact patterns and TA recruitment.

Contribution ID: 342
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Are extensor digitorum brevis and gastrocnemius working together? Surface EMG analysis in healthy children

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A relationship between ankle flexors and intrinsic/extrinsic foot muscles is acknowledged during walking. Literature on foot-muscle recruitment in children is not very extensive. Purpose of the study was the surface-EMG-based evaluation of possible concomitant recruitment of ankle flexors and foot muscles during healthy-children walking. Gastrocnemius lateralis (GL) was analyzed as representative muscle for ankle plantar flexors. Extensor digitorum brevis (EDB) is one of the main intrinsic foot muscles, controlling foot movement and stability. In this study, EDB was considered as representative of foot muscles. Surface-EMG signals during 4-minute walking trial were acquired in eight healthy school-age children (mean±SD: age 8.3±1.7 years; height 136±8 cm; mass 30.9±6.2 kg) to fulfill the goal of the study. Then, Statistical gait analysis, a recent methodology performing a statistical characterization of gait, was applied to process EMG data. An exceptional number of strides were analyzed to consider the expected variability (mean±SD = 265±30 strides for each child, nearly 2500 in total). The research was undertaken in compliance with ethical principles of Helsinki Declaration and approved by institutional expert committee. Results showed that in 73.4±17.3% of strides EDB activity is localized in two separate regions of gait cycle: mid-stance (from 8.2±7.0 to 50.3±15.0 % of gait cycle) and swing phase, from 73.8±13.8% to 91.5±7.1%. Main GL activity (61.4±11.6% of strides) occurred in the same regions: mid-stance (from 5.7±2.5 to 49.7±4.6% of gait cycle) and swing phase, from 69.1±18.7% to 87.3±7.5%. These findings showed that regions of activity of EDB and GL were practically overlapped, suggesting that EDB and GL worked synergistically for ankle-joint control in children walking, in a large percentage of strides. Present study produced novel data on the variability of the reciprocal role of EDB and GL during children walking, providing a deeper insight in mechanisms regulating ankle-foot stability.

Contribution ID: 362
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Investigation of changes in causality due to age – a Granger causality and transfer entropy study

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Over the past few years, the use of magnetoencephalogram (MEG) signals has increased as a cognitive neuroscience research tool to analyse complex networks in the brain. Furthermore, the analysis of MEGs with advanced signal processing techniques has resulted in increased knowledge about the functioning of the brain. In this work, a sensor space study made use of resting state MEGs from 220 healthy volunteers (aged 7-84) to determine the changes in causality with age and gender in different brain regions. Granger Causality (GC) and Transfer entropy (TE) were used to assess whether TE is more robust than GC at determining the changes in causality due to age. GC and TE results were combined with graph theory principles to evaluate different network components such as integration (global efficiency), segregation (clustering coefficient and modularity), centrality (betweenness), and resilience (strength and assortativity). It was found that males had higher causality (using GC) than females until mid-adulthood (~ 60years), however when the analysis was repeated without any a priori assumptions (using TE) this gender difference was not observed. Additionally, complex network analysis results of low global efficiency, high clustering coefficient and low node strength, alluded to the existence of many small local clusters that combined to form a more ‘regular’ network structure. This topology was made up of loosely connected modules that had segregated and disassortative nodes with low resistance to change. Statistical analyses of results from both techniques, using pairwise t-test and two-way ANOVA, showed that age had a significant effect ($p < 0.05$) in all brain regions for both genders with significant gender differences being observed in the central and left lateral regions of the brain. Whilst it was initially expected that TE would yield better results than GC, this study showed that when analysing background brain activity GC outperforms TE.

Contribution ID: 454
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Proposed method of sub-windows in an autoregressive segmentation EEG signals

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Segmentation of EEG signals is a common practice for processing of collected data which allows easier orientation and reading of results. An original method of two connected wide windows is

typically used for an autoregressive segmentation of EEG. The different-sized windows could be used for the identification of Spike, Spike-wave Complex and Complex in next passes through. This multi-passes approach is a time/CPU consuming. To save a processing time a modified method is suggested. Proposed method (tested on synthetic signal) calculates a G-function for each element by a dividing of standard size window to sub-windows. A forward standard size window (R-window) is computed in four steps with separate outputs (G-functions) for Spike, Spike-wave complex, Complex finding and typical segmentation. We used a hierarchy structure of sub-windows to calculate values of G-functions. This proposed method provides more outputs (G-functions) during computing in one pass through and collected results have a practical positive impact on a processing of EEG signal.

Contribution ID: 509
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Temporal association between phase coupling of respiratory sinus arrhythmia and slow wave brain activity during sleep

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Slow wave sleep (SWS) is considered to be the most restorative period for the brain and body. A lack of SWS may lead to medical problems such as obesity, diabetes, and cardiovascular diseases. Thus, detecting the quantity and length of SWS during sleep is of importance and interest. Our previous study demonstrated that phase coupling of respiratory sinus arrhythmia (RSA) could act as an index for standardization when evaluating autonomic nervous system (ANS) activity. Since ANS activity towards parasympathetic dominance during SWS period, we assumed that if SWS induced strong cardiorespiratory coupling as a reflection of cardiac parasympathetic activation and sympathetic inhibition, phase coupling of RSA could be used as an indicator for detecting SWS.
Overnight electroencephalograms (EEG) and electrocardiograms (ECG) were recorded from 25 healthy volunteers. The EEGs were band-pass filtered to extract activity in the delta, theta, alpha, and beta-ranges. From the oscillatory signals of RSA and respiration, each analytic signal was constructed from a real signal and its Hilbert transform and then phase coherence (Cp) was computed. Additionally, frequency-domain indices of the heart rate variability (HRV) were calculated. Using auto- and cross-correlation analyses, we found that periodicity of Cp was quite similar to that of delta-wave (88.5 ± 18.1 min vs. 88.6 ± 17.5 min, r = 0.935) and that overnight profiles of Cp and delta-wave were related with highly significant cross-correlation coefficients (0.426 ± 0.086) that was greater than that for the relationships between the delta-wave and HRV indices. These results suggest that Cp is closely linked with EEG delta-activity and that phase coupling analysis of RSA may provide a novel method to objectively predict SWS and to evaluate cardiac autonomic modulation during sleep.

Contribution ID: 524
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Development of microminiaturized electrode intramuscular advanced multichannel EMG system

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A new multichannel EMG with microminiaturized intramuscular microelectrode system is developed having five channel pentode electrodes with a special reference to neurological syndromes and/or disorders. The electrode array is a pentagon five angle geometrical concept (arranged two electrodes at ECR and ECU sites, two electrodes at FCR and FCU sites and fifth electrode is at EDC, EPL & EPB, EIP, EIL, FPL, FPB, ADP, APB & APL muscle sites.
The input impedance offered by one Op-Amp differential amplifier is far too less for high resistance sources like the human-body. Here it is essential that the body does not source any kind of current because it is required to drive the circuit. The requirement is of an amplifier-circuit that has high-end input impedance so as to faithfully effectively reproduce the signal fed to it. This kind of requirement is perfectly provided by the Three-Op-Amp instrumentation amplifier. In addition to high input impedance, the amplifier configuration also has a very high common-mode rejection ratio (CMRR), which effectively removes the 50 Hz line frequency inherent in most of the signals.
While designing benchmark formalism followed and built with the following technical—specifications configuration. Instrumentation Amplifier Gain = 10, common-mode rejection-ratio(CMRR) is 69 dB, Gain select amplifier (gain 30), Low pass filter with lower cut off frequency going up to 10 kHz (Gain-2), High-pass-filter with Lower cut off frequency 0.5Hz (Gain-2), Input impedance > 200 Mega Ohms (CMRR=69dB) 5 to 8chnnels provided (expandable as per the user requirement), Sampling-frequency 8 kHz/channel (five-channels 40k-samples can be recorded), user choices provided, 50Hz Notch/band-pass-filter developed employed in this work.
Nomenclature:
ECR Extensor-Carpi-Radialis
ECU Extensor-Carpi-Ulnaris
FCR Flexor-Carpi-Radialis
FCU Flexor-Carpi-Ulnaris
EDC (ED2)Extensor-Digitorum-
Communis-2nd digit fascicle
EPL & EPB Extensor-Pollicis-Longus & Brevis
EIP Extensor-Indicis-Proprius
EIL Extensor-Indicis-Longus
FPL Flexor-Pollicis-Longus
FPB Flexor Pollicis Brevis
ADP Adductor-Pollicis
APB & APL Abductor-Pollicis-Brevis & Longus

Contribution ID: 534
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Automatic detection of P wave in ECG during ventricular extrasystoles

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This work introduces a new method for P wave detection in ECG signals during ventricular extrasystoles. The detection of atrial activity (represented by P wave) has been studied in many previous works with good results, but only in case of physiological records (sinus rhythm). The automatic and reliable detection of atrial activity in pathological situation is still an unsolved problem. The automatic and reliable detection of atrial activity in pathological situation is still an unsolved problem. In this work, phasor transform is used for P wave detection. Phasor transform converts each ECG sample into a phasor and enhances changes in the ECG signal. Waves with small voltage are then easily detectable. The main innovation in our approach is using of classification algorithm, which is able to detect ventricular extrasystoles. The classification is based on extraction of morphological features which are derived from each QRS complex (e.g. amplitude of QRS complex, width of QRS complex, area under the curve of QRS complex, differences between actual and previous QRS complexes). The classification algorithm was trained on the whole MIT-BIH arrhythmia database (apart from four records on which it was tested – signals no. 106, 119, 214, and 223). These four signals were used in order to compare the accuracy of our algorithm with previous works. The results of classification are used for demarcation of areas in which P waves are searched using phasor transform and thresholding. The accuracy of P wave detection in four signals with ventricular extrasystoles is 96.03 % (for comparison, the authors of previous works reached the accuracy of 84.5 % and 92.5 % using the same signals).

Contribution ID: 540
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

An impulsive noise rejection filter for wearable ECG signal processing

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Objective: QRS detection is essential for ECG signal processing. For real-time dynamic ECG, QRS detection is usually performed on a fixed time window, lengths from several to dozens of seconds. However, the unexpected impulsive noise (usually short-term but large amplitude) within the ECG episode is a disaster for QRS detectors. Thus we aimed to propose a new filter to handle this impulsive noise to improve the QRS detection accuracy in wearable ECG measurement.
Methods: ECG signals were acquired by the Lenovo Smart-vest, which is a 12-lead wearable ECG collection device, with a sample rate of 500 Hz. The consecutive ECG signals were manually visual-scanned to pick out the episodes including impulsive noises. A fixed time window of 10 s was used for segmenting the ECG episodes. Then, each 10-s ECG episode was processed by Butterworth band-pass filter (0.5-35 Hz). The common Pan&Tompkins (P&T) QRS detector was performed on the filtered signals. A flexible threshold of 60 ms was used to confirm the true positive detection for QRS complex. One hundred episodes with the detection accuracy less than 60% were selected as the test data for the new proposed impulsive noise rejection (INR) filter. The new INR filter was designed with the combination of first order difference, fast Fourier transformation (FFT) and adaptive filtering.
Results: Before the INR filtering, the average QRS detection accuracy of the 100 challenging ECG episodes was only 40%. As contrast, with the help of the INR filter, P&T detector can achieve a high detection accuracy of 82%.
Significance: Impulsive noise is a challenging noise existing in the wearable ECG signals. The new designed INR filter can efficiently reject the impulsive noise, and make benefit for the accurate QRS detection in the dynamic environment.

Contribution ID: 544
9. Biosignals Processing

09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

A Novel Hybrid Swarm Algorithm for P300-Based BCI Channel Selection

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Brain–Computer Interfaces (BCI) have proven to be able to establish an effective communication system that allows users to control applications using their own brain signals. Channel selection procedures are essential to reduce the curse of dimensionality, assure suitable performances and increase the users' comfort. Nevertheless, these selection is not trivial, owing to the fact that there are 2^N possible subsets for an N–channel cap, making the exhaustive search intractable. Several methods have been applied in this regard. However, most of them use single-objective approaches, ignoring the trade-off between the final number of selected channels and the system performance. In this study, a novel multi-objective hybrid algorithm is proposed to simultaneously: (i) reduce the required number of channels and (ii) increase the accuracy of the system. The method, which merges the key aspects of forward selection (FS) and multi-objective particle swarm optimization (MOPSO), returns a set of pareto-optimal solutions in function of the number of used channels. The proposed algorithm (MOPSO/FS) has been tested with a 16-channel dataset recorded from 4 control subjects, as well as compared with the traditional MOPSO and the common 8-channel set. Results show that MOPSO/FS is not only able to overcome the aforementioned methods, but also to reach similar or even higher accuracies than that obtained without employing any selection algorithm. In fact, MOPSO/FS overcomes the 8-set accuracies (mean of 95.25%) using only 4 channels for every single user (mean of 97.75%), reaching performances that are also superior to the 16-set ones (mean of 97.00%). Moreover, the FS inclusion leads MOPSO/FS to converge to more spread pareto-front solutions than traditional MOPSO, which performs a less thorough search, limiting the number of optimal solutions. For these reasons, we conclude that the proposed method is suitable for use in P300-based BCI systems channel selection procedures.

Contribution ID: 582
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Development of wearable hand motion estimation system using conductive fabric paste

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Gesture interface is effective in intuitive operation for anthropomorphic robot, virtual reality and augmented reality. There are some methods for tracking human motion using time-varying image processing, acceleration sensor and surface Electrical myogram (sEMG). The merit of using image processing is simple measurement of motion. However, this method causes restriction of workspace and occlusion. Acceleration sensors securely measure motion but they obstruct hand motion because we need to directly set module device on the hand. The method using sEMG enables to infer muscular force and does not restrict workspace for measurement. Myoelectric potentials precede the muscle action. Consequently, it is possible to operate with law latency. Because of mentioned above , sEMG is suitable to track human motion for gesture interface.
The aim of this study is to develop a wearable hand and finger motion estimation system using sEMG signals which is useable anywhere and easy to equip. This system has twelve electrodes for

bipolar lead (6ch) placed on around the forearm at even intervals. We enable wearable sensing using conductive fabric paste which has very low impedance and usability for wiring to EMG detection circuit. Thirteen healthy males and females took part in the experiment (mean age: 22±1.6 years). Each subjects performed in six motions about finger and wrist. And their griping force were simultaneously measured. We extract feature quantities from frequency component, mean absolute value and integral absolute value of sEMG for further analysis. Subject's motion data were classified to six class with Support Vector Machine. And feature quantities were used to estimate griping force. Cross-validation was utilized for calculating classification accuracies. Next, we compared measured value and estimated value for present validity of griping force estimation.
As the results, we can show around 70% classification rate in total by only using developed system.

Contribution ID: 623
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Determination of the Electrocardiographic Changes Induced by Endurance Training using Signal Processing Techniques

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Training-induced electrocardiographic (ECG) changes are common in adult athletes. ECG quantitates cardiac adaptation to exercise training. Sustained training often leads to anatomical changes in the heart that can translate into changes and abnormalities in ECG. An increased PR interval, widening of the QRS complex and repolarization alterations is among the most common ECG abnormalities. The ECG changes seen in training athletes are likely to increase with the increasing competitiveness in sports. ECG is an important tool due to its ability to detect underlying cardiovascular conditions that would increase the risk of heart diseases. Therefore, ECG screening in athletes is important to remove the risk of death of young athletes because of heart disease. In this study, active young athletes and sedentary adolescent controls were underwent ECG examination. Seventy nine healthy athletes active in five different disciplines which are hokey, running, football, swimming and gymnastic (age 20.0 ± 2.6 yr; 49% male) and control group that contained 82 healthy sedentary adolescent (age 20.8 ± 2.2 yr, 49% male) volunteered to participate in this study. All volunteer athletes were selected from local sports teams and sports academy, while all control group members were included in this study among local healthy volunteers who were students at the university or medical staff from the hospital. Measured ECG signals from all volunteers were analyzed to observe the effects of training in ECG main wave parameters (P wave, T wave, QRS complex). All these parameters were extracted from signal using developed signal processing techniques. Then each were compared using statistical analysis according to both gender and whether they are athletes or sedentary. The results and corresponding conclusions will be given in full conference paper of the IUPESM-2018.

Contribution ID: 680
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Variation of the EEG-energy in a second language class

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The domain of English as a second language in Ecuador has presented a slight improvement in the last year according to the EF EPI 2017 report, locating to Ecuador in the position 55, considered as a low domain category. The attention, concentration, memory, and anxiety of the students are fundamental in the learning process of a second language; however, the effort done by the teachers to hold the attention along a class are quantified using traditional tools as questionnaires or visual manual reports using TIC's.
This study presents a tool to quantify the attention students level, analyzing the energy of electroencephalography (EEG) signals registered using the device Emotiv Epoc. EEG data was registered on 52 healthy male volunteers aged 18-22-year-old. The data was registered while attending to a level 1 English language class based on the European common framework through 12 minutes. The signals were filtered using a Butterworth bandpass filter (0.5 to 45 Hz). Finally, a Wavelet Transform Symlet 6 was applied with five levels of decomposition to analyze two frequency bands: Alpha (8-16 Hz) and Beta (16-32 Hz).
The variation of the EEG-energy can provoke a direct change in the student's attention and concentration. The results revealed an increment in the energy on the electrodes AF3, AF4, F3, and F4 (frontal lobes) in the Alpha and Beta bands between 37.25 and 43.41% of the students, and decrements between 25.49 and 43.13%. When analyzing the electrodes T7 y T8 (temporal lobe), there were an increment of the energy in 35.30% of the students and decrements between 39.22 and 47.60% of theirs. Finally, the electrodes O1 and O2 (occipital lobes) showed an increment in the signal's energy between 43.13 and 45.10% of the students and decrements between 39.22 and 41.18% of theirs.

Contribution ID: 682
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

The value of new atomic sensors in medical diagnostic procedures

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The new generation of atomic magnetic sensors with sensitivity of 10 pT/rtHz provides new tool for assessment of biological magnetic signals such as MCG, MEG or other neurological signals. The atomic sensors with such high sensitivity always require attenuation of the spurious magnetic signals with shielding of the sensor and the subject. Additionally the best sensitivity of sensors is achieved in the total magnetic earth field close to zero. Such conditions are provided by the three dimensional system of compensation coils situated within a magnetically shielded room. Authors have designed, based on a Vacuumschmelze room, the laboratory for the atomic sensors measurements with the compensation coils system zeroing out the magnetic field of the earth within whole area inside the shielded volume. The preliminary measurements have proven that diagnostic signal of MCG can be monitored by two parallel sensors. The results confirmed the ability of the multisensors examination of the distribution of the magnetic field magnitude on the surfaces of chest, scalp or other fragments of human body. In most practical situations the vector of the magnetic field is perpendicular to the surface of tissue generating it and the field maximum is exactly over the area of interest e.g where the neurons are placed. Therefore the maps measured by the atomic sensor arrays can be more precise than isopotential maps where the magnetic field gradient parallel to the surface is detected. We could also expect that the measured magnetic field will have high amplitude because of the smaller dimensions of sensors and low attenuation of the

magnetic field by bones. In conclusion, the novel magnetic sensors seems to be a promising diagnostic tool for the brain and heart activities and should provide the opportunity for new diagnostic applications such as monitoring of disturbances of the fetal cardiac rhythm.

Contribution ID: 738
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

EEG coherence analysis in subjects after rehabilitation from stroke with motor imagery

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Stroke is caused by a lack of blood supply in a particular region of the brain that may be a consequence of clot formation or rupture of the blood vessel. It presents high incidence, generating permanent neurological sequelae, which leads to motor impairment and functional limitations. It is necessary to identify techniques of motor rehabilitation that help the cortical reorganization and the functional recovery of affected individuals. Motor imagery (MI) is a technique used in motor rehabilitation of individuals with motor deficit. MI is defined as mental simulation of movements without movement actually occurring. It activates the same cortical regions as the movement execution, especially the motor area and the somatosensory cortex. The objective of this study was to investigate changes in cortical activity related to MI rehabilitation in hemiparetic individuals after stroke, before and after training with MI during one month (three session/week). EEG signals from eight post-stroke individuals who underwent training with MI were analysed at 2 different conditions: one week before MI training (BMI) and one month after training (follow-up), during both motor and imagery task performance. Magnitude squared of coherence (MSC) was evaluated, using 50 epochs, artefact-free EEG signals. The delta band presented the highest MSC values in both conditions, mainly in frontal and central regions. The sum of MSC (S_MSC) in delta band was calculated, with higher values occurring mainly in frontal region. Such values were also greater before MI training in comparison with the follow-up condition. In six subjects, the S_MSC temporal evolution showed higher values in the beginning of the tasks. Although the rehabilitation resulted in physical improvement, the results show that MI practice had a low influence in MSC (synchronous response) in post-stroke individuals, which is not expected in individuals without neurological dysfunction.

Contribution ID: 758
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Nonlinear dimensionality reduction and feature analysis for artifact component identification in hdEEG datasets

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The ICA is commonly used technique for neural and noise signal separation in EEG. Nevertheless, the estimated sources have to be further classified by an expert, using predefined or learned features. Generally, the source component classification can be performed automatically. However, available algorithms suffer from unsatisfactory sensitivity and specificity mostly due to

large inter-subject variability of the human EEG. Deep learning techniques favourably increased power of classifiers and they have been increasingly applied in neuroimaging. However, generalization of each learning machine depends on whether some robust and meaningful features exist in component space which simultaneously separate neural and noise components. Here, we examine if there are any regularities in hdEEG component space that can be learned by deep structures across subjects and how they are related to the known features from the literature. The testing dataset is composed of 5 minute long, resting state, EEG recordings acquired by EGI256-channel EEG system from 40 subjects. Data acquisition was approved by the local ethical committee of National Institute of Mental Health, Czech Republic. Raw EEG data were downsampled to 250Hz, filtered by zero-phase bandpass filter, and manually inspected. Each recording was decomposed by Infomax ICA algorithm. All components were evaluated in accordance with standard criteria: energy, autocorrelation, focal topography, and focal trial activity. Simultaneously, the stochastic neighbour embedding algorithm (tSNE) was applied to reduce data dimension and to extract nonlinear features exclusively from ICs topographies. The extracted data structure was scored by density-based clustering algorithm. Using the non-linear approach, we were able to extract cluster like data structure. Each cluster consisted of a mixture of components across subjects. Furthermore, relationship between non-linear features and three standard criteria (autocorrelation, focus trial activity, and energy) was clearly observed. Kruskal-Wallis test will be used to judge the found relationships and observations.

Contribution ID: 761
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Comparison of spline methods for 3D brain mapping

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The brain mapping is a topographic method for visual representation of the brain potential distribution. This method is used in neuroscience to evaluate EEG recordings. The result of this method is the two-dimensional or the three-dimensional brain electrical potential map. Currently, electrical activity of the brain is measured in animals as well, in order to study the pharmaco-effects of the drugs on the brain. We compared methods for three-dimensional brain mapping in humans and in Wistar’s rats. We used the 3D brain model from Brain Atlas Reconstructor for imaging purposes of Wistar‘s rat. We used the 3D brain model from Wave-Finder software (set of EEG analysis methods written in C++) for imaging purposes of the human brain. Based on research we choose spherical splines and 3D splines as methods for 3D brain mapping. Both of these methods were used in brain mapping in humans. The spherical splines were determined by the parameters: the order of interpolation (m = 4) and the number of terms of Legendre polynomials (n=7). The 3D splines were determined by the parameter: order of interpolation (m= 3). We have implemented spherical spline curves and 3D spline curves in MATLAB software. The 3D maps were created by using simulated signals of human and rat’s brain activity. The Root Mean Square error (RMS error) was calculated for the evaluation of interpolation methods. For the human brain model, there is the RMS error 0.5702 after spherical spline interpolation and 0.0669 after 3D spline interpolation. For Wistar’s rat brain model, there is the RMS error 0.5934 after spherical spline interpolation 0.0694 after 3D spline interpolation. The results showed that the 3D spline interpolation gave better electrical potential map in both models – in the human brain model and also in the rat brain model.

Contribution ID: 782
9. Biosignals Processing

09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Automatic detection of strict left bundle branch block

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Strict (true) left bundle branch block (tLBBB) ECG morphology is a new diagnostic marker in cardiology that was proposed to predict cardiac resynchronization therapy responders. The criteria for tLBBB include the presence of QS or rS in V1 and V2, the presence of mid-QRS notching or slurring in at least two of leads V1, V2, V5, V6, I and avL and finally a QRS duration of more than 130 ms for women and more than 140 ms for men. Mid-QRS notching and slurring are not precisely defined and therefore their automatic detection is difficult.
Here we present an algorithm for the automatic detection of the QRS morphology, as well as the mid-QRS notching or slurring. Detection of the notch in the time domain and thresholding of its width and depth was used to detect mid-QRS notching. Detection of standard deviation change in several different floating windows was used to detect mid-QRS slurring. The type of QRS morphology was evaluated according to the dominant deflection of the QRS, which must be negative without positive deflection at the end of the QRS. Publicly available algorithm (ecgpuwave, the PhysioNet database) was used for measurement of the QRS duration.
In order to test our algorithms, three experts labelled 78 ECG records (12 leads, fs=5 kHz, 15 minutes); 51 records were labeled as tLBBB. One representative QRS was used to analyze the entire record. This QRS was obtained by averaging all QRS with the same morphology. The proposed algorithms were tested showing overall sensitivity and specificity 98 and 86%, respectively, in cases where all three experts had full consensus (82% of the dataset). Our method showed lower sensitivity and higher specificity 96% and 88%, respectively, for the dataset including cases where experts mutually disagreed, consensus has been determine based on expert discussion in these records.

Contribution ID: 823
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Methodology for quantification of electromyographic contamination of frontal muscle at the electroencephalogram

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The electroencephalogram (EEG) is the record of cerebral electrophysiological activity along the scalp in which it has been widely used in several applications, for example, the quantification of the cognitive capacity focusing on the diagnosis or even Brain Machine Interfaces (BCI). However, neural data is frequently contaminated by artifacts that may originate from recording devices or by non-brain physiological activities, such as the blink and the contraction of the scalp muscles. This last represents a considerable challenge in the removal of EEG artifacts due to high amplitude and broad frequency range which makes it difficult to remove by conventional filtering. Thus, some applications such as BCI systems may occasionally be associated with frequent contractions of head muscles corrupting the EEG control signal. This requires an application of a number of

filtering techniques, as can be divided into multichannel approaches and single channel approach. However, the standard gold techniques still contain limitations, such as not eliminating wholly noise in all EEG channels. For this reason, besides to the study of the techniques is helpful understand the electromyography (EMG) contamination along the scalp. Consequently, several studies concluded that EMG artifact contaminates the EEG at frequencies beginning at 15 Hz in topographic distribution that encompasses practically the entire scalp. The present work aims to quantitatively estimate EMG noise in 16 bipolar channels of EEG distributed along the scalp according to the 10-20 system. This estimation was done by an experimental protocol that is based on the simultaneous acquisition of EEG and EMG of the frontal muscle sampling at 5 kHz. And as epochs of the time series are then compared by similarity features which estimate the noise in each of the EEG channels based on the signal of the EMG electrode.

Contribution ID: 843
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Latent variate factorial PC and cluster analysis of multichannel multisited EMG Writer`s Cramp Signals (Based on means and variances)

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Multivariate-techniques applied on EMG-Writer`sCramp signals-data of 12-subjects(neurological-syndrome patients). Latent variate-factorial(or factor) principal-components(PCs) analysis (PCA-approach, of differences of 12patient’s scores) targeting and cluster-analysis based on means and variances of 12-subjects were analyzed and inferences deduced. Eigen-values and corresponding dominant Eigen-vectors were computed. In our computation, 12-subjects points are well-scattered-out, without any-clear-cut-pattern except for case of subjects {(a6),(a4),(a7)}. These three are near enough to each other as compared to remaining 9-subjects. Indeed, these three seem to form a lineal ordered-set like a radial-curve (and thus forming ellipsoidal-curves or resembling clouds in the space) explaining 80%variance.
However, these findings are to be cross-validated with clinical-findings on same-subjects. It is interesting that the D -group patients do not form a cluster in this scenario. This perhaps needs further looking into the clinical-picture-of-patterns, other than C and D-groupings. Other approach, which is being investigated, is to examine the distribution of ‘signal—blocks’ like ‘horse-jumps’ and the effect on same when block-size (which on a-priori-grounds are taken as 100consecutive-samples in deciding-about-noisiness of horse-jump(block), is changed.
Micro-analysis of the structure of ‘signals’ by using PCA and other advanced-multivariate-techniques of signal—block-data be performed. However, they do not seem to be of immediate-relevance in clinical/differential-diagnosis, and therefore is beyond the purview-of-present-study. Future developments for clinical-utility needed the study of ‘normal’ peoples' data as a control.
While the cluster-analysis based-on-dissimilarity among patient’s-signals showed a possibility that in addition to groupings-of-patients as C or D, some-other-groupings are meaningful. The data-analyses made in this direction showed significant-findings which led to attempts at more sophisticated-analysis using advanced-multivariate-techniques leading to effective-data-summarization and measures-of-dissimilarity between patients as reflected in the signals—waveforms- recorded and consequent-possible-clustering among them. However, these did not lead to any meaningful-clinical-conclusions. These-analyses could-possibly be applied to longitudinal follow-ups, microanalysis and correlations with normal-controls-population in future to better-comprehend phenomenon of WC`s at microstructure level.

Contribution ID: 846
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Muscle synergies for motor control evaluation

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Muscle synergies have been proposed to be a modular organization for muscle coordination that map high-level task goals, or motor intentions, into motor actions. Muscle synergies and other types of modular organization have been used to explain muscle coordination during a variety of motor behaviours in many different species. In some instances, new synergies may emerge when a new motor task is presented and the recruitment of the synergies may be altered. Here, we used a database to investigate muscle activity of the right hand during seven distinct limb motions in order to extract muscle synergies: hand open, hand close, supination, pronation, wrist flexion, wrist extension, and rest. Database content EMG signals collected from seven sites on the forearm and one site on the bicep, with an electrode placed on the wrist to provide a common ground reference. Classification scheme is based on the synergies between a functional group of muscles. The muscular synergy is evaluated using different techniques like the normalized power spectral densities (PSD), the cross-correlation matrix of muscular force (estimated through the root mean square (RMS) value of sEMG amplitude) and the intermuscular coherence between different sets of muscles. Artificial neural networks were training from resulting features set. We investigate the relationship between muscle synergy recruitment and functional motor outputs and hypothesized that a common pool of muscle synergies producing consistent task-level biomechanical functions is used to generate different motor behaviours.

Contribution ID: 885
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

A brain connectivity metric based on phase linearity measurement

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In this work we present a novel metric to estimate connectivity between brain areas. In brief, the aim is to evaluate the amount of information exchange between two brain regions, and this is done by measuring the similarities between the recorded signals. The proposed metric, named the Phase Linearity Metric (PLM), is designed to exploit Electroencephalographic (EEG) or Magnetoencephalographic (MEG) signals. More in detail, the behavior of the phase differences of two signals is analyzed in order to find linear trends over time. The measurement of the linear components is done by computing their energies in the Fourier domain. The PLM can be seen as an evolution of a widely adopted phase based metric, the Phase Lag Index (PLI). Our approach has been designed to be more resilient to noise as compared to other metrics, while remaining a purely phase based metric insensitive to volume conduction. To achieve these features, our approach takes into account small differences between the central frequency of the two signals taken into account. The performances of the PLM have been evaluated both in case of simulated and real (MEG) datasets. In particular, a study on the robustness to noise of the PLM has been carried out by varying the number of epochs considered for the average. The PLM performs significantly better than the PLM when dealing with noise . This is an interesting feature of the

PLM, since it allows a reduction of the number of epochs required to obtain a reliable measurement of phase based connectivity. This might in turn allow the estimation of connectivity at the single subject level.

Contribution ID: 895
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Ultra-short Entropy for Mental Stress Detection

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Approximate Entropy (ApEn) and Sample Entropy (SampEn) are measures of signals' complexity and are widely used in Heart Rate Variability (HRV) analysis. However, the choice of the threshold value r and minimum number of samples of the time series (N) requested for their computation, are controversial. In fact, most of the entropy measures are considered not reliable below N=5 minutes and different threshold values r showed to affect the analysis and provide incorrect conclusion.
The aim of this study was to understand the impact of changing those parameters individually (i.e. r or N) or as pair (i.e. r and N) for both ApEn and SampEn measures and to select the best parameters to detect stress in healthy subjects. In fact, recent studies proved that almost all the features measuring complexity of the time series statistically decreased during the stress and therefore being able alone to detect stress.
Thus, 84 stationary HRV time series, extracted from electrocardiographic databases, acquired during real life stress, were analyzed. We computed the values of r threshold using two different methods and the minimum number N varied between 100 and 500 samples, and the corresponding ApEn and SampEn were estimated. The differences in ApEn and SampEn with different values of r and N were assessed by a non-parametric test.
The paper will present the results of this analysis.

Contribution ID: 918
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Assessment of human authentication model based on the activity of regulatory systems

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Human authentication via the electrocardiogram (ECG) is an advanced technology for high-level automated security. This topic of contemporary research should consider different aspects of ECG stability over time. The aim of this study is to analyse the applicability of ECG for human authentication, considering the influence of the cardiac autonomous regulation (CAR) on the ECG changes. The hypothesis was that assessment of CAR at distant moments (assuming identical CAR activity) could predict the ECG applicability for human authentication.
We analyse standard 12-lead ECG couples from 30 volunteers (age 42.9+/-13.4 years, 50% men), recorded at remote time points T1 and T2 (mean of 16 months after T1). CAR is estimated via a modified Bajevskiy Indicator of the Activity of Regulatory Systems (IARS) based on calculation of heart rate variability (HRV) features: heart rate HR (bpm), standard deviation of the RR intervals between normal beats STDNN (ms), HRV TriangularIndex, low frequencies LF (%), very low frequencies VLF (%). Each feature is evaluated via 5-degree scale (-2,-1,0,1,2) depending on its

numerical value. The proportion of positive and negative estimates in the total IARS (considering the sum of their absolute values) is a sign for the prevalence of sympathetic/parasympathetic part of CAR activity: normal (1-2), moderately increased (3-4), highly increased (5-6), hyperactivity (>7).
Our observations show:
- G1: IARS (T2)=IARS (T1)-N1, N1=0,1,2 for 23 volunteers;
- G2: IARS (T2)=IARS (T1)+N2, N2=3,4 for 5 volunteers;
- G3: IARS (T2)=IARS (T1)+N3, N3=5,6 for 2 volunteers.

We propose a human authentication model based on 12-lead morphologi-cal features. The analysis of 30 ECG couples shows 100% accuracy for G1, 40% for G2 and 0% for G3 couples, proving the relation between IARS index and human identification accuracy. In conclusion, we prove the hypothesized potential of CAR to predict the ECG applicability for human authentication.

Contribution ID: 933
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Effect of ectopic beats on heart rate variability indices in heart failure patients

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Heart rate variability (HRV) provides an important insight for understanding the underlying mechanisms of the cardiovascular system, and provides a valuable tool for early detection of cardiovascular abnormalities. Ectopic beats have been proven to have an influence on HRV results, but their influence on analysis of congestive heart failure (CHF) patient rhythms has not been verified. In this study, we tested the commonly used HRV indices for significant differences between RR time series with and without ectopic beats. Eight long-term CHF RR interval recordings from http://www.physionet.org were studied. Each recording (about 24 h) was divided into non-overlapping segments of 5-min RR sequences (total 2,072 segments). All RR segments were classified into one of two groups: 1,279 ectopic segments and 793 ectopic free segments. Two time-domain HRV indices of SDNN and RMSSD and two frequency-domain indices of normalized low frequency (LFn) and high frequency (HFn) powers were employed. Results showed that ectopic segments had significantly larger values for SDNN (39±18 vs. ectopic free segments 28±16 ms, $P<0.05$), RMSSD (47±29 vs. 24±23 ms, $P<0.05$) and HFn (0.66±0.13 vs. 0.52±0.14, $P<0.01$), and significantly lower values for LFn (0.34±0.13 vs. ectopic free segments 0.48±0.14, $P<0.01$). This study confirmed that ectopic beats in RR segments have a significant influence on the HRV results for CHF patients.

Contribution ID: 936
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Correlation of facial expressions and physiological signals in mental stress estimation

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Stress is one of the many major problems in modern society. Ratio of people who regularly experience physical symptoms caused by stress is 77% and 73% of the society regularly experiences psychological symptoms caused by stress in U.S in 2014. This condition may result as performance degradation, minor but costly mistakes or even depression causing suicides in working or educational environments. This paper presents not only a new approach for mental stress detection but also tries to correlate facial expressions and physiological parameters. This correlation and the corresponding mental stress condition are tools for explaining the relationship between face features and physiological features extracted from various signals. Proposed algorithm uses face images to extract multiple features including eye closure and opening duration, eye blink, eye opening, yawning, head position information in addition to features of Electrodermalactivity (EDA), Electrocardiogram (ECG), Respiration, Body Temperature such as maxima, variance, frequency of the signals, P-T wave characteristics, amplitudes etc. Features are extracted from synchronous video recording and physiological signal acquisition. Subjects are divided into two classes as normal or stressful. 10 subjects are tested for high or low level of stress in their lives. Traditional characteristics as pulse rate or respiratory rate show no evidence for stress detection, however; EDA features and combination of multiple features increase the estimation rate.

Contribution ID: 959
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Alarm System Pilot Fatigue

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When individuals start sleeping, their brain signals change and change again when they wake up. We have invented a system that detects this change. It processes brain signals and based on these signals, it may send two alerts: one is a mild electric shock delivered to the individual’s earlobe and the other is the presentation of visual stimuli.
The Physiobank was used to detect electroencephalographic signals such as alpha, beta, and theta, where alpha-beta brain waves begin to change during the sleep phase. We used a wavelet transform to undertake the function of detecting when the alpha-beta brain signals changed to 50 microvolts, which signaled when the sleep phase commenced, and then applied associative memories with the modified Johnson Möbius code. The optimization approach utilized simple genetic algorithms, a computational search heuristic that mimics the process of natural selection. The process involved 100 generations and associated mutation, selection, and crossover processes. The alarm system was based on a surface electrode that transmitted less than 5 V/1 mA charge when the sleep condition was met. Also, a secondary stimulus was provided by an orange light emitting diode. The power to the system was supplied by a set of 8 solar cells at 0.5 V and 280 mA.
The system was 95% efficient in detecting sleep. When applying genetic algorithms with fewer than 100 generations, the detection rate dropped to 80%, and when more than 100 generations were used, this rate dropped further.
Artificial intelligence and signal processing techniques are excellent tools for the development of biomedical devices for use in aerospace operations. The device was shown to be a highly efficient device to detect sleep and wakefulness and thus can be a useful for pilots performing long-haul flights to mitigate the risks posed by fatigue.

Contribution ID: 969
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Portable device for neurophysiological exploration of the human vision

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Neurophysiological testing of visual perception in humans represents a sensitive method used in neurology, neuroophthalmology, or psychiatry (Holder, Celesia, Miyake, Tobimatsu, & Weleber, Clinical Neurphysiology 2010; Odom et al., Documenta Ophthalmologica, 2016), and it is often used in brain computer interface systems (Bin et al., Journal of Neural Engineering, 2011; Wang, Wang, Gao, Hong, & Gao, IEEE Transactions on Neural Systems and Rehabilitation Engineering, 2006). However, current approaches for recording of neural data linked to visual stimuli are not robust enough; especially the timing of visual stimuli may be delayed due to a PC multitasking environment interfering with the stimulation or slow responses of, mostly LCD, stimulators. Another limitation may be a demand for a laboratory registration environment.
To eliminate the above limitations, we have designed a device synchronously controlling visual stimulation and data acquisition. Stimulator with 2 x 16 LEDs, noise-resistant EEG amplifiers, analog-to-digital converter and micro-controller are built into a compact headset.
With a sub-milliseconds accuracy, the device triggers light stimulus and simultaneously records 4 EEG channels at 1 kHz sampling rate. In the same time and with the same precision, it also allows registering of the reaction time. The device is also equipped with an accelerometer, allowing to monitor a movement of examinee’s head and to adapt the acquisition/stimulation procedure accordingly. It is also possible to evaluate changes in ambient lighting and consequently control stimulus parameters.
The device is particularly suited for recording of Electroretinograms (ERG), Visual Evoked Potentials (VEP), or Event Related Potentials (ERP) evoked to luminance or color changes of the visual stimuli. The device is connected with an analyzing PC via a USB port. The registration,stimuli design and delivery is controlled from MATLAB environment.
The device development and manufacturing was supported by the project of Charles Univ. PROGRES Q40/07.

Contribution ID: 988
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Diagnosis of lower urinary tract dysfunction from uroflowmetry-emg signals

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Lower Urinary Tract Dysfunction (LUTD) is a disease which is commonly seen among children. Frequent urination, urinary incontinence, feeling of tightness, poor urine flow, etc., are symptoms of LUTD. There are different ways for diagnosis of LUTD. The most popular method is Uroflowmetry-Electromyography (UF-EMG) test in which both UF and EMG signals are recorded synchronously. The main aim of this study is to classify UF-EMG signals with different classification methods and determine which method will Show the best classification performance. These results are expected to provide physicians supplementary information for diagnosis. Three different classification methods were used for this study. These methods are Support Vector Machine (SVM), Artificial Neural Networks (ANN) and K-Nearest Neighborhood (KNN). In literature there are studies generally discuss the physiological reasons of this syndrome rathen than focusing on computer-aided diagnosis. Few studies investigate Uroflowmetry signals alone and classify these signals using a single learning algorithm. In this study UF-EMG signals are analyzed and the outputs of

SVM, DTL and KNN are classified into three groups, which are, 'healthy', 'possibly pathologic' and 'pathologic'. UF-EMG signals which were used in this study were obtained from Urodinami Center of Gulhane Education and Research Hospital. Average age of patients is 8 of total 967 patient data. %80 of the data were used for training of the system and other %20of the data were used for the test. All dataset has been analyzed by specialists and the accuracy, sensitivity and specificity values of the learning algorithms are calculated considering specialist judgment is gold standard.

Contribution ID: 990
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

An investigation of changes in myoelectric control features during muscle fatigue based on a surface electromyogram signal

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Surface Electromyogram (sEMG) is a non-invasive approach to measure the electrical biopotentials of muscle activation. The changes in amplitude and frequency of this biological signal can be observed during the muscle contraction and can be used to identify the intention of performing a body movement. Accordingly, sEMG can be used as an interface between human and machine, a so-called Myoelectric Control System. The system has been investigated for decades to achieve an intuitive approach for arm prosthesis control. However, the sEMG signal can be influenced by several factors that cause unreliability to the system, e.g., electrode shifting, sweating, crosstalk among muscles, etc. Therefore, attempting a novel approach, which is able to handle these influences, has become an issue to be explored.
In this study, muscle fatigue, a situation in which a muscle is unable to maintain the required force, is being investigated. The situation occurs slowly during the use of myoelectric control system. However, there are just a few studies which investigated the effects of muscle fatigue on its use as a controlling source. sEMG signals of muscle contraction are recorded from biceps brachii muscle during a dynamic movement exercise. The popular feature extraction methods as frequently used in myoelectric control systems are selected among three different domains, i.e., time, frequency, and time-frequency domains. Features are extracted from sEMG signals, recorded from healthy muscles during fatigueing exercises with either of the 3 methods. Then, the changes of the feature are analyzed and compared. This investigation leads to a selection of features for myoelectric control, which appear robust to the muscle fatigue. Furthermore, the dynamic behavior of an adaptive myoelectric controller to muscle fatigue could be explored.

Contribution ID: 1022
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Power spectral density analysis in spindles epochs in healthy children

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Sleep spindles are important components of the N-REM stage-2 in the sleep EEG. In particular, sleep spindles are oscillatory EEG activities of fusiform morphology in the range of 11-15 Hz and duration between 0.5-3 seconds. Several studies consider spindles because they have been associated with cognitive skills and with sleep-dependent memory consolidation. The aim of this study is to assess differences in the before ("pre"), during ("dur") and after ("post") spindle epochs by means of main power spectral bands delta (0.5-4 Hz), theta (4-8 Hz), alpha (8-13 Hz), beta (13-30 Hz), gamma (30-45 Hz), total (0.5-45 Hz) and spindle bands (11-15Hz), calculated by the Welch periodogram, and by Fractal dimension (FD). The analysis was carried out on 7 healthy children (mean age=8.9±1.34 years) deprived of sleep on the day of the acquisition to enhance the deep sleep during the recording. For each EEG record (standard 10-20, 19 electrodes, sampling rate 512 Hz), two neurophysiologists labeled the start and the end points of the three sleep epochs. The results showed statistical differences between "dur" and both "pre" and "post" epochs in almost all channels (except O1 and O2) for all bands, except delta and gamma. Furthermore, also the values of FD were significantly different between "dur" and both "pre" and "post" epochs, for all channels while in "post" epochs, the FD values were similar to those in "pre" periods. The FD values in "dur" epochs were smaller than in both "pre" and "post" ones, showing a lower EEG complexity during spindles, compared with the "pre" and "post" epochs. These differences could be useful to comprehend the generator system of the spindles and their changes during sleep time.

Contribution ID: 1036
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Round cosine transform based feature extraction of motor imagery EEG signals

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BACKGROUND: Brain Computer Interfaces (BCIs) are systems with great potential for the rehabilitation of people with severe motor injuries. By analyzing a subject's brain waves, it is possible to detect patterns and translate his "thinking" into device commands, like prosthesis or a robotic arm. METHODS: This research presents an EEG processing method, which is capable of detecting patterns of the subject's motor imagery, splitting the patters in left or right hand imagery. The proposed method considers the Round Cosine Transform (RCT), a low computational complexity transform, and an artificial neural network module which identifies the patterns. The method is tested in a real time continuous EEG processing experiment simulation, controlling a mouse arrow horizontally on a screen based on the subject's imagery motor activity. The performance of the proposed method is evaluated in terms of the mutual information (MI), classification time and misclassification rate (%). RESULTS: A 10-fold cross validation analysis, with test data, resulted in a mean accuracy of 84.4%, a signal-to-noise-ratio (SNR) of 0.99, a time for classification of 5.25 s, and a value of 0.49 for maximum MI bits for the classification of the EEG signal between the left and right hand classes. CONCLUSION: The use of the RCT makes the system faster and simpler than it would be with other feature extraction methods, which makes it an attractive approach for the fast processing of EEG.

Contribution ID: 1118
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Assessment of micro t-wave alternans using t-wave morphology-based methods

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Microvolt T-wave alternans (MTWA) is a risk marker for life threatening arrhythmias, defined as beat-by-beat alternation of the T-waves amplitude. The classical method (CM) for MTWA requires accurate determination of T-wave peaks, making it sensitive to noise. This study assessed methods prescinding T-wave peak detection, as appropriate alternatives for MTWA assessment. Fifty-three low noise ECG recordings from PhysioNet T-Wave Alternans Database were assessed, using channels 1 and 2. A sequence of 128 sinus beats were extracted from each signal after removing baseline drifting and respiratory interference. The FFT of the series of the 128 T-wave peak values was employed to perform CM, taken as reference. Further, 300 ms windows containing whole T-waves were isolated and consecutively concatenated, composing an artificial continuous T-wave (ACT) signal. Two MTWA methods were investigated over ACT: i) Hilbert Transform approach (HT) –assessed by the FFT of the ACT envelope, calculated by HT; ii) Short-time spectral approach (STS) – assessed in the average of 96 FFT obtained from windows with 32 consecutive T-waves displaced one by one. MTWA was assessed as ‘alternans ratio’, defined as the alternans peak divided by the SD of 10 harmonics vicinal to the peak. CM vs. HT and CM vs. STS were compared by correlation coefficient, Bland-Altman charts and ROC. Correlation coefficient were, respectively, 0.910 and 0.963 for channel 1, and 0.841 and 0.930 for channel 2 ($p<0.001$ for all). Bland-Altman plots showed nonsignificant (NS) differences (respectively, $\chi^2=0.017$; $p=0.87$ for channel 1, $\chi^2=0.04$; $p=0.83$, for channel 2). The area under ROC curves of CM, HT and STS were, respectively, 0.75, 0.80 and 0.71 for channel 1, and 0.77, 0.80 and 0.70 for channel 2 (p=NS for all). As a conclusion, quantification of MTWA based on T-wave morphology analysis is feasible, accurate and reproducible, and have potential clinical application.

Contribution ID: 1159
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Preprocessing of the BSPM Signals with Untraditionally Extreme Baseline Wandering

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The BSPM is a special setup of the ECG measurement with many of electrodes (20-256) on the body surface. Results of the measurement are strongly dependent on many conditions like body shape, contact of electrodes and skin, patient position and movements. Of course, these conditions are crucial also for standard ECG measurement, but obviously, problems with the conditions are more probable during the BSPM signals acquisition.
In this paper, we would like to present a problem with the Body Surface Potential Mapping (BSPM) ECG preprocessing caused by unexpected signal interruption due to the rapid baseline wandering and derivated problems which are generated by solving of this rapid baseline wandering filtration.

This issue is significant for next signal processing (mainly ECG delineation) because the baseline wandering problem is intimately connected with the determination of ECG signals' isoline.
Within a joint project of Czech Technical University in Prague and University Hospital Motol in Prague, we aim to electrical and mechanical heart dyssynchrony for cardiac resynchronization therapy (CRT). The BSPM signals are one of the essential data in this issue. For BSPM acquisition, we use a system of 120 electrodes on body front and back. The experimental measurements are arranged in the clinical environment with maximal treatment to electrodes position and contact of electrodes and skin at the beginning of the measurement. Unfortunately, obtained signals contain often extreme baseline wandering bedsides of standard artifacts. This baseline wandering seems to be created most likely by patient movements and a change of the electrodes contact. Moreover, we have observed that the standard artifact filtration and the extreme baseline wandering filtration are against each other.

Contribution ID: 1193
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

A new approach of brain source position estimation based on the eigenvalues of the EEG sensors spatial covariance matrix

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Abstract – Electroencephalography (EEG) measurements are widely used for clinical analysis and research due to present valuable information about neural activity and for their noninvasive nature. This activity reflects characteristics and behaviors linked to functions and disorders, including epilepsy syndromes. Partial epilepsy is defined as a seizure that is originated only on a neuron group and shows high drug resistance. In such cases, surgical interventions are recommended and the accurate location of the seizure becomes a sine qua non prerequisite for those procedures. Brain source position estimation can help in the selection and classification of brain spots related with seizures, and whether or not surgical intervention is possible. Direction of Arrival (DOA) estimation methods can be adapted to the EEG interface in order to estimate the sources positions inside the brain. Then, this article proposes a new DOA method that estimates the source positions from spectral peaks produced by the eigenvalues of the sum of the spatial covariance matrices of the measured EEG signals and of a simulated source that is numerically swept throughout every point on different horizontal layers of the brain. The key approach was to select the eigenvalues that were less affected by the noise and use them to produce the search spectrum. In order to assess the accuracy and robustness of the proposed method, we compared its RMSE performance at different SNRs to those of MUSIC, a method based on orthogonal subspaces, and NSF, a method based on subspace fitting. The proposed method showed the lowest SNR threshold and the highest estimation accuracy under noisy conditions.

Contribution ID: 1204
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Do physiological responses change with the difficulty level of a casual videogame?

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Videogames have been used in psychophysiology as cognitive tasks, which may pose different demands depending on the interactions between player skills and game difficulty. This work aimed at comparing cardiorespiratory and electrodermal activity (EDA) responses of healthy individuals playing three difficulty levels of a casual videogame. Electrocardiogram (ECG), respiratory gas flow and EDA were recorded during rest and game playing from 30 male subjects (24±3.1 years old), who also filled a Positive and Negative Affect Schedule (PANAS) state questionnaire. Game scores and moves were also recorded at each level. All subjects played the easiest, tutorial level first; half played the game in increasing levels of difficulty. Respiratory indices -- respiratory period (RP) and its variation coefficient (RV) -- and heart period variability (HPV) indices -- RMSSD and SDNN of interbeat intervals (iRR) -- were computed. Respiratory Sinus Arrhythmia (RSA) was measured as the amplitude of the averaged interpolated iRR from all respiratory cycles at each period. Average positive affect score (29±6) suggested engagement (negative affect score of 15±5). The comparison of the hardest with the other 2 levels, and of resting periods with gameplay showed, respectively, significantly different scores and physiological indices. During gameplay, HPV, RSA, RP and RV decreased. EDA response, measured as the time-normalized sum of phasic peaks, varied among subjects, being the highest, for 12 of the subjects, mostly during the last resting period, instead of during gameplay like the others'. RSA correlated with classical HPV indices ($r>0.7$) and RP ($r=0.66$); the latter finding suggests accounting for respiration in RSA analysis. Physiological responses to a casual videogame exist, although eliciting their dependence on the difficulty level may require careful design of the game. Further analyses may require modeling factors such as skill level, expectations, skin conductance and other individual characteristics. Work approved by the HUCFF/FM/UFRJ Ethics Committee.

Contribution ID: 1232

9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Study of the reading activity through the processing of EEG signals, using an approach of the FDFA fluctuation function

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The process of reading is considered as a complex and little-known brain activity, since it involves the sense of vision, and brain functions such as memory, motor control, learning, among others, are present. On the other hand, there are few studies on the subject of learning and knowledge regarding the tasks of reading texts, by quantitative studies with EEG. A quantitative EEG experiment was carried out to study the text reading activity, using a novel approach that employs the detrended fluctuation analysis method (DFA), reported by our group. The experiment was characterized by the reading of a specific text, performed by two people, while 22 EEG channels recorded all the brain activity through the NEUROMAP model EQSA260. We also added to the experiment the recording of the vocal signals through an MP3 format recorder, with a rate of 128 Kbps in a shielded environment ranging from 42-46 dB. The volunteers were laid out in such a way that they could have visual access to a monitor with the text being read, thus excluding involuntary movements that activated regions of the brain that were not being stimulated by reading. For a subject, the text was presented with sufficient time for it to be learned, and for the other, we present the text only at the time of reading. For the analysis of the results the bioelectrodes Fpz23, F322, F637, T943, Cz11, T1044, P349, P654 and Iz64 were chosen. All distributed in the regions: frontal, parietal, temporal and occipital. The results of the correlation of multi-channel EEG biosensors have demonstrated that the use of the ΔlogFDFA function may be useful for the study of complex superior brain activities, such as reading of texts, in the area of neuroscience.

Contribution ID: 1322
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

An M/EEG analysis pipeline for event related source connectivity estimation

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Emerging evidence in the field of neuroscience supports the notion that complex cognitive functions depend on the interaction among a widespread distribution of cortical areas, which are topologically described with tools of contemporary network science. Within this framework, we propose an analysis pipeline, assessing the large-scale functional connectome of human brain, as derived from event related M/EEG data. This approach has been successfully applied to previous studies of our group (Paraskevopoulos et al. 2015; Paraskevopoulos, Chalas, and Bamidis 2017). Brain Electrical Source Analysis software (BESA research, version 6, Megis Software, Heidelberg, Germany) is utilized to pre-process the collected M/EEG data, including filtering, rejection of the artifacts, epoching and averaging across trials. Thereafter, averaged trials are used to calculate current density reconstructions (CDRs) at each sample-point for the complete response time-window, while using an individualized FEM model for the forward problem solution. Images are then processed with a mask, excluding deep sources such as the brainstem and cerebellum so that voxel time-series are extracted from physiologically plausible space. Connectivity between the corresponding sources is estimated by using an information theory metric, via the HERMES toolbox within MATLAB environment. Lastly, adjacency matrices representing brain graphs are inserted into Network Based Statistics to extract the statistically significant -node to node-connections. Calculations are based upon a general linear model corrected for multiple comparisons. The significant network, is then visualized via BrainNet viewer. Finally, network characteristics (node strength, density, clustering coefficients, global efficiency etc.) are investigated, adapting functions from Brain Connectivity Toolbox. Examples of application of this methodology will be presented, focusing on neuroplastic reorganization of the cortical network due to musical training. Overall, the proposed functional connectivity pipeline provides a user-friendly and well-certified analysis of event related M/EEG data through a network science's intuition, contributing in a fertile ground within the community.

Contribution ID: 1362
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

A novel dipole source estimation of motor imagery eeg

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The analysis of Motor Imagery EEG（MI-EEG）always play a significant role in brain computer interface. Although the EEG signals collected from scalp have a high time-frequency resolution, it merely contains limited and partial available information related to the corresponding MI-task in sensor domain. With the development of brain neurology, the EEG Source Imaging (ESI) has been generated to convert the scale potential into the dipole of brain source space. However, in the traditional data preprocessing of ESI, the raw EEG signals are usually decomposed to independent components, and the most relevant component to MI-tasks is selected as the input of ESI

algorithm to generate the estimated value of dipole in source domain. This process may result in loss of partial information from the raw EEG, which conflicts with the purpose of amplifying the information of EEG while transforming sensor domain to source domain. So, a novel Dipole Source Estimation (DSE) is proposed by applying Minimum Norm Estimates (MNE) and overlapping averaging in the temporal domain to solve the EEG inverse problem in this paper. Firstly, the evoked response of each channel is yielded by means of overlapping averaging the identical segment of a kind of MI-EEG. Secondly, the evoked signal corresponding with every sampling point for multiple channels is applied to compute the dipole source estimation in the complete time series using MNE. Finally, the dipole values around the maximum peaks are averaged and the set of dipole source estimation are put to the virtual brain model to visualize cortex topological information. Based on a public dataset with 64-channels of MI-EEG, a large number of experiments are conducted, and the experiment results show that DSE can obtain more comprehensive information with higher spatial resolution, which is beneficial to decoding MI-tasks in source domain.

Contribution ID: 1379
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

The automatic detection of epileptic seizures based on EEG signals processing: investigation of different features and classification algorithms

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Automatic detection of epileptic seizures has been extensively studied and documented in literature. However, the topic continues to be of interest as reliable algorithms for off-the-shelf, general use are still being investigated. The challenge comes from the complex nature of the EEG signal and of the epileptic seizure, as both show patient specific characteristics. This makes highly performant algorithms developed on a specific dataset difficult to translate to a more general application of the developed models.
To provide more insights into the characteristics of seizure and non-seizure EEG segments, this paper proposes and investigates several features. In the time domain, we examined the maximum signal amplitude, skewness, kurtosis and entropy. For the frequency domain, relevant values were extracted as the maximum power spectral density and the corresponding frequency, the mean power in the gamma, beta, alpha, theta and delta bands. After a statistical analysis, several feature combinations are selected and fed per patient to both an SVM and Random Forest classifier. Both the training and test datasets are part of the PhysioNet, CHB-MIT Scalp EEG Database containing pediatric EEG recordings for subjects with intractable seizures.
The performance of the trained models varied per patient, feature combination and training algorithm, with the highest accuracy reaching 94%. The random forest classification performed better in most of the cases. Using only frequency domain features resulted in a poorer performance than for the combination of time and frequency domain features. Results suggest that training patient specific models would enhance detection accuracy.

Contribution ID: 1451
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Simulation, modification and dimension reduction of EEG feature space

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EEG is a quasistationary signal that consists segments with characteristic graphoelements of physiological and non-physiological condition and artefacts. In clinical practice and research, the EEG recordings are usually segmented and subsequently classified into classes (with similar characteristics) according to their features. There are hundreds of features described in the literature, both in time and frequency domain. In this study, we focus on a simulation of a feature space, characteristics of the features and their relations in the feature space. Using linear and non-linear dimension reduction methods (e.g. PCA, tSNE), we evaluate visually the distribution of features in 2D space and separability of classes.
Characteristic segments of physiological brain activity, epileptic activity, muscle artefacts and electrode artefacts are chosen from the real EEG recordings by the DBSCAN method based on density and the expert. We calculate features for each chosen EEG segment and we create boxplot for each feature. We simulate a feature space based on the interquartile range from the boxplot and we analyse intergroup and intragroup feature correlations of segment classes. We apply methods for dimension reduction on simulated data with known number of classes and we verify the number of classes by evaluating the number of separable clusters. The main goal of this study is to create a database of typical values of EEG features and validate the methodology of feature space simulation.

Contribution ID: 1455
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Assessment of early muscle fatigue in type 2 diabetes with and without diabetic peripheral neuropathy using high density surface electromyography

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Diabetes Mellitus (DM) is a chronic disease that affects millions of people around the world. Among many complications caused by this condition, the most common is Diabetic Peripheral Neuropathy (DPN), affecting 50% of the DM population; impairing motor and sensory functions. The clinical motor symptoms include loss of muscular strength in the inferior distal muscles, mainly those with bigger proportion of type I fibres, such as the Tibialis Anterior (TA). The objective of this work was to evaluate motor dysfunctions caused by DPN in the TA muscle, through analysis of High Density Surface Electromyography (HD-sEMG) signal parameters. In order to assess these variations, HD-sEMG signals were recorded from the TA muscle, during 50% of maximum voluntary isometric dorsiflexion, for the period of 30 s using an 8x4 matrix of electrodes. The test was performed in healthy subjects (n=6) and type 2 DM individuals with DPN (n=6) and without DPN (n=6). The parameters used to assess motor dysfunctions were Root Mean Square (RMS) and Mean Frequency (MNF). The differences were investigated with a linear model with interactions, considering a 5% level of significance. For the RMS parameter, there was a significant difference between the intercept values of the three groups, control (53.8±1.8 μV), DM without DPN (38.4±2.6 μV) and DM with DPN (30.0±2.79 μV), but there was no significant difference in the rate of change of the variable. As for the MNF parameter, there was a significant difference in the rate of change

between the control group (-0.30±0.18 Hz/s) and DM with DPN (-0.86±0.20 Hz/s), showing that MNF in individuals with DPN decrease significantly faster. Therefore, the results indicate that individuals with DM show premature muscle fatigue only when evaluating MNF. Meanwhile, the RMS variable was only able to distinguish the intercept value between the groups.

Contribution ID: 1467
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Extraction and analysis of VLF, LF and HF components from R-R time intervals during hemodialysis by applying the wavelet transform

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Patients suffering chronic renal failure undergo hemodialysis (HD) therapy to improve their living condition. Almost 30% of these patients experience an episode of intradialytic hypotension, where the autonomic nervous system (ANS) plays a key role given its control on peripheral organs. The state of the ANS and other mechanisms acting on controlling blood pressure during HD, can be evaluated indirectly through the spectral analysis of heart rate variability (HRV), obtained from R-R time intervals or tachograms. Extraction of energy within the low-frequency (LF: 0.04-0.15 Hz) and high-frequency (HF: 0.14-0.4 Hz) bands from tachograms is necessary for this evaluation, since they are related to the activation level of the sympathetic and parasympathetic systems, respectively. Wavelet Transform (WT) is a time-frequency analysis that does not require stationarity of the signal for its processing. Traditional analysis of the HRV neither has been reported in recordings acquired during HD therapy, nor including the very low-frequency band (VLF: 0.003-0.04Hz), which is believed to contain information about parasympathetic modulation, temperature regulation and renin-angiotensin system. In this study, we analyzed tachograms extracted from 3h long ECGs recorded from 20 patients during HD. Raw tachograms were processed by continuous WT (CWT) to obtain the time-frequency representation, and later inverse continuous WT (ICWT) was done to recover the VLF, LF and HF components. Trends in tachograms were not removed prior to WT analysis to avoid the possibility of eliminating information in the VLF band. Analytic Morse wavelet was used to perform both CWT and ICWT. Sum of powers were normalized to unity before correlation analysis. Results obtained for VLF, LF and HF bands were r=0.649 (p<<0.05), r=-0.716 (p<<0.05) and r=-0.044 (p=0.792), respectively. This suggests that the activity of hormonal and modulatory mechanisms present in the VLF band increase during HD to compensate changes in blood pressure.

Contribution ID: 1470
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Optimal window for the estimation of very low frequency content in heart rate variability analysis

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The spectral analysis of the heart rate variability (HRV) is an accepted method for assessing the autonomic control of the cardiovascular system. The electrocardiographic recordings used to extract the duration between consecutive R waves (RR intervals or tachogram) consist of 5 minutes or 24 hours, according to the recommendations of the TASK FORCE. The three frequency bands studied are the VLF (0.003-0.04 Hz), the LF (0.04-0.15 Hz) and the HF (0.15-0.4 Hz), which are associated with cardiovascular modulatory mechanisms. Due to the fact that the estimation of VLF in 5 minutes recordings is unreliable and that in some circumstances (orthostatism, controlled breathing, etc.) it is not possible to obtain 24 hours recordings, it becomes necessary to consider other window sizes in order to estimate it with greater certainty. To show how the size of the window affects the estimation of the power spectral density, synthetic signals were evaluated using the Welch periodogram, comparing the power and spectral resolution obtained with conventional 5 minutes windows versus windows that ranged from 300s to 4000s with increments of 300s. Noise-free signals were generated, contaminated with white Gaussian noise and mounted on a linear trend, to approximate the conditions of a real tachogram. The results suggest that the optimal size of the analysis window is 50 minutes, decreasing the power estimation error of the VLF band from 24.91% to 8.06%, increasing the spectral resolution and increasing the confidence in the evaluation of the three frequency bands defined for the HRV, especially for the VLF. These results suggest an alternative analysis for recordings with duration less than 24 hours but that require evaluating the VLF, as in the HRV recordings of patients during their hemodialysis session.

Contribution ID: 1524
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Recent advances in sleep neuroscience for extreme environments and its terrestrial applications

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Sleep is an important aspect of mental and physical well-being. However, it is deteriorated in extreme environments, ageing or due to non-healthy life style profile. Recent neuroscientific research provides contemporary mathematical tools for studying co-operative activity among distant brain regions or brain-heart interactions during sleep. We propose a novel and integrative neuroscience framework for analyzing polysomnographic data, derived from both the European Space Agency (ESA) RSL head down tilt (HDT) bed-rest study and the SmokeFreeBrain (SFB) project. SFB is an ongoing, smoking cessation program through varenicline intervention (http://smokefreebrain.eu/). The RSL study investigated whether microgravity deteriorates sleep quality and if reactive-sledge jump countermeasure, performed by a training group would

ameliorate the detrimental effects of microgravity. RSL analysis was initially focused on the light sleep stage (N1) during the baseline data collection (BDC) period and 21 days after the initiation of the HDT period. It estimated the spectral electroencephalographic activity and revealed a significant main effect of time for high beta (18-22 Hz) and gamma rhythm (22-40 Hz). There was also a time by group interaction since the training group increased theta (4-8 Hz) and alpha (8-12 Hz) during HDT21. Further analysis on the Default Mode Network (DMN) activity on the same frequency bands verified these results. Control participants failed to inhibit DMN activity on the anterior DMN nodes, increasing their functional connectivity with posterior regions statistically significant. There were also significant changes in the brain-heart interaction which was dependent from the experimental phase, study group and sleep stage. These results demonstrate that extreme conditions deteriorate sleep quality but this effect is partially reversible in case of physical activity increase. This analysis is currently employed additionally to the manual sleep staging in the SFB to identify the mechanisms that induced sleep macro-architecture alterations due to both the varenicline treatment and smoking cessation.

Contribution ID: 1675
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Respiration monitoring by combining EMG and bioimpedance measurements

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A common technique to measure diaphragm electrical activation (EAdi) is the acquisition of the occurring electromyography signals using surface electrodes. One of the major problems of this technique is its sensitivity against motion artifacts. Forces or vibrations can influence the electrode skin contacts, which generate changes of the electrodes' half-cell voltages as well as the electrode skin impedance. Both effects result in noise in the same frequency range as the typical electromyography signal and therefore it's hard to separate these distortions from the desired signal.
Another technique to detect muscle contractions is the electrical impedance myography. By applying a small alternating current to the tissue of interest and measuring the occurring voltage drop, the bioimpedance can be determined. It contains the information about muscle contractions and relaxations. The major advantage of this technique is, that the impedance information is coded as the amplitude modulation of that voltage drop. The frequency of the excitation current is typically chosen in the range of tens of kHz and thus can easily be separated from the above mentioned artefacts.
This work describes a measurement setup which is capable of acquiring electromyography as well as bioimpedance signals simultaneously, sharing the same electrodes. An analog circuit is presented which combines the information of both measurement techniques, allowing their common analog-to-digital con-version by a single converter. The system is capable to acquire 1000 bioimpedances/electromyography samples per second with a resolution of 24 bits.
First measurements show that signal distortions, caused by vibrations at the electrodes, are attenuated significantly in bioimpedance measurements.

Contribution ID: 1717
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Stable EEG spatiospectral sources using relative power as group-ICA input

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Within the last decade, various blind source separation algorithms (BSS) isolating distinct EEG oscillations were derived and implemented. Group Independent Component Analysis (group-ICA) is a promising tool for decomposing spatiospectral EEG maps across multiple subjects. However, researchers are faced with many preprocessing options prior to performing group-ICA, which potentially influences the results. To examine the influence of preprocessing steps, within this article we compare results derived from group-ICA using the absolute power of spatiospectral maps and the relative power of spatiospectral maps. Within a previous study, we used K-means clustering to demonstrate group-ICA of absolute power spatiospectral maps generates sources which are stable across different paradigms (i.e. resting-state, semantic decision, visual oddball) Within the current study, we compare these maps with those obtained using relative power of spatiospectral maps as input to group-ICA. We find that relative EEG power contains 10 stable spatiospectral patterns which were similar to those observed using absolute power as inputs. Interestingly, relative power revealed two -band (20-40Hz) patterns which were present across 3 paradigms, but not present using absolute power. This finding suggests that relative power potentially emphasizes low energy signals which are obscured by the high energy low frequency which dominates absolute power measures.

Contribution ID: 1769
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Design of Android mobile application for open-source brain-computer interface

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In this work, a prototype of mobile application to process biosignal captured using OpenBCI Cyton is designed. OpenBCI Cyton is an open-source, medical-grade brain computer interface (BCI) board for capturing biosignal using eight channels at 250 Hz frequency. The hardware utilizes Bluetooth Low Energy (BLE) to transmit data to USB dongle connected to remote host, after which the signal can be observed and saved using OpenBCI's graphical user interface (GUI).
Due to its small size and open-source nature, OpenBCI Cyton has great potential for low cost mobile BCI implementation. However, by default, the GUI is only available for PC. Furthermore, the board's firmware currently does not support direct communication with other BLE devices such as mobile phones, thus inhibiting the mobility. To address this, a prototype of mobile application to communicate with OpenBCI Cyton is developed. There are three points to be considered during development; first, the application must be interfaced to communicate with the USB dongle. Second, it must be able to process data at speed suitable with the board's sampling rate. Third, the application must be verified to ensure the final data correctly represents the captured signal.
The application is developed for phones running Android 4.1 and above, and the phone must support USB on-the-go feature. Additional libraries are used to enable communication with the

USB dongle and data processing: Java D2xx driver, Apache Commons Math, and MPAndroidChart.
Currently, the application can capture raw test data from the board in real time. For the next phase of the work, digital filter will be implemented, and the application will be tested using the board's built-in test signals. The result is aimed to serve as foundation for further BCI research in other applications.

Contribution ID: 1794
9. Biosignals Processing
09.06. EEG, MEG, ECG, CTG, EMG, MEG, ERG signal processing

Evaluation and comparison of conductive carbon black and polydimethylsiloxane electrodes for long term ECG monitoring in harsh environment

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The human heart is a muscular organ whose function is to pump blood through the body via the circulatory system. Before every heartbeat, electric potential goes through the whole heart causing its contraction. Using the electrodes placed on human chest or limbs it is possible to monitor and record the direction and magnitude of generated electrical potential. Graphic recording from so recorded signal is also known as electrocardiogram (ECG). Long term ECG monitoring during regular daily activities or sports represents an important physiological parameter in determining the potential heart related diseases, general health or physical condition of the human. In such monitoring, standard and very accurate adhesive gel electrodes are often uncomfortable and may cause skin irritations or allergic reactions. Therefore, dry electrodes could be used as a solution. Dry electrodes can be made of different materials, such as stainless steel, silver, AgCl (dry), textile etc., but in this paper, we will talk about self-made electrodes from conductive carbon black and polydimethylsiloxane (CB/PDMS). For electrode comparison, ECG monitoring was done with different electrodes, with CB/PDMS electrodes and standard adhesive Ag/AgCl electrodes, placed according to Einthoven's triangle. In experiments, beside different electrodes, we also used two different wearable devices, self-development device and commercial device Shimmer. All measurements were designed and done in order to get suitable signals so it can be used for normal ECG feature extraction. CB/PDMS electrodes also did not seem to cause skin irritation.

Contribution ID: 150
10. Biomechanics, Rehabilitation and Prosthetics
10.01. Orthopaedic biomechanics

Stability after high tibial osteotomy: Effect of screw length

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Locking plate is widely used during medial opening wedge high tibial osteotomy as it provides satisfactory mechanical stability. However, several factors may affect the stability after medial opening wedge high tibial osteotomy using locking plate. We aim to determine the effect of screw-length on the stability after medial opening wedge high tibial osteotomy.

We randomly allocated 40 tibiae from fresh-frozen cadavers into 3 groups. MOWHTO was performed using locking plate (TomoFix®). Three groups received different surgeries in relation to the length of the proximal screws. Group A was fixated bicortically, while group B and C were fixated using shorter screws: 90% and 55% of drilled tunnel length, respectively. We defined the Group B as standard group. There was no difference in the demographics, tibial plateau size and tunnel length between these groups. Operated tibiae were tested under axial compressive load using material testing machine. The medial gap change under axial load of 100, 200, 300, 400, 500, 600N and ultimate failure load were measured. The medial gap change showed an increasing tendency as the screw length was getting shorter, but the difference was not significant between group A (bicortical fiaxation), B (90% length-screws) and C (55% length-screws). The difference of ultimate failure load was also not significant between these three groups. Unicortical fixation in proximal screw holes of a locking plate was not inferior to the bicortical fixation regarding axial stability in MOWHTO, although too short proximal screw should be avoided.

Contribution ID: 209
10. Biomechanics, Rehabilitation and Prosthetics
10.01. Orthopaedic biomechanics

The piezoelectric effect in ultrasound for cancellous bone

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The bone is stimulated by bone fluid flow, electrokinetic effect, and/or piezoelectric effect. General governing equation is derived for bone poroelasticity in cancellous bone. Two waves, a fast and a slow waves are observed. Two terms, electrokienetic effect and piezoelectric effect are included into general poroelasticity theory. The newly formed governing equations are solved numerically. A fast wave velocity and attenuation are significantly affected by electrokinetic effect, but a slow wave velocity and attenuation is not changed as much as a fast wave does. As the term for piezoelectic effect is considered, the piezoelectric effects are not sensitive for both fast and slow wave, but the confirmation for using this term is necessary by comparing it's result to other formulation, such as the formulation using energy concept. This results can be in use for therapeutic ultrasound for cancellous bone.

Contribution ID: 225
10. Biomechanics, Rehabilitation and Prosthetics
10.01. Orthopaedic biomechanics

Bone-anabolic action of low-intensity whole-body vibration and the involvement of bone vascularization in juvenile mice

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This study was undertaken to evaluate the effect of low-intensity whole-body vibration (WBV) on bone formation during growth. Experiments were conducted with an approval of the Animal Research Committee of Tokushima University. Male C57BL/6J mice aged 6 weeks were randomly assigned to four groups (n=8 each): C2, W2, C4, and W4. Mice in W2 and W4 were exposed to WBV (0.3g at 90Hz) for 20min every day, and mice in C2 and C4 received a non-vibrated sham treatment. After 2 weeks of treatment, mice in C2 and W2 were thoracotomized under isoflurane anesthesia, euthanized by pentobarbital overdose (i.p.), and perfused with zirconia-based vascular

contrast-casting agent (Zr-CA) from the left ventricle. The animals immersed in ice-cold water for solidifying Zr-CA, and then the right tibia was harvested and fixed with 4% paraformaldehyde. Mice in C4 and W4 were subjected to vascular casting similarly after 4 weeks of treatment. The proximal metaphyseal portion was scanned by synchrotron light at 17.9 and 18.1 keV, below and above the zirconia k-edge respectively. The two scan data sets were reconstructed, and vascular and bone images (2.7-μm voxel resolution) were obtained through image subtraction. The volume fraction of cancellous bone (B.Vf) and the number density (V.Nd) and diameter (V.D) of marrow blood vessels were tested for significance of between-group differences by Mann-Whitney U test. These indexes did not differ between C2 and W2. However, both B.Vf and V.Nd were higher in W4 than in C4 (4.8±0.6 vs. 4.1±0.6% and 1114±193 vs 707±443 /mm3, respectively), and V.D was lower in W4 than in C4 (17.6±3.5 vs. 20.2±3.7 μm), resulting in similar vascular volume fraction in W4 and C4 (1.7±0.5 vs. 1.6±0.7%). These results suggest that WBV facilitates bone formation during growth, and this bone-anabolic effect may be associated with the modulation of bone vascularization.

Contribution ID: 226

10. Biomechanics, Rehabilitation and Prosthetics

10.01. Orthopaedic biomechanics

Methods of motion assessment of clever orthosis of upper limb for rehabilitation at the clinic and at home

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The aim of this work is to describe proposed and tested methods for evaluation of short-term and long-term movement activity of a clever orthosis for the upper limbs during a rehabilitation process. To quantify the description of motion we used methods of evaluation of the time domain data, and the relationship between measured variables and non-linear methods of data. The parameters used for the evaluation were as follows: variance of motion intensity, mean of movement intensity, signal magnitude area, range of measured variables, power of movement, largest Lyapunov exponent, sample entropy and Hurst exponent. To test the functionality of the methods, we compared the movement of the dominant and non-dominant limbs, assuming cyclical and acyclic movement, so as to obtain the expected values for a healthy population. In accordance with the goal, a group of cyclic and non-cyclic movements common to the home environment were proposed. The movements were divided according to the activities performed during sitting, standing and walking. It was: pen writing, typing on the keyboard / using the mouse, eating with a spoon and eating a croissant combing, lifting weights, reading a book, etc. Twenty healthy subjects participated in the study. Four gyro-accelerometers (Xsens Technologies B.V.) attached to the forearms and upper arms of both upper limbs were used to record the upper limb movements. The results show that the calculated values of dominant and non-dominant limb parameters differ significantly in acyclic movements. The clever orthosis which uses the proposed methods can be used to evaluate the physical activity, quantify the evaluation of the rehabilitation process, and thus, it finds use in clinical practice. The result is a scientific finding of potential differences in proposed parameters for the dominant and non-dominant limb for follow-up clinical analysis.

Keywords: Motion assessment, Clever orthosis, Upper limb, Gyro-accelerometer

Contribution ID: 236

10. Biomechanics, Rehabilitation and Prosthetics

10.01. Orthopaedic biomechanics

Micro-Finite element analysis of geometrically different micro-screws for cranial implant fixation

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Implantology has gone advanced rapidly in the past decade. Thanks to 3D printing technology, patient specific approach has become a possible way of manufacturing implants. 3D printing in medicine provides opportunity to manufacture very complex shapes, e.g. of cranial implants. One of the greatest challenges in cranial biomechanics is to improve implant and fixture reliability. From that point of view, understanding of the interaction of the artificial objects (such as implant, fixation mini-plates and micro-screws) with the bone tissue is highly important.
Micro-screws, which connect fixation mini-plates with cranial bone and with an implant, are highly mechanically stressed in case of loading of the implant (e. g. own weight of head while sleeping). Stress-strain states can be determined by computational modeling using numerical methods. In recent years, finite element analysis (FEA) has been introduced as a successful representative, based on long-term successful experiences in field of human biomechanics.
The evaluation of the mechanical interaction of the micro thread of the screw and the bone tissue must be performed at the appropriate level – in this particular case on micro level. Computational models of cranial bone tissue were created including micro-structures, which form cancellous structure.
The aim of this study was to evaluate mechanical interaction of the cranial bone tissue and micro-screw of various lengths and diameters using micro-FEA. Due to computational difficulty, both 3D and 2D models and submodeling were used for solution.
Bone tissue structure, especially thickness of cortical bone and volume density of cancellous structure, significantly affects mechanical behavior of micro-screws. Micro-screws with larger and/or greater length are more in contact with bone tissue, which leads to the fact that the bone tissue is less stressed. However, some limitations may occur such as thickness of the skull. In this case, the length and diameter of micro-screws should be considered.

Contribution ID: 461
10. Biomechanics, Rehabilitation and Prosthetics
10.01. Orthopaedic biomechanics

Detection of excessive pronation and supination for walking and running gait with smart socks

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Excessive pronation and supination are gait conditions that could lead to such injuries as ankle sprains, shin splints, Achilles tendinitis and others. Early detection of excessive pronation and supination in running and walking gait are important for injury prevention not only for professional athletes but also for the general population. Unfortunately, the typical equipment necessary for detection of these conditions is relatively expensive and therefore is not widely used by non-professionals. Moreover, most of the typical equipment is either designed for operation under laboratory conditions only or is too bulky and consequently affects the performance of the wearer during the performed activity.

This study proposes a method for pronation and supination detection by using smart textile socks with integrated pressure sensors and a specific sensor measurement processing algorithm. Each sock has five sensors, two on the heel, one in the middle and two in the front sole area. These sensors are knit from a conductive thread and have a resistivity inversely proportional to the pressure, which allows monitoring of the feet pressure at different parts during a physical activity. From smart textile manufactured socks are relatively inexpensive and allow the measurement to be performed in any type of shoes both indoors and outdoors. The measurement acquisition unit is compact and light to not disturb the wearer during the activity. A special pressure vector is calculated from the sensor values to characterize the step. The value and the angle of this pressure vector give information about the step and allows detection of excessive supination and pronation in the gait.
The preliminary tests demonstrated a significant difference between the pressure vector values during normal gait and gait performed with pronation and supination, thus allowing detection of these gait conditions.

Contribution ID: 555
10. Biomechanics, Rehabilitation and Prosthetics
10.01. Orthopaedic biomechanics

Biomechanical evaluation of the impact of different weight loading conditions on the mechanical environment of the hip joint endoprosthesis

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Total hip arthroplasty is a reconstructive procedure which restores mobility and relieves pain related to several types of hip arthritis. Worldwide, about 2 billion people are overweight and one third of them obese implying that excessive body weight could be a potential factor of implant failure [1]. The proposed biomechanical study evaluates the effect of different weight loading conditions on the mechanical environment of the hip joint endoprosthesis. Medium left, fourth generation, composite femoral models were used (Sawbones®) and a Spotorno type prosthesis (PROFEMUR-E®). The bones were osteotomized and specifically machined for the experiments by an orthopaedic surgeon according to the procedure recommended by the manufacturer. Load cycles were programmed to simulate single-leg stance of gait of a normal-weight individual (70 kg) and an overweight individual (100 kg). The discrimination between normal and overweight subjects was based on the calculation of the body mass index according to the standards of the World Health Organization. To measure the microstrains on the femur during single-leg stance of gait, 14 uni-axial 120-Ohm strain gages (KYOWA, KFG-5-120-C1-11L1M2R, Kyowa Electronic Instrument, Tokyo, Japan) were positioned on critical stress points of the femur based on the Gruen femoral zones. For all the examined zones, the microstrain values were found to increase with increasing the weight. This indicates that the displacement in the hip joint endoprosthesis is higher for overweight subjects increasing the risk of failure. Also, the mean microstrain difference was higher on the greater trochanter compared to other zones. To our knowledge, this is the first biomechanical study which quantifies the impact of weight loading conditions on the mechanical environment of the hip joint endoprosthesis and proposes optimal measurement positions.
[1] Seidell JC, Halberstadt J. The global burden of obesity and the challenges of prevention, Ann Nutr Metab 2015;66(suppl 2):7–12.

Contribution ID: 686
10. Biomechanics, Rehabilitation and Prosthetics
10.01. Orthopaedic biomechanics

Application of Smart sock system for testing of shoe cushioning properties

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Appropriate choice of shoes with required cushioning characteristics is rather an urgent problem for people from very different groups, such as sportsmen, elderly people, people with foot disorders and locomotion problems. Existing devices which can provide shoe cushioning estimation are quite complicated and expensive and most of them are only for indoor application and cannot be used in outdoor shoe tests.
Present research is devoted to further development of wireless DAid TMPressure Sock System and its application for shoe cushioning estimation. In particular, a new version of pressure sensors with improved sensitivity and working range is designed and tested. The possibility of a relatively easy change of sensors placement is demonstrated, as well.
On the bases of above-mentioned developments, the possibility of shoe cushioning testing by using DAid TMPressure Sock System was studied. For this purpose, gait records of several test subjects who used sets of shoes with different cushioning properties, as well as bare walking, were made. Data analysis showed that the developed system gives the possibility to recognize different shoe cushioning. Several approaches to data processing to increase the sensitivity of such recognition are discussed. Finally, results obtained by DAid TMPressure Sock System are compared with results from reference system RSscan footscan®.
The comparison showed the potential ability of the developed system of wireless shoe cushioning tests in real outdoor conditions. Such ability provides also the possibility to monitor and estimate degradation of cushioning quality of shoes under deterioration and environment.

Contribution ID: 1063
10. Biomechanics, Rehabilitation and Prosthetics
10.01. Orthopaedic biomechanics

Comparisons of migrations of ring flexor digitorum superficialis tendon between pre- and post-carpal tunnel release

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Carpal tunnel syndrome (CTS) is a common neuropathic disorder. The common surgical treatment of CTS is carpal tunnel release (CTR). After CTR, the increased space in the carpal tunnel would cause the volar migration of flexor digitorum superficialis (FDS) tendons and possibly induces trigger finger. In addition, the frequently affected trigger finger after CTR was the middle and ring

fingers. However, previous studies seldom focused on the ring finger. The aim of this study was thus to investigate the effect of CTR on the volar-dorsal and ulnar-radial migrations of ring FDS tendon in the carpal tunnel.
Six freshly frozen cadaver hands with intact extrinsic flexors and hand were used. Ultrasonographically-guided carpal tunnel release was applied on each specimen. The specimens underwent the experiments in the pre-CTR and post-CTR conditions and in wrist neutral and 30° flexion postures. The ring FDS tendon was applied from 0 to 500 grams to simulate the finger flexion motion. The ultrasound transducer was securely positioned on the carpal tunnel in transverse plane to record the volar-dorsal and ulnar-radial migrations of ring finger. The positions of the tendon in the ultrasononic images were then measured and analyzed at each condition.
In wrist neutral posture, the volar-dorsal and ulnar-radial migrations had no significant difference between pre- and post-CTR. In wrist 30° flexion posture, the results of ring FDS tendon migrations showed a significant increase toward the volar side and ulnar side after CTR. The increased volar and ulnar migrations might cause the more contact to the tissues on the volar and ulnar side. It was supposed to develop trigger finger. Hence, our findings indicated that applying force in wrist flexion posture could increase the migrations to the volar and ulnar side and would increase the risk of developing trigger finger.

Contribution ID: 1064
10. Biomechanics, Rehabilitation and Prosthetics
10.01. Orthopaedic biomechanics

Investigation of the bowstring effect at the level of metacarpophalangeal joint with a biomechanical model

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Carpal tunnel syndrome (CTS) is a common neuropathy affecting hands. In clinical, if conservative treatments failed, carpal tunnel release (CTR) surgery would be applied to reduce the pressure in the carpal tunnel. However, researchers observed bowstring phenomenon, volar migration of flexor tendon, in patients receiving CTR surgeries. From the viewpoint of biomechanics, increased volar migration of flexor tendon in the carpal tunnel might result in increased moment arm of the affected tendons at the metacarpophalangeal (MCP) joint. However, how the bowstring effect impacts the tendon tensions is still uncertain. Thus, the purpose of the study was to investigate effects of changes of moment arm on muscle tensions at MCP joint with a biomechanical model. A biomechanical model considering equilibrium equations, physiology limitations and non-linear optimization was developed. Inputs of this model are joint angles of DIP, PIP and MCP joints of the long finger and the applied force during grasping a cylinder. Outputs were tendon forces and joint constraints. To thoroughly estimate the impact on the tendons from the bowstring phenomenon at the MCP joint, in this model, the moment arms of flexor tendons were modulated from 100% to 150% of the original moment arm. Results indicated when the moment arms increased, there is a trend that the tension of FDP tendon dropped initially and then increased for approximately 20%. As for the extension tendon, the tension increased gradually. As the moment arm of the flexor

tendon increased, the moment generated by the flexor tendons around the joint might increase. In order to balance the increased flexion moment, the extension tendon tension increased. Findings from the model agreed that bowstring effect amplifies the torque produced by the tendons, which may affect tendon-pulley mechanics. This biomechanical model can be further applied to examine clinical intervention for preventing bowstring phenomenon.

Contribution ID: 1066
10. Biomechanics, Rehabilitation and Prosthetics
10.01. Orthopaedic biomechanics

Investigation of age-related changes in force control and brain activities in finger pressing

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The population of elderly adults has increased rapidly around the world. Poor sensory input and degeneration in the musculoskeletal system and the central nervous system in elderly can cause the hand functions decrease. Studies have proved that the quality of functional tasks in daily living is highly correlated with hand functions. Elderly adults require more time to complete the functional tasks and they are prone to exert excessive force during object manipulations. Cerebral structure, blood volume, and oxygenation in the cerebral cortex might explain the age-related changes in the brain. The purpose of the study is to investigate the brain activities in the young and elderly groups during the digits pressing tasks, and examine the influence of force level on brain activity.
Fifteen young subjects and fifteen elderly subjects were asked to perform the force ramp tasks, 30% and 50% maximal voluntary contraction force (MVC), respectively, with the Pressing Evaluation and Training System (PETS). Near infrared spectroscopy (NIRS) was used to collect the brain activities in the bilateral prefrontal lobe (PFC) and primary motor area (M1) during the finger movements. In addition, Purdue Pegboard Test was used to examine manual dexterity.
Results showed that both force ramp tasks could induce significant cortical activation in PFC and M1 in elderly and young groups as compared to the base level. A significant higher hemodynamic response was found in the contralateral M1 during the 30% MVC force ramp task in the elderly group than that in the young group. Both groups showed the tendency of higher hemodynamic responses in the 50% MVC force ramp task than those in the 30% MVC. T Our finding demonstrated that the finger pressing tasks could efficiently induce cortical activation, especially for the elderly.

Contribution ID: 1068
10. Biomechanics, Rehabilitation and Prosthetics
10.01. Orthopaedic biomechanics

Changes of the subacromial space while performing seated push up

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Subacromial impingement syndrome is commonly seen in wheelchair users due to repetitively confined arm movements during wheelchair propulsion and other daily activities such as weight relief lifting and transfer. In particular, narrowing of the subacromial space resulted from weight-bearing activities is shown to be a major cause of subacromial impingement syndrome. Therefore, this study aims to investigate the changes in the subacromial space during weight bearing activities of the upper extremities for assessment of possible risks of shoulder impingement. Seven healthy subjects (age: 26.1±6.5 years; height: 167.7±7.9 cm; weight: 64.0±12.7 kg) participated in this study. Participants performed seated push up with bilateral hands holding on push up bars. The height of push up bars was adjusted according to body height to conform elbow joints were flexed at 120 degrees at initial positions. An ultrasound system synchronized with two force plates was used to capture images of clear contour of acromion and humeral head as well as push force applied by the upper extremities. Images before and during push up were analyzed to calculate changes in the acromiohumeral distance (AHD) representing changes of subacromial space during movement. The average AHD before and during push up was 9.8±1.3 mm and 8.5±1.2 mm, respectively. The AHD significantly decreased while performing seated push up. Changes of normalized AHD ranged from 6.7 % to 19.2 % of the initial AHD with the applied force ranged from 15.9 kg to 31.2 kg, which indicated a trend that greater applied force is related to greater changes in AHD. Seated push up was usually adopted in wheelchair users to achieve weight relief lifting or transfer. Other strategies or assistive devices could be designed to reduce the effects of weight-bearing on narrowing of the subacromial space to prevent subacromial impingement syndrome.

Contribution ID: 1383
10. Biomechanics, Rehabilitation and Prosthetics
10.01. Orthopaedic biomechanics

Photoelastic analysis of shoulder arthroplasty: current descriptive analysis of research in scientific journals

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Introduction: Shoulder joint complex poses a biomechanical challenge due to its complexity and the number of structures involved. Shoulder pain is one of the most prevalent reasons for consultation in primary health. The main chosen surgical treatments for joint degeneration, as a consequence of the chronic injury of the rotator cuff, are reverse arthroplasty, hemiarthroplasty and anatomic arthroplasty. Photoelasticity is an experimental method used to evaluate the strain environment under mechanical loading. The aim of this study is to present a systematic revision of the literature in academic journals for the period 2000-2017 related to the study of stresses and deformations in the shoulder joint with arthroplasty through photoelasticity technique. Materials and Methods: To obtain the data, specialised search engines were used: Google Scholar Advanced, Scopus, Web of Science and PubMed. Descriptive investigation was performed through a combination of values and boolean algebra. Results: A total of 13 articles were selected, which

were reviewed and classified in two categories: those focused in the analysis of the deformation in the shoulder joint with experimental optomechanic techniques, and those focused in the study of photoelasticity in models with shoulder arthroplasty. There distribution of articles by year, journal and investigation method was also described. Conclusions: The photoelasticity by stress freezing allows the study of internal zones, something that is not possible with other techniques. The analysis is frequently performed with prosthetic components of total anatomical shoulder arthroplasty, but there are barely any precedents in reverse shoulder arthroplasty. Therefore, new investigations that show the effect of reverse arthroplasty are suggested, since it is present in the treatment of many other prevalent pathologies. The present work is useful for consultation for both scholars and professionals interested in the study of stresses in the glenohumeral joint with photoelasticity technique in its variant of stress freezing.

Contribution ID: 1819
10. Biomechanics, Rehabilitation and Prosthetics
10.01. Orthopaedic biomechanics

Evaluation of ligamentum flavum thickness in specific lumbar postures with computed tomography

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Study Design: A quantitative study of the ligamentum flavum (LF) thickness in different lumbar postures with CT images acquired in cadaver samples .
Purpose: Different postures may cause bulking of LF which induce the symptoms of spinal stenosis. Therefore, we aim to investigate the influence of different lumbar postures on the change of LF thickness. We disclose the effect of different postures on the LF bulking which may have clinical implications.
Method: Eleven fresh frozen cadaveric specimens of lumbar spine were used in this study. We obtained the CT images of these specimens from four postures – extension, flexion, right lateral bending and right axial rotation. The LF was segmented from images manually, and thickness was calculated by BoneJ and in-house programs developed with MATLAB. We then compared the thickness of LF from L1 to L5 in different postures. Results were analyzed statistically by unpaired or paired t test.
Result: In comparison of flexion and extension postures, the thickness of LF in flexion was larger on L1-2 and L2-3 levels, while the thickness in extension was larger on L3-4, L4-5 and L5-S1 levels. The L2-3 and L4-5 reached significant differences ($P<0.05$). In right lateral bending posture, the thickness of LF on right side was thicker than left side on all levels. In right axial rotation posture, the thickness of LF on left side was thicker on L2-3 and L3-4 levels, while that on right side was thicker on L1-2, L4-5 and L5-S1 levels.
Conclusion: In contrast to flexion posture, extension posture may cause LF bulking on lower lumbar levels which may further decrease spinal canal. Lateral bending or axial rotation posture can further increase the thickness of the LF over the movement direction.

Contribution ID: 130
10. Biomechanics, Rehabilitation and Prosthetics
10.02. Cardiovascular biomechanics

Effects of lipid core stiffness and cap thickness on atherosclerotic plaque wall stress

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Rupture of atherosclerotic plaque is related to mechanical stress, plaque geometry and the material properties of plaque tissues. In order to clarify the effects of lipid core properties on cap wall stress, advanced plaques in eccentric stenotic arteries was modelled, and stress analysis with fluid structure interactions was performed. Three different cap thicknesses (45µm, 65µm and 200µm) and core stiffnesses (very soft, soft and hard) were considered. The maximum stress and strain were found at proximal sites of stenosis, and the maximum stress and strain increased more than 320% and 155%, respectively, as the cap thickness decreased from 200 to 45µm. Lipid core stiffness did not affect much on maximum stress and strain for a cap thickness larger than 65µm; however, it affected wall stress in the very thin (45µm) cap noticeably. The very soft core model showed higher stress and strain comparing with hard lipid core. Therfere, a very thin cap with very soft lipid core may influence the stability and vulnerability of atherosclerotic coronary plaque.

Contribution ID: 232
10. Biomechanics, Rehabilitation and Prosthetics
10.02. Cardiovascular biomechanics

A Novel Structure Design with Strong Support of Biodegradable Zinc Alloy Stent

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Biodegradable zinc alloy stent provides a promising solution for long-term adverse events caused by the interactions between vessels and permanent stents. However, the poor scaffolding is the main limitation of the biodegradable zinc alloy stent in clinical therapy. Therefore, in this study, a new design concept of biodegradable zinc alloy stent was proposed. The highlight of the new design stent is that six short strutting rings are inserted into the links. This structure allows the stent to expand but not contract. Furthermore, the finite element method was applied to simulate the deployment process of stent. A stent without the strutting rings is chosen as the control stent to analyze the simulation results. The results show that compared the control stent, the radial recoiling rate of the new stent is decreased by 20%, which suggests that the supporting performance of the new stent is significantly improved. Novel structure design and optimization is of triggering perspective for the application of the biodegradable zinc alloy stent in clinical treatment.

Contribution ID: 384
10. Biomechanics, Rehabilitation and Prosthetics
10.02. Cardiovascular biomechanics

Recent progress on preferential covered stent development

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Carotid artery stenosis can be treated by carotid endarterectomy operations (CEA) and carotid artery stenting procedures (CAS). Unlike other artery stents, the effectiveness and safety of carotid artery stenting is not prevailing though it has many advantages. Our group has been developing new generation carotid artery stent since 2011. The innovative carotid stent was named as preferential covered stent (PCS) as it could prevent both emboli release at internal carotid artery (ICA) and provide perfusion to external carotid artery (ECA). A series of studies have been carried out to verify the carotid stent design through modeling and simulation, in vitro loop testing, and in vivo pilot animal testing in our previous proof of concept (POC) stage. We are now doing animal trials with pig model and continue to improve the stent design as well as the delivery system. Here we report some recent findings on PCS development, including simulation and experimental work on stent crimpability with different designs, membrane material fabrication and characterization, and the flow response for different slit designs in vitro.

Contribution ID: 1513
10. Biomechanics, Rehabilitation and Prosthetics
10.02. Cardiovascular biomechanics

Pressure pulse wave velocity and axial prestretch in arteries

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The velocity of the propagation of a pressure pulse wave is considered to be a useful marker of the state of health of the cardiovascular system. Many clinical measurements, laboratory experiments and computational simulations have proved that the pressure pulse velocity correlates with age-related changes in the mechanical properties of arteries. Age-related stiffening of arteries, referred to as arteriosclerosis, leads to the increase in the pressure pulse velocity. However, the stress and strain state of an artery is not given solely by its loading and mechanical properties. Arteries are residually stressed that can be seen when cylindrical segment of an artery is excised from the body. The segment retracts because the axial prestretch is released. This prestretch declines with age, as a consequence of the damage accumulated to elastic lamellae during aging. Previous studies have paid little attention to the effect of axial prestretch on the velocity of the pressure pulse wave. The study presented here is based on a combination of a linearized 1D model of the fluid dynamics and the nonlinear anisotropic response of the human abdominal aorta. The model predicts that the application of axial prestretch can significantly change the velocity of the pressure pulse.

Contribution ID: 13
10. Biomechanics, Rehabilitation and Prosthetics
10.03. Dental biomechanics

Experimental measurement and numerical simulation of temperature during drilling with two specific dental drills

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High temperature during bone drilling is not required. The aim of presented study was experimentally measure and simulate thermal diffusion differences in the surrounding of the two specific drills during hole drilling into the polyurethane (PUR) foam block (from Sawbones Europe AB). Polyurethane (PUR) block was ("artificial bone") with 6 holes in 5mm depth for semiconductor

termoelements. Holes for thermocouple were distributed in perpendicular direction along the drilling direction. These thermocouples measure thermal diffusion in according to the drill depth into the PUR blocks. Experiment was performed with and without cooling and in three different revolution speeds, 800rpm, 3000rpm and 5000rpm. Experimental investigation was realized on four types of drills. Two cylindrical and two conical drills from two different manufacturers: i) cylindrical Drill no.1610.928b Ihde Dental; ii) cylindrical Drill no.1610.928b-k Dentamechanik.
In both cylindrical drills, no.1610.928b IhdeDental and no.1610.928b-k Dentamechanik were detected very similar temperatures. In case with cooling were lower temperatures in drill no.1610.928b-k Dentamechanik and in case without cooling were lower temperatures in drill no.1610.928b IhdeDental. In drill no.1610.928b IhdeDental was detected significantly highest temperature with revolution speed 5000rpm surrounding of drill in case without cooling.
The aim of created numerical FE simulations was heat production analysis of drills during hole drilling into the polyurethane (PUR) foam cylinder. Final recommendation for the design of drills is based on obtained results of the heating production analysis.
Created FE simulations analyzed influence of the drill geometry to the heat production during drilling (friction drill on PUR foam). FE analyzes were focused only to friction problem and drill geometry optimization towards to heat reduction. Generally drilling is more complicated process, where are acted more factors (material removing, chip transport, drill geometry, drill size, cutting face cooling etc.).

Contribution ID: 1058
10. Biomechanics, Rehabilitation and Prosthetics
10.03. Dental biomechanics

Assessing dental implant osseointegration stability through vibro-acoustic technique based handheld device

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Based on resonance frequency analysis, the non-contact detection device, which uses vibro-acoustic technique with acoustic excitation and displacement sensing, is developed to quantify the stability of implants. Interface-tissue made from different mixing ratios of epoxies and casted in artificial bone blocks was used to mimic different phases of osseointegration in in-vitro experiments. Additionally, animal trails via rabbits were conducted to observe osseointegration in live bodies.
In-vitro experimental results show that the frequencies in the mesial-distal measurements increase as the mixing ratios get higher except for one designated case. The reason which makes the trend variant in the buccal-lingual measurements originates from fixing conditions. The connection between the implant and its surrounding structure also affect experimental results. In in-vivo experiments, the results show that the secondary stability dominates stability after a stability dip and increases as time passing. Primary stability influences the success of following adaptation. The advantages of this technique are to monitor the dental implant osseointegration stability without using an extra accessory mounted, and without invasion during the healing process.

Contribution ID: 1076
10. Biomechanics, Rehabilitation and Prosthetics
10.03. Dental biomechanics

Measurement of Mechanical Properties of Enamel Based on Resonant Ultrasound Spectroscopy

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The tooth enamel is a kind of biomaterial. It is hardest human tissue and covers the crown surface of tooth to protect the inner tissues[1]. The mechanical properties in relation to the compositional and hierarchal microstructural characteristics of enamel are an essential factor for understanding its natural properties and developing new repair materials. Resonant ultrasound spectroscopy (RUS) is an efficient method to characterize the material mechanical properties and has been regarded as the gold standard for measuring the elastic moduli of solid materials with high

Contribution ID: 1132
10. Biomechanics, Rehabilitation and Prosthetics
10.03. Dental biomechanics

Development of a force measurement device for the evaluation of biting force

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Initially, the maximum bite force and the efficiency of the mastication have been examined to find the force needed to bite food. However, research has been extended to investigate the masticatory force after post-traumatic injuries and maxillary facial plastic surgery, during mouth restriction and Craniomandibular development/formation via examination of the affected masticating muscles, joints, teeth and neuromuscular system. The methods dating back to 1681 have been based on the simple levering mechanism and assessment of the jaw force. About 200 years later, force magnitudes were measured with helical, leaf and ellipsoidal springs. By using these two systems, the spring and lever mechanism has begun to be used. As electronic systems have evolved, mechanical systems have been replaced with electronic equivalents. In this respect, the use of strain gauges for strength measurement has come to the forefront due to their superior features such as accuracy, lower cost and higher functionality. Systems formed with strain gauges utilize metallic forks and force is measured by the induced strains on the forks. While the measurement of bite force is calculated by shape and position changes, measurements are recorded in different modes so that effects are observed during operation of masseter, temporalis or digastric muscles. Information on bite force and masticating efficiency is obtained via measurements which are obtained at specific positions of the jaw. In this study, it is aimed to measure the different spans of the masticating muscles, and to determine the values of masticating efficiency at different spans. For this purpose, a strain gauge based jaw opening device has been developed. Factors such as maximum amplitude, speed of change of force are calculated by sampling the strain values obtained during experiments with microcontroller.

Contribution ID: 1685
10. Biomechanics, Rehabilitation and Prosthetics
10.03. Dental biomechanics

Topology optimization of porcelain-fused- to-metal dentures using alternating active phase algorithm

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With the ever-aging population and increasing oral rehabilitation, there has been a great demand for dental prostheses. All-ceramic fixed partial dentures are widely used for replacing missing

teeth. However, metal-ceramic or Porcelain- Fused-to-Metal (PFM) systems are preferred because of their clinical longevity and biocompatibility. This study aims at developing mechanically sound novel topological designs for PFM dental bridges under volume constraints by minimizing the compliance. For this purpose, bi-directional evolutionary structural optimization (BESO) technique based on the alternating active phase algorithm is implemented in Abaqus Scripting Interface (ASI) environment. The ASI provides a convenient access to advanced finite element analysis during topology optimization iterations leading to more accurate results. The BESO technique distributes metal, ceramic and void materials in an optimal way such that the design objective is met. The alternating active phase algorithm divides the multi-material topology optimization problem into a series of traditional binary phase sub-problems. These sub-problems are solved separately and sequentially using the BESO method. The numerical studies showed that the stiffness of PFM bridges is significantly improved by redistributing materials in optimal topological configurations. The manufacturing of such optimal designs is possible through 3D printing techniques or dental CAD/CAM.
Keywords: multi-material topology optimization, fixed partial dentures, porcelain-fused-to-metal, alternating active phase algorithm, abaqus scripting interface, BESO.

Contribution ID: 43

10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Study on walking training system for using high-performance shoes with human compatibility

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The number of elderly in the Japanese population has been increasing, and is expected to reach about 40% by 2060. This means that those aged 65 and over in Japan will be roughly every one in 2.5 persons [1]. With this are increases in the need for elder-to-elder nursing and shortage in and an increased burden on care takers. These developments have resulted in efforts to promote independence among the elderly - something that has brought walking to the attention of those promoting good health and independence among the elderly. The increasing number of accidental falls among the elderly while walking [2]. Among the main factors in falls are a deteriorating center of gravity of balance due to declining physical performance and weakening in the muscular strength of the lower limbs.
In this study, we focused on shoes to be worn daily in walking aimed at both assisting walking and preventing falls. Further, we proposed training in walking that is continues and daily that detects and corrects the center of balance during walking. To add detection of staggering, we used a sponge-core soft-rubber actuator (SCSRA) consisting of open-cell foam sponge coated in silicon rubber. This actuator changes stiffness with inner pressure. Equipping insoles, with it means that it can be used for both detecting the pressure distribution of the foot sole while prompting correct walking by changing the stiffness of the insole. We also developed a means of walking status presentation that confirms walking status on a display in real time.

Contribution ID: 147

10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

A new pegboard developed for accurate time measurement of individual’s peg motion

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Various kinds of pegboards have been developed and widely used in research and clinics of rehabilitation for evaluation and training of patient's hand function. Introduction of electrical measurement technology to the apparatus, on the other hand, has been delayed. The present work introduces development of a pegboard with an electric sensor to detect moments of individual peg's insertion and removal. Two 10-hole peg-board boxes installed with a small photo-reflector and a DC amplifier at the bottom of each hole were designed and built. The amplified electric signals were A/D converted at 500 Hz per channel, and stored in a PC. The boxes were set at different distances (25, 50, 75, and 125 mm) in parallel to examine the hole-to-hole distance effect. Fifty healthy young volunteers (25 in each gender) performed successive fast 80 time peg transfers at each distance using their dominant and non-dominant hands. The data gathered showed a clear-cut light interruption/continuation moment by the pegs, allowing accurately (no tester's error involved) and precisely (an order of milliseconds) to determine the pull out and insertion times of each peg. This further permitted computation of individual peg movement duration (PMD: from peg-lift-off to insertion) apart from hand reaching duration (HRD: from peg insertion to lift-off). An accidental drop of a peg led to an exceptionally long (< mean + 3 SD) PMD, which was readily detected from an examination of data distribution. The PMD data in most of the individuals were right-skewed, suggesting that the median is a better estimate of individual PMD than the mean. Repeated measures ANOVA revealed significant hole-to-hole distance, and hand dominance effects, suggesting that these need to be fixed in accurate evaluation of PMD. Performance consistency can also be evaluated by the use of quartile variation coefficient computed from multiple trial PMD data, if necessary.

Contribution ID: 175
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Dynamic Model of the cdmit I hand finger mechanism

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This paper presents a dynamic Euler Lagrange mathematical model of the prosthetic hand prototype CDMIT I anthropomorphic fingers, an improved version of the TBM hand. One finger has been modeled as a generic multi-link system model with only one DOF; therefore the model for each finger can be then obtained by substituting their respective dimensions on it. The simulation results of the index finger are consistent with the performance of the real finger.

Contribution ID: 229
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Design of clever orthosis of upper limb for rehabilitation

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Movement problems of the upper limb are a common consequence of many dis-eases and can drastically affect the daily life impairing normal activities. To regain motor function and muscle power is necessary to treat these diseases with an in-tense physical therapy. The clever orthosis is an effective and modern method used in the process of muscle rehabilitation. We propose a design of motorized orthosis subsystems for the upper limbs. The orthosis is a motor assist robotic system that, with the help of actuators, will allow the movement of selected parts of the upper limb. The main point is to offer a reliable low weighted exoskeleton with selected sensors to move and control the upper limbs covering 6 motions: shoulder adduction and abduction, shoulder flexion and extension and elbow flexion and extension. The device is a junction of a hard orthosis with a soft or-thosis to perform passive physical therapist exercises in clinical practice. The ac-tuation is made by Bowden cables connected in one end to the limb and another to a stepper motor located at a backpack carried by the patient decreasing the ap-paratus weight substantially. The project also includes a selection of sensors comprising accelerometers, strain gages, thermostats, oximeters, that can provide the necessary information to move the limbs quantifying the muscle activity and physical condition through time. Also, a cooling subsystem based on Peltier thermoelectric modules was implemented in order to control the muscle tempera-ture in case of an inflammatory reaction. The design was certified by kinematic and structural strength simulation using SolidWorks software.
Keywords: Cever orthosis, Upper limb, Rehabilitation, SolidWorks

Contribution ID: 275
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Adaptive impedance control of a robotic orthosis actuated by pneumatic artificial muscle: a repetitive learning control approach

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In recent years, rehabilitation robots which help the patient regain the function of the injured limb via training sessions have been developed with great attention. Since these types of robot interact closely with humans, safety is always the top priority considered in the design. Besides, the compliance of the robot must also be controlled to give the subject the best comforts. To fulfill the above mentioned requirements, a two degrees of freedom (2DOF) robotic orthosis based on the pneumatic artificial muscles (PAMs) is developed in this study. The system is capable of tracking any desired trajectories by using a modified feedforward-feedback control strategy. To give the subject a better comfort, a repetitive learning control approach which utilized the periodic action of the human is also employed for the impedance control. The feasibility and effectiveness of the developed system are verified by experiments.

Contribution ID: 291
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

A wearable gait assessment system for evaluating post-stroke patients' rehabilitation

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Most of the post stroke patients are common with walking difficulty. The gait pattern could be taken as the severity of the patients. About 88% of stroke patients have certain degrees of hemiparesis. Hemiparesis will attribute to weakness of one side of the body. For post-stroke patients, the rehabilitation is a tedious and long term process. It needs tremendous medical cost and care manpower. Therefore, how to develop a simple wearable device for evaluating the rehabilitation outcome becomes a needful clinical issue. In this study, two wearable devices with accelerometer and gyroscope are placed in both sides of foot. Therefore, the gait patterns can be obtained from the information of both side accelerometer and gyroscope. The gait pattern is also shown in smartphone through wireless techniques. This device can be used to evaluate the rehabilitation outcome and as biofeedback training for stroke patients.
The MPU-6050 which contains accelerometer and gyroscope are placed in both side of foot. The obtained both side data were transmitted via Bluetooth low energy protocol to smartphone. An algorithm was developed with Madgwick attitude and heading reference system algorithm which was adjusted to let accelerometer and gyroscope be calibrated each other and performed gait analysis. Then we calculated various spatiotemporal parameters to analyze gait and assess symmetry. Finally, the results and data were visualized on smartphone app.
The system was tested when normal subject was asked to walk straight in comfortable or self-selected walking speed, but the stride length was limited to 1.2 m. The results indicated stride length closed to 1.2 m. And the symmetry ratio of various spatiotemporal parameters between both feet is around 1.0 which means normal. More subject test will report during conference.

Contribution ID: 298
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Validation of the novel body weight support system using pneumatic artificial muscle: a case study

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Locomotion gait training system plays a significant role in therapy for the patients who are in recovering from hemiplegia, paraplegia, spinal cord injury or after stroke. Modern gait training systems commonly use a Body Weight Support (BWS) system which is to enable the spinal cord injury or stroke patients bearing their weight during the walking practice. The conventional rope-pulley mechanism in conventional BWS systems could cause the “pendulum effect” during gait training and make subject be uncomfortable. Furthermore, using only one rope-pulley mechanism the conventional BWS system could not flexibly modulate the supported force, for example, the hemiplegic patient. This research is aimed to develop a novel BWS system which will be used to support the spinal cord injury patient during gait training. The novel BWS system will be applied Pneumatic Artificial Muscles (PAM) for generating the support force. The mechanical structure of the new BWS system is totally different from the conventional body weight support system. Therefore, the new BWS system will have several advantages, such as simplicity, low cost and flexibly adjusting the unloading force. The purpose is to develop a very simple BWS system for gait training, however, its capabilities generating active unloading forces. An experiment with a perturbation was conducted using the new BWS system and a representative conventional BWS system (Counter Weight system) to verify the performance of the new BWS system and to investigate the gait variance of the subject under both two BWS system. The results showed that the new BWS system presented a better performance in comparison with the Counter Weight system.

Contribution ID: 322
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Two-dimensional phased array ultrasound stimulator for highly accurate targeting in neuromuscular rehabilitation

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Ultrasound stimulation has been widely studied as a noninvasive therapy for nerve or muscle injury. In previous studies, low-intensity ultrasound stimulation evoked the effective regeneration of the damaged peripheral nerves and muscle tissues. However, in the conventional configurations with a single transducer, it is difficult to take exact aim at a target point because the only way of shifting the focus is to adjust the transducer location that is hardly fine-tuned without a highly accurate machinery. In that beamforming with high-speed time delay control enables the fine adjustment of the focal location, phased array ultrasound holds a key to surmount the above limitation. In this study, we developed a two-dimensional phased array ultrasound stimulator which is able to form the focus at an arbitrary location in three-dimensional space. In addition, to improve the targeting accuracy, spatial information of the stimulated site can be acquired through a multi-channel pulse-echo system integrated with the stimulator. In the stimulator, high-voltage ultrasound pulsers are used to generate bipolar voltage pulses with the maximum amplitude of 200 V. The pulse-echo system is composed of low-noise differential amplifiers, anti-aliasing filters, bias compensation circuits, analog-to-digital converters, and a digital signal processor. Experimental results show that the developed stimulator achieved to concentrate the ultrasound energy at the focus with a radius of 1.16 mm which is small enough to take aim at a bundle of peripheral nerves or muscle fibers. Also, the focal location was finely adjusted with the mm-scale shift. The spatial average-pulse average intensity was measured as 2.32 W/cm^2 which is sufficiently high to regenerate the injured peripheral nerves and muscle tissues. Moreover, the pulse-echo system successfully detected ultrasonic echo providing the spatial information of the stimulated site. From these results, we anticipate that the developed ultrasound stimulator can be utilized for neuromuscular rehabilitation.

Contribution ID: 390
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Split-belt treadmill to study reactive responses to unexpected gait perturbation

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Abstract. The aim is to presents a solution and realization of the design of new split-belt treadmill for controlled, unexpected perturbation during walking to study recovery responses and dynamic stability of the human gait. The construc-tion of the split-belt treadmill consists of several subsystems. The most important subsystems are: actuator, control and sensory subsystem. Actuator subsystem is based on two asynchronous motors, two inverters and two gears (for each belt separately). Control subsystem is made up of Modbus communications between the control computer and two inverters with respect to the parameters of the asyn-chronous motors. The

sensory subsystem is based on the incremental angular speed sensor used to record the behavior of the treadmill belts. The control itself is created through the MatLab sw and special custom-made user interface that al-lows to define a wide range of perturbation schemes with the possibility of stor-ing them and provides a summary report of the perturbation sequence being per-formed. The new split-belt treadmill was tested. Experimental verification of the gait perturbation simulator was accomplished by comparing the entered values of the motor speeds, i.e. belts, and then running speeds, which can be used to de-termine the response of the system. It was then verified whether the belts had the desired speed. Verification of the system has shown that at the recommended speeds of running the belts (at 2.4 km/h), the system is stable, shows no varia-tions in proband load, and real changes in belt velocities are achieved with mini-mum deviations from the desired values. The main benefit of the described work is the creation of a functional control of the prototype of the treadmill for con-trolled, mechanical gait perturbations. The split-belt treadmill is designed to study reactive responses during walking that can be further used to fall-risk assessment, clinical or rehabilitation intervention.

Contribution ID: 391
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Evaluating the effect of changes in bone geometry has on the trans-femoral socket-residual limb interface using finite element analysis

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A prosthetic socket used by a lower limb amputee should accommodate for the patients geometry and biomechanical needs. The creation of a geometrically accurate subject-specific finite element model can be used to provide a better understanding of the load transfer between socket and limb. There has been a limited number of finite element studies of trans-femoral sockets with all current models only including the femur. This study looked to evaluate the effect of including the pelvic bone as well as the femur in a finite element model has on the contact interface between the prosthetic socket and residual limb. This was done by creating a finite element model from a computerised tomography scan of a trans-femoral amputee. This model included three-dimensional geometry, nonlinear material properties and frictional contact between the residual limb and prosthetic socket. It was found that without the pelvic bone the contact pressures peaked at the distal end region of the residual limb (peak of 95 kPa). However by including the pelvic bone the contact pressures were instead concentrated at the ischial loading region (peak of 364 kPa). The shear stresses experienced on the socket-residual limb interface were also simulated. The results obtained in this study can be used to provide more of an understanding of the loading on the residual limb for the design and creation of future trans-femoral sockets.

Contribution ID: 462
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Monitor aided radio control mobile robot (msrcmr)

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The term robot comes from the Czech word robota, which when translated means "forced labour". Generally all the robots in the world are designed for monotonous tasks. The robots handle the

jobs that are difficult, dangerous or boring for a human to perform. In the medical world robots have now taken over many tasks; from a basic robotic helping hand to complex mimetic robotic arm based surgery and these chores have shown promising results. Our robotic arm is based on an innovative idea which provides help to the less mobile or paralysed patients. Our robotic arm: Monitor Aided Radio Controlled Mobile Robot (MARCMR) is based on a robotic arm mounted over a moveable shaft, which can move from one place to another place by radio control. It uses simple gripping and dropping process to move the object which will facilitate paralysed patients. MARCMR may also be helpful to work as laboratory equipment handing tool. MARCMR is controlled by using RF remote. The robot is also attached with a camera which enhances the real time view of the user. The MARCMR can be fixed by the side of a patient so that they can be able to perform their daily routine tasks and secondly they can be installed at various locations within an area where humans do not prefer to go or it might be hazardous. Keeping in mind the durability and flexibility, the MARCMR is built by using Aluminium, Plastic (PVC) and Iron. It has a wrist, elbow and shoulder joints to provide maximum closeness with a human arm. The joints are controlled with DC motors. The MARCMR revealed encouraging outcome as the patients will be able to perform their tasks with ease and they may also be allocated to the places where humans don't wish to go.

Contribution ID: 549
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

The options in robotic control of rehabilitating patient´s lower limbs

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The use of robotics is currently expanding in all spheres including healthcare. There are many fields of healthcare, where robotics is being or can be used. A design of new rehabilitation devices and aids has to come out from the knowledge of anatomy and physiology of specific body-part movements combined with proper analysis of body movements in particular rehabilitation methods. This article analyses physiological movements in selected rehabilitation methods focused on lower limbs rehabilitation. It also proposes options for realisation proprioceptive neuromuscular facilitation by using robotic devices.

Contribution ID: 568
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Ergonomic assessment of an active orthosis for the rehabilitation of flexion and extension of wrist

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Muscular stiffness and limb rigidity are two main consequences of Parkinson's disease. These motor symptoms may be present in distinct parts of the body, influencing over the execution of functional tasks, in particular those executed by hands. In order to aid people suffering from these

motor conditions, we developed an active wrist orthosis whose purpose is to enable increase in the angular amplitude of the flexion and extension of the wrist joint. We identified five relevant ergonomic variables that should be taken into account for using the orthosis in the clinical practice: (i) the mass of the device; (ii) the relative position of the arm while wearing the device; (iii) the influence of the orthosis on the natural flexion and extension of movements of the wrist; (iv) the stability of the orthosis on the arm; (v) the impact of inertia on the initiation of movements. These variables were identified based on the observation of movements while users executed the flexion and extension of the wrist with and without the device. In this research we present a description of the developed orthosis together with the evaluation of ergonomic variables that may impact on its practical use. A set of inertial sensors and infrared cameras was used for data collection, in order to objectively assess the variables. Based on this evaluation it is possible to suggest modifications in the current design of the orthosis so that it can be improved.

Contribution ID: 581

10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Development of new style Braille learning materials for Braille beginner readers with vocal guidance function using optical indentation method

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Braille is an important communication medium for the visually impaired. Even though the reading speed for Braille is about a quarter that for visual characters, highly experienced Braille readers can read up to 200 letters per minute. The number of patients with acquired visual impairment has increased in recent years. However, most of these patients cannot read Braille. Thus, intensive training is required to achieve even a modest level of reading ability due to a lack of adequate Braille learning text. Based on these situations, in this study, we developed prototype of Braille reading materials for Braille beginner readers. This Braille reading materials were applied to use vocal guidance function. Concretely, to add the vocal guidance function, small dot patterns with different dot-distances per type of space for each Braille character, were printed on fine paper by a laser printer based on optical indentation method. Next, we printed Braille characters on the fine paper by our developed Braille printing production system. For the vocal guidance function, we used an infrared camera mounted on a wand reader interface to read the small dot patterns. We stored vocal data tailored to meaning of Braille character in the memory of pen shaped dot code reader interface.
In this study, we also conducted one experiment to investigate area sizes of dot code corresponding to Braille that Braille readers were easy to touch dot code by using the dot code reader interface. From this experiment, we found adequate area sizes of dot code corresponding to Braille. This study will be useful in providing a new style for future Braille learning text.

Contribution ID: 584

10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Development of learning materials of stiffness sensation for beginner acupuncturists

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Stiffness sensation is one of the most important tactile senses. However, the mechanism used by the human forefinger to percept stiffness levels has not been clarified. In our previous, we investigated the mechanism used to distinguish stiffness when the tip of a human forefinger contacts an elastic object. Concretely, we created test pieces with different stiffness levels and then quantified the ability to perceive different levels of stiffness (such as hard, medium, and soft) by employing the method of successive categories. And also we conducted an experiment to quantify the ability to distinguish stiffness levels by using a constant method. From these results, we found that stiffness sensation correlates directly to the strength of the mechanical stimuli. In addition, it was found that the ability of the human forefinger to distinguish stiffness was lower for extremely hard or extremely soft stimuli than for stimuli of intermediate degrees of stiffness. As above stated, the stiffness sensation characteristics of the human forefinger were clarified by our previous studies. Therefore, based on our previous studies, it is definitely expected to develop learning materials of stiffness perception by acupuncturists who usually distinguish stiffness. In this study, we developed prototype of learning materials of stiffness perception for beginner acupuncturists and examined their perceptibility of stiffness by using the learning materials. This study will be useful in developing a new learning materials of stiffness perception for beginner acupuncturists.

Contribution ID: 764
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Development of a gait simulation system in hypogravity for studies about human physiology on earth and space

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Running and walking stimulate the musculoskeletal and cardiopulmonary systems, maintaining strength, coordination, and body posture on earth and space missions. The aim of this article was to developing a low-cost gait simulation system in hypogravity (GSSH) for studies of human physiology. For the construction, 5 subsystems were developed: structural, suspension, simulation, force and communication. The GSSH constituted a body suspension with a vertical treadmill associated with the force platform with the volunteer suspended by vest and elastic cables, and positioned in parallel to the ground. The maximum stipulated weight for the system was 100kg,

taking into consideration the load capacity of the materials and components. To test the force platform, a 72kg object was pressed against a treadmill and for the gait test, a motor with two “legs” and an articulated mechanical foot was fastened near the treadmill allowing the touch of the ground during a simulation of the human gait. The GSSH was able to suspend an object, keeping it pressed against a treadmill without load oscillations. The subsystem of communication and data transfer from the CPU of the power platform to the computer. A force platform showed a percentage error of 2.84% as the weight of the object (72kg± 2,84 kg). The gait test demonstrated that the force platform was able to collect the touch time of each foot as ground reaction forces, in a real time. The GSSH was able to maintaining communication between force and data reception platforms.

Contribution ID: 971

10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Development of a modular bionic prototype arm prosthesis integrating a closed-loop control system

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An active prosthetic arm is not only dependent on critical factors for clinical use, such as weight or bulk but also needs reliable control inputs for accurate and safe positioning. Particularly with a high level of amputation, light but robust devices are essential.
Our concept is composed of a modular system, based on bionic design principles, that is adaptable to the specific level of amputation of an arm. By following three basic rules: proximal weight, flexibility and lightweight but silent operation, it is possible to mimic the weight distribution of a human arm.
A custom developed control hardware attached on top (HAT) is based on a Raspberry Pi 3 (RPi3) and holds the ADS1299 that is capable of acquiring sensor and other bioelectrical signals. The motion and position data are gathered using a 9-axis inertial measurement units (IMUs). Based on the processed data a control signal is sent to an independent actuator control unit. The use of the RPi3 allows performing complex decisions and control algorithms fast enough for real-time control of the prosthesis actuators.
The resulting ranges of motion are 120° for the elbow joint and 270° for the wrist joint. The elbow joint can lift a weight of maximal 3.3 kg with a lever of 30 cm through the entire range of motion within two seconds. The system provides a novel bionic design that allows usage not only for transradial but also transhumeral amputation. The proximal weight distribution and the used materials increase the wearing comfort in daily tasks and mimic to a high extent physiological conditions. Furthermore, the speed of the control system is within the range of the electromechanical delay of human muscle contractions, which not only is beneficial for control purposes but also increases the acceptance of the prosthesis for daily use.

Contribution ID: 976

10. Biomechanics, Rehabilitation and Prosthetics

10.05. Rehabilitation engineering and robotics

Cycling speed increases through Functional Electrical Stimulation (FES) assisted tricycling trainings of spinal cord injured individuals

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FES driven lower limb cycling is studied on a tricycle (Reha-Funtrike, OVG, Munich, Germany), adapted for this purpose. Two patients cycled for 30 minutes, weekly twice during 6 weeks. The results presented, are from the case of 2 complete spinal cord injured participants (P1 and P2) lesioned in the cauda equina. P1 was younger (32 years) and his level of injury was (T10) compared to P2 (45 years, T12). P1 and P2 started the training 3 and 7 months post-injury respectively. We examined whether the cycling speed have been increased during this period and how speed changed within individual trainings.
The participant was cycling on the tricycle which was equipped by a custom build 4 channel electrical stimulator for denervated muscles. Two channels were used to activate the quadriceps muscle groups on both legs during knee extension. Bilateral knee extension is actively driving the bike. Passive knee flexion is supported by arm pull at steering handles (“rowing mode”). The stimulation is activated and deactivated by a push button.
The average cycling speed of the two participants were 5.0 and 4.0 km/h. The speed was computed for 3 equal phases of the total cycling time. The speed in the first and third phases were similar but in the middle phase it was lower. Average speed for P1 in the 1st, 2nd and 3rd phase was 5.4 km/h, 4.4 km/h, 5.1 km/h respectively. The same values for P2: 4.4 km/h, 3.7km/h, 3.9km/h.
Average speed increased for both participants during the training period (slope=0.89 and 0.94 for P1 and P2). While the level of injury was akin, we assume that the significantly higher speed achieved by P1 was due to younger age, shortest time since injury and higher motivation, rather than to the level of injury. Supported by grants GINOP 2.3.2-15-2016-00022 and 94öu7

Contribution ID: 998
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Determination of Changes in Ankle Foot employing EMG for Designing of Smart Ankle Foot Orthotic Device

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Foot drop is the inability of an individual to lift their foot due to reduced or no muscle activity around their ankle joint. Electromyography (EMG) is a technique which deals with detection, analysis and utilization of electrical activity emanating from skeletal muscles of human body. Number of devices since long has been developed for lower limb rehabilitation purposes like splints, braces etc. Orthotic treatment is the most common method for several foot-drop cases. Now a days it is the most challenging to design an integrated device that can support muscles, immobilize joints and correct the position of foot. This paper represents a comparative study between normal gait of ankle joint for healthy subjects and patients with foot drop during walking. The movements at ankle joint considered during normal gait are plantarflexion, dorsiflexion, pronation and supination.

During our study, we have considered fifteen subjects with age group of 15-60years, height of 152-182 cm and weight of 50-85kg. Subjects were asked to undergo required movements of foot and the activities of electrical signals acquired from the muscles which are responsible for the considered movements are recorded using Trigno Wireless EMG system manufactured by Delsys Inc. After acquisition of signals, amplification and filtration has been done to remove any interference or noise from the recorded signal and get the better signal. From the above study we conclude that Tibialis anterior, Gastronemius/solenus, Tibialis posterior and Peroneal muscle are largely responsible considering movement during normal gait activities. The signals from these muscles can be feedback to the ankle foot orthotic device to control the functionality of ankle foot for foot drop patients during walking. This study will helpful in development of better and compatible ankle foot orthotic device that is patient specific and can be customized.

Contribution ID: 1021
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

The elbow and forearm portable rehabilitation device

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In this paper the design of a new rehabilitation device for the elbow joint and forearm will be presented. In the beginning of the article key requirements (such as mass of the device, movement amplitude, degrees of freedom etc.) will be discussed and established. Then, the design concept of the rehabilitation device will be presented. The main functional and design features, such as two degrees of freedom or placement of bidirectional load cells, will be highlighted and discussed. Key equations connected to the requirements and the results of strength analysis of mostly pressured parts of the construction will be reported. Then, the control system, which included active and passive control mode, will be presented. Finally, an overview of the whole device with full functionality and the plan of further improvements will be given.

Contribution ID: 1070
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Is bilateral control using a hydraulic robot useful for upper limb rehabilitation?: a preliminary study

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In recent years, there is a growing need for bilateral upper limb training for stroke rehabilitation. Bilateral upper limb training has several advantages. Among them, force feedback function has the greatest advantage. The function of bilateral control makes it easy to determine the patient's personal training intensity. Since a therapist applied suitable load to the patient while feeling the load to the patient in real time. The purpose of this study is to confirm whether bilateral upper limb rehabilitation systems which is consist of a hydraulic dual arm robot (H1U) is available for upper limb rehabilitation. H1U has a six degree -of-freedom (DOF). Each arm have three joints driven by hydraulic linear servo actuators, which has torque controllability. Author defined right and left arm as master and slave-arm. It is assumed that a rehabilitation therapist operate master-arm and a patient is fixed in slave-arm to be supported by the therapist.Author applied bilateral control based on symmetric position servo type and unilateral control for H1U. The parameter to compare is

maximum value of end effector position and joint torque error between bilateral and unilateral control mode. As the results, bilateral control showed smaller end effector position error than that of unilateral control. By contrast, joint torque error was larger in bilateral control mode than unilateral control mode. This is attributed to characteristic of symmetric position servo type bilateral control. Master-arm and slave-arm generated joint torque in the opposite direction to achieve the same end effector position each other in this mode. New bilateral control types based on force reflection and force reflecting servo type is set to apply H1U to improve force feedback function. For this purpose, we have selected force sensor to install with end effectors. The next step is to do experiments on human subject.

Contribution ID: 1079
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Locomotion therapy for infants

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Children with neurological impairments start walking later and sometimes it is even impossible for them to learn a physiological gait pattern. This has a major impact on the physical development and moreover on the social wellbeing with increasing age. Devices for locomotor therapy, which are currently available on the market are not suitable. Only children with a body height of more than 90cm are in the range of intended use of such products. Therefore, to improve motor functions of affected infants an automated locomotor therapy device for infants was developed to close the gap in therapy possibilities for this patient group.
The prototype was designed and constructed as close as possible to a market-ready medical device. Actual medical-technical standards like the EN60601-1, EN/ISO14971 or IEC62304 for software development were considered. The new device is usable for infants ageing from 1 to 4 years with a maximum body height of 90cm. Drive parameters for the movement of the orthosis were estimated from data of gait cycles of healthy children. The developed software controls the electrical drives and considers safety aspects gathered from risk analysis. After implementation of a prototype that fulfills the given requirements, a procedure based on the EN62366 was developed to enable exten-sive testing and analysis of different aspects of usability. This tests revealed a usability value of 77.4%, being interpreted as “satisfactory”.
The prototypic device was tested with a healthy child under supervision and consent of the mother and a physical therapist. A therapy session of 15 minutes at a walking speed of about 50 steps per minute was simulated successfully. Now a clinical study is in preparation according the ethical standards to evaluate and assess the clinical usability. This new therapeutic approach will aid in re-duced impairments for affected children and thus in improved quality of life.

Contribution ID: 1218
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Upper limb motions analysis for development of an upper limb rehabilitation robotic system

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This paper presents ongoing research activities for development of an upper limb rehabilitation robotic system needed to Prokinetic Rehabilitation Clinic. Prokinetic therapists identified the need of a passive rehabilitation robotic system (RRS) with 3 degrees of freedom for upper limb.
Within the project we used several tools such as participant observation, interviews and questionnaires to understand people in their natural work environment. Observation sessions and interviews were limited to observing therapists' interactions with their patients at Prokinetic Rehabilitation Clinic. Understanding of the treatment methods and of the rehabilitation targets used by therapists is important to guide the design and integration of robotic systems in clinical practice.
Upper limb motion analysis has been done using Vicon system (14 Vicon T10 video cameras and Vicon Nexus software). We used this analysis in order to implement the control algorithms. The video analysis aim was to evaluate the joint trajectories and range of motion of a human upper limb. An experimental motion analysis was performed using a modern equipment and the interest joints were elbow and wrist.
The obtained results will be useful for the rehabilitation robotics, in order to implement the rehabilitation exercises with an upper limb rehabilitation robotic system.
We designed the mechanical, actuation and control systems. The RRS allow flexion/extension of elbow, supination/pronation for hand and flexion/extension for wrist. Some components of our RRS were fabricated using a 3D printer. After considering the deficiencies and problems found in existing control systems, we proposed a hybrid architecture, two-level structure for the robotic control system.
This project aims to use a user-centered design process to create an upper limb RRS for patients and therapists from Prokinetic. The end-users will be involved actively, continuously throughout the RRS design and development.

Contribution ID: 1282
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Wheel chair control skill assessment for the persons with severe physical disabilities

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Self-reliance is one of the most important thing to live for not only able-bodied persons but also disabled persons. Especially, for severe disabled persons, it is very important that getting ability to move themselves.
Our rehabilitation center, we assess a severe physical disabled person's ability to control a powered wheel chair. Body movement of these severe physical disabled persons is very slight and is not sophisticated. Moreover the movement is affected by their seating posture or control targets. Therefore, it is very difficult to assess their ability appropriate. In this paper, we present a controller position assessment system for the persons with a severe physical disabled, and show a preliminary result of the method applied to an able-bodied participant.
The assessment system and the measurement procedure were as follows. A joystick of a controller for a powered wheel chair was mounted on a universal mounting system to find suitable controller position in experiments. A participant sat a chair with the controller and gripped the joystick of the controller. The controller was initially positioned on the extended line of the right arm support and at the distance where the participant can grip the joystick without contraction of any muscles. The participant moved joystick according to an experimenter's instructions. The participant's posture

and the position of the joystick were tracked and recorded by a portable motion capture system. We recorded the motions of several controller position in this experiment.
According the experiment results, we showed the proposed system was able to assess the control ability of a participant quantitatively. And we showed possibility to find a suitable position of a powered wheel chair controller.
All experiments in this paper were reviewed and approved by institutional review board of the National Rehabilitation Center for Persons with Disabilities.

Contribution ID: 1320
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Using NIRS to measure hand finger position

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Several factors can lead a person to lose the full use of his hands. In addition to trauma and the natural aging of the musculoskeletal system, cerebrovascular accidents (CVAs) are among the leading causes of hand disability. Rehabilitation training plays a fundamental role in the recovery process and robotic systems can be an aid to restore limb functions more quickly. This work proposes the development of a system to measure flexion of the fingers of one hand using near-infrared spectroscopy (NIRS) on the forearm. The system consists of an optical emitter and sensor pair (infrared LED and phototransistor), a software interface for signal processing and a virtual environment with a 3D hand used as a test platform. The main objective of the system is to enable the mirroring of finger movements for use in rehabilitation systems.

Contribution ID: 1405
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Development of a safety validation framework for a powered upper extremity rehabilitation exoskeleton

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The science of rehabilitation exoskeleton is still on its developing phase. But with the current status and prevalence of neurological impairment steadily increasing, the need for more possible solutions has become eminent. Despite the potential of rehabilitation exoskeleton in bringing about efficient therapeutic rehabilitation treatment, standards and regulations hinders its marketability. There is not much evidence and studies showing the reliability and acceptability of these devices in terms of technical safety. The US Food and Drug Administration has classified exoskeletons under the Class II category for posing higher risks to its users, thus the establishment of special controls are necessary. There is still, however, an unclear regulatory controls for these devices which makes compliance lengthy or unattainable. A framework for exoskeleton developers was presented that can be used as a protocol in testing and validating the safety of the device in terms

of technical and non-clinical aspects. It is a vital step towards human pilot testing and clinical employment. Based from previous studies while carefully taking into consideration the ISO 14971 standard, the risks that upper limb rehabilitation exoskeletons pose were identified along with the ones already mentioned by the FDA. Each risk can be mitigated through a series of tests. These tests are the special controls the regulation committee is requiring. Standards give specifications and necessary procedures for the mitigating process. Finally, a discussion of each tests, and how these will help verify and validate the safety of rehabilitation exoskeleton was done.

Contribution ID: 1462
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Development of a customised wrist orthosis for flexion and extension treatment using reverse engineering and 3D printing.

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Hand disability implies impairment and limitation in daily activities, affecting patient’s life quality. Broken bones, congenital conditions or cerebrovascular diseases frequently demand the use of structural support in the form of orthoses. Orthoses are categorised according to their mechanical functions in: static, static progressive or dynamic. While static orthoses are usually made of a single piece and do not allow movement, static progressive and dynamic orthoses are made of a main body with assembled with mechanical elements such as rods, pins, straps, springs, etc., thus allowing a limited amount of movement. Hand orthoses demand a high degree of personalisation to suit patients’ anatomy and pathology. A reverse engineering method has been proposed for the development of static progressive and dynamic orthoses for the hand for the rehabilitation of hand disabilities. The method involves the image acquisition of the patient’s anatomy and the mechanical design of the orthosis by Computer Aided Design (CAD) software. This method offers a high degree of personalisation and the development of low bulky devices with a reduction of weight at low cost by using 3D printing. The case presented on this paper is the design of an original static progressive orthosis for flexion and extension treatment of the wrist. The main body of the orthosis was designed using the data from Computer Tomography (CT) scan images and a CAD software to fit the hand anatomy. Mechanical elements were chosen to provide a variation from 0 up to 90 degrees of extension, and up to 90 degrees of flexion with mechanical resistance to assist in the improvement of the wrist flexor muscles strength.

Contribution ID: 1503
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Adaptive Design and Biomechanical Analysis of a 6-DOF Wearable Robotic Arm for Functional Post-Stroke Rehabilitation

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An adaptive design of a 6-degree-of-freedom wearable robotic arm for functional post-stroke rehabilitation was subjected to biomechanical analysis using CAD simulation, 3D printing and motion capture technology. The wearable robotic arm accounts for the movements of the shoulder, elbow and the wrist in order to perform functional arm movements during therapy. Adjustable links

and ergonomic attachments were incorporated in the design to adapt with the anthropometric features of the human upper limb. Finite element analyses of the critical components as well as the robotic workspace were simulated using the CAD/CAE software CATIA. Individual parts were then 3D-printed to produce a mock-up mechanism to be used for biomechanical analysis using motion capture. As a result, each prescribed upper limb movement was executed with ease by the wearable robotic device and within the prescribed range-of- motion. The proposed adaptive design of the wearable robotic arm was then recommended for fabrication and further testing for its safety and clinical efficiency.

Contribution ID: 1504
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

New technologies for range improvement and numerically measurement of movement restricted patients

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There are few options to numerically measure the evolution of patients with movement restriction. We built a robotic hand controlled by low-cost sensorized glove with the purpose to evaluate numerically the range of motion on fingers of patients with restricted movement and help to solve this problem quicker with our "high gain" technique. In this technique, the restricted patient wears the glove and try to move his fingers. We apply a gain on this movement, generating a greater amplitude in the robotic hand compared to the human hand. This gain decreases gradually over the days, stimulating the patient to make a continuous stretcher movement, helping his recovery. This article examines the measurement quality of these sensors, as well as the evolution of patients with movement restriction using our technology. The tests were carried out at UCL College, in Serra city, Espírito Santo, Brazil. The equipment was tested by 10 people from 18 to 40 years old who held a 90 and 45-degree scale to compare with the value reported by the sensors. We are just waiting etic committee agreement to begin tests on our "high gain" technique for patients with movement restriction. The numerically evaluation in other hand, showed a precision of 5 degrees of movement. By this study, we concluded that the equipment developed by the authors is a useful tool to evaluate numerically the movement amplitude of hand fingers.

Contribution ID: 1693
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Knee and Ankle Powered Above-Knee Prosthesis Design and Development

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Amputation has vast influence on life of amputees. Despite technology advancements, above-knee leg amputees still have quite a problem ascending stairs. At Faculty of Mechanical Engineering and Computing, University of Mostar, we are developing above-knee prosthesis that would be able to perform stair ascent in natural manner. The goal is to mimic main leg muscles by using actuators. First tests of the prosthesis showed that it is not enough only to power prosthesis using only knee actuator and that in order to achieve more natural stair ascent ankle actuator should be integrated into a prosthesis design. This paper presents our current design of the above-knee prosthesis and its functions. The prosthesis is powered in the knee and in the ankle by hydraulic actuators. With the ankle actuator integrated into design, prosthesis showed much better results,

closer to the natural stair ascent. Current prototype of the prosthesis was designed by using mostly of off-the-shelf components which proved to be good for initial tests and experimental purposes. However, unique novel components need to be developed in order to optimize the prosthesis and make its design less rough, more ergonomic and user friendly.

Contribution ID: 1699
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Design and manufactur a haptic system to rehabilitate the muscles of the fingers

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The project has been aimed to construct a haptic system to record the forces exerted by the muscles of a
person which for any reason have been experiencing muscle weakness and have been in trouble for doing different works by his hands as well as to send a reply commensurate to the patient according to the records and hand muscles rehabilitation protocols. In fact, the difference between this haptic system and other devices for upper limbs (extremities) rehabilitation (which are able to record the level of force exerted by the patient's muscles, such as Isokinetic) is that the system is simultaneously able to measure the force exerted by a hand as well as to provide a person's hand with resistance by taking into account these forces exerted that since this resistance provided is simultaneously enabled, therefore provides the physician with more accurate measures for distance of treatment. In this project we contributed a novel method to compute the level of the force exerted to the haptic system by a user. No force sensor has been used in this project, and the only by receiving feedback the current drawn by DC motor.

Contribution ID: 1742
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

A bicondylar knee for walking robots, exoskeletons and prosthetics

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We have designed and manufactured a new bioinspired knee joint whose design can be tuned to reduce actuator size and power requirements for common high load tasks such as stair ascent and sit-to-stand. The design achieves this by replicating the geometry of the human knee.
It has two smooth curved surfaces that slide and roll over each other as the joint rotates; two ligament-like springs hold the joint surfaces together; Actuators drive the joint via cables to represent tendons. As a result, the moment arm the actuators can impart changes as a function of joint angle with the locations of the cable attachment points affecting the shape of this curve. The peak moments required to perform high load tasks are found to be in the mid-range of motion. We use this to our advantage, selecting the cable attachment points so that the moment arm is largest in this central region. When this geometry is optimized for stair ascent a reduction in actuator size of 13% can be achieved compared to a constant moment arm knee.
Additionally, inspired by the mechanoreceptors in the human knee, stretch sensors have been fitted in the mechanical ligaments. We show experimentally that measurements of this stretch can

be used to estimate joint angle, overcoming the complexity of measuring position for our mechanism.
Bioinspiration in walking robots is typically achieved by adding compliance to the drive train in order to replicate the overall dynamics of human motion. Differently from this, we have focused instead on the specific geometrical properties of the human knee. These results show that by incorporating this type of joint into exoskeletons, walking robots and above knee prostheses, actuators sizes can be reduced while still providing sufficient joint control.

Contribution ID: 1831
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Adaptive control scheme for a peadiatric rehabilitation exoesqueleton

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There're different diseases that cause motor impairment generating disability. Training with robotic devices has a positive effect on the rehabilitation process in patients with motor disabilities due to brain problems, increasing the possibility of constructing exoskeletons that allow a positive development.
A therapy device is proposed in an 11-year-old patient who suffers neurological problems: Agenesis of the corpus callosum, which prevents an assertive communication between hemispheres and left cerebral palsy. The difference between patients with agenesis, generates a unique case study and the need of an specific rehabilitation program.
Taking the articulation movement ranges established by the American Academy of Orthopedic Surgeons as standard, the measurements of a healthy test subject with weight, height and age similar to the patient, and comparing them with the patient's measurements can be viewed some differences.
Movement – Standart range – Test subject – Patient
Flexion - 0º-80º - 0º-81.3º - 0º-130º
Extension - 0º-70º - 0º-69.5º - 0º
The position of rest on the patient's wrist (flexion) would cause damage to bone, muscle and tendons if no improvement is obtained, also has problems in the mobility of their fingers. This is due to the spasticity conditions like the angle of the joint, there's a variation in the force exerted by the patient's hand in the resting state, which is calculated at 15N in the vertical, while the test subject performs a force of around 4N in the vertical.
The main objective is propose a device, modelled as an open chain of 4 links, based in the values previously detailed. Kinematic model represents the metacarpus and 3 phalanges in order to perform a position control based in the dynamic model that allows a force control scheme. The parameters obtained are suitable for an adaptive control design. The work is in simulation and modelling stage.

Contribution ID: 1847
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Interdisciplinary evaluation software for neurorehabilitation

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The integral approach proposed for neurorehabilitation needs a special patient's data management system. To accomplish with this requirement, customized software was designed, that includes three main areas of evaluation: neurological, functional tests scores and neuropsychological (cognitive and language tests). Also, personal and medical data are included with confidentiality and security considerations.
The neurological evaluation consists in three windows. In the first one, the neurologist includes the stroke diagnostic, treatment and rehabilitation received. In the second window the neurologist carries out the neurological evaluation based in the NIHSS test. This test is presented with the options for that the physician ticks the correct options. In the third window a human figure appears with specific boxes for evaluation of cranial nerves. This way the information is complete and it is available for other professionals.
The physiotherapy evaluation consists in four windows. The first window is the Barthel Test and the physiotherapist should complete it by ticking off the correct option. The second window is the FIM test, where the physiotherapist selects the score corresponding to the evaluation. When the test finishes, the global score is obtained. The third window presents the DANIELS Test and the MODIFY ASHWORTH Test, both presented for physiotherapist selection. When the tests are finished all global scores are presented.
The neuropsychological evaluation consists in six windows for the ACER Test that involves five cognitive domains: attention/orientation, memory, language, verbal fluency, and visuospatial skills. For this reason, this test has six windows in where images of animals, places, geometrics figures and objects of the diary life, phrases, dates and addresses are presented.
In addition, the soft enables the simultaneous evaluation and the data storage in a database to statistical and clinical analysis, and it can be accessed through cell phones, tablets and computers.

Contribution ID: 1848
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Analysis of postural reference points using Kinect sensor and Wii Balance Board

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The mechanisms of equilibrium and stability are multisystemic processes, and they have a great impact in the activities of each person's daily life. There are not accurate evaluations that show the functional deficits caused by pathologies affecting these mechanisms. For this reason, from the areas of bioengineering and kinesiology it is proposed to carry out a quantitative analysis of the trunk movements and of the weight transfer to the lower limbs.
In this work we used the Wii Balance Board and the Kinect sensor, considering the reference points such as the center of gravity (COG), represented by a point that projects the skeleton of the Kinect sensor on the column, and the Center of Pressure (COP) projected by the Wii Balance Board. The data were processed by the MATLAB platform.
The experiment was performed in 10 healthy subjects without equilibrium disorders with an average age of 25 years. The proposed protocol consisted of precession movements taken simultaneously with the user placed in the area of sensing of both devices. The measurement parameters registered were the length and maximum amplitude of the trajectory draw by the user, and the velocity of the oscillations.

The results showed a significant correlation between the Wii Balance Board and the Kinect Sensor curves, for all the variables calculated. We can conclude that is possible to compare and interchange the results of COG and COP, obtaining equivalent parameters in the Anteroposterior and lateromedial planes. New experiments with more patients are necessary for an assertive conclusion about clinical use of both devices.

Contribution ID: 1852
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Instrumentalized orthosis for hand's therapy of people who suffered stroke

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Every day, a lot of people are affected by disease or syndromes which may cause some kind of loss of motor or sensory function. The most common causes for the loss of muscular function is the Stroke. According to the last Brazilian National Health survey conducted by IBGE in 2013, 2.2 million of people were diagnosed with Stroke in Brazil, where, if no death occurs early in the first few days, it will be necessary some kind of rehabilitation therapy. In this way, the aim of this project was to adapt a passive orthosis design, made by means of a 3D printer, to an active orthosis, using servomotors, for bimanual therapeutic rehabilitation of hemiplegic people who suffered stroke. The developed orthosis may works with an instrumentalized glove (mirror movements) or a computerized interface (pre-defined movements). Sensors inside the glove makes the acquisition of movements of the healthy hand, using flex sensors. The computerized interface has already pre-defined flexion and extension movements in a program routine. Bluetooth wireless adapters makes the communication between the instrumentalized glove and the electronic control active orthosis, eliminating cables, thus facilitating the use of the devices in day-to-day, while the computerized interface runs by means of the USB communication. Healthy volunteers had tested the operation of the system. Repetitive movements of flexion and extension of the fingers were proposed in order to to verify the repeatability of the movements. Results indicate little difference in the values of movement amplitude in relation to those picked by the glove with flexion sensors attached to the glove. Therefore, the developed device may be used as a therapeutic orthosis.

Contribution ID: 1894
10. Biomechanics, Rehabilitation and Prosthetics
10.05. Rehabilitation engineering and robotics

Design and implement of a neural bridge system for peripheral nervous system rehabilitation

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The damage of peripheral nervous system caused by accidents, lesion, cuts, and etc. are of those major issues of injured people. Such injuries lead to disability and loss of functions of organs and muscles or complete paralysis.
The present study was aimed to help such people to restore their ability with combination of medical and engineering science. In this study a system with the ability of regeneration blocked or weakens neural signals due to injury was designed. To do so, neural signals of proximal site of

injury should be recorded by cuff electrode. The recorded signals processed and main featured are extracted. Then stimulation unit stimulate distal site of injury by the cuff electrode. The main challenges of this study were as follow: The optimum size and best location of the contacts on cuff electrode, peripheral nervous system and cuff electrode model extraction, appropriate parameters for nerve stimulation and recording, and design the recording and stimulating circuit with low noise and high precision. COMSOL software were used for the modelling of cuff and nerve and the kind and location of contacts were investigated for optimally recording and stimulating. There were two approach to implement this structure: Using discrete components such as operational amplifiers and resistors and capacitors and using of PSoC (Programmable System on Chip). The second approach was selected because of its high integrity and efficiency. The experiments done on animal samples (RAT) showed desirable results and the efficiency of such a structure.

Contribution ID: 64
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Muscle activity assessment during balance chair sitting

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The experimental investigation on muscle activity during sitting and movement activity on the balance chair REDSPINAL, therapy ball and “normal” office chair was done. The experimental investigation was done on 10 specimens. Used method was surface electromyography and 3D motion analysis. Investigated muscles were: erector spinae, rectus abdominis, external obliquus, internal obliquus, quadratus lumborum, symetrically on left and right body part.
It was found that during the muscle activity on balance chair are activated muscles in lumbar and thoratic part of spine, which is approximately 2x higher than during seat and movement on normal fixed office chair. Each movement of sitting part of chear, which is not fixed, activate muscles which stabilizing the spine in upright position. It was foud in all experimentally investigated muscles. Limit of used methodology was, that were measured only main surface muscles, and measured specimens were not people, active in sport and with big musculature. Generally was found, that higher activity was higher in the back muscles, errectors and quadratus lumborum.
It was found that the muscle activity on balance chair is significantly higher than on the office chair with fixed seat, and is very simmilar as the muscle activity on seating ball.

Contribution ID: 97
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Effects of anterior rocker sole shoe profiles on the plantar fascia stress distributions during stance phase of gait

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Plantar fasciitis is commonly observed in patients with heel pain. It is obvious that the plantar fascia bears loading during the push-off phase, the windlass effect is induced by dorsiflexion of the toes, and brings on the peak loading on the plantar fascia. In clinical practice, anterior rocker sole

is a common orthosis prescribed for the treatment of plantar fasciitis. The objective of the current study was to use gait analysis and dynamic finite element analysis (FEA) to investigate the effect of anterior rocker shoe designs on the loading of planter fascia during the stance phase of gait.
A 3-D finite element foot model, including the bones, planter fascia and other soft tissues, were reconstructed in this study. A total contact insole and the anterior rocker soles with 3 different designs of rocker angle were also created. The kinematic data obtained from the gait analysis was used as the boundary conditions to simulate the motion of the foot with different anterior rocker soles during the stance phase. A commercial FE software (LS-Dyna) was used to perform the dynamic simulation during the stance-phase of gait.
The result showed that the maximum tensile loading on the planter fascia under barefoot, RBS10°, RBS20° and RBS30° conditions were 1338.2 N, 1077.7 N, 907.5 N and 752.3 N, respectively. The maximal peak von Mises stresses in the plantar fascia near the calcaneal tuberosity calculated 22.2 MPa, 15.49 MPa, 14.04 MPa and 11.87 MPa under barefoot, RBS10°, RBS20° and RBS30° conditions, respectively.
As a result, wearing a shoe with larger anterior rocker angle would inhibit the windlass effect, and the peak loading of the plantar fascia will thus be relieved. The results from this study can provide a treatment guideline for treating plantar fasciitis, and could provide quantitative reference to orthotists in designing foot orthosis.

Contribution ID: 111
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Development of a system to quantify the depth of tendon stimulus for the illusion of motion achieved by a vibrator

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Vibration devices can be applied to tendons to evoke the illusion of motion and allow sensorimotor characteristics of human to be studied. The purpose of this study is to establish a quantification system for the determination of the depth of a tendon pushed by the contact head of a vibration device. Previous studies used the amplitude of vibration (not under load), as a base specification for the vibration device. However, load is applied when the contact head pushes a tendon, calling the accuracy of this assumption into question. In addition, previous work did not consider the potential vibration suppression of the researcher's grasp on the vibration device. In this study, we develop and evaluate a quantification system consisting of a vibrator-stand, an armrest, and measuring apparatus. We conduct three experiments to verify the validity of the proposed system. Firstly, we use a palm-sized vibration device with a column-shaped contact head. We attach an acceleration pickup to the contact head and the trunk of the vibrator, and record the acceleration at 1000 Hz. We verify that the vibration of the contact head is not suppressed by the vibration of the device's trunk. Next, we stimulate the biceps brachii tendon in the right arm at 100 Hz and verify that our proposed system successfully evokes the illusion of motion. Then, we attach the acceleration pickup to the vibrator's contact head only (the second experimental condition) and record the acceleration at 1000 Hz. Then we calculate the depth of tendon stimulus achieved by the contact head. We present and explain our results here.

Contribution ID: 203
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Stiffness estimation using center-of-pressure fluctuations induced by electrical stimulation

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Stiffness plays an important role in maintaining a standing posture. We propose a novel technique to estimate stiffness using center-of-pressure fluctuations induced by electrical stimulation. Healthy male participants aged 22 to 24 stood on a force plate. The displacement of the center of pressure was measured. Measurements were carried out with and without electrical stimulation applied to the gastrocnemius muscle. The displacement measured in the stimulated condition, ds, involved intrinsic fluctuation of the displacement of the center of pressure and electrically induced fluctuation de. The displacement ds was smoothed using a Kalman filter, which was constructed by approximating the displacement measured in the non-stimulated condition with an autoregressive model, to obtain the intrinsic fluctuation. The intrinsic fluctuation was subtracted from the displacement ds to obtain the electrically induced fluctuation de. The induced fluctuation de was used to identify the transfer function from the electrical stimulation to de. The transfer function was identified using a singular value decomposition method. The transfer function was the fourth-order model. Thus, the transfer function had two natural frequencies that were proportional to the square root of the stiffness. One of the natural frequencies was 2–3 Hz, and another was around 0.5 Hz. The former was close to the natural frequency of the gastrocnemius muscle, and the latter was close to the resonance frequency around the ankle joint. The proposed method can provide muscle stiffness and ankle-joint stiffness in a standing posture.

Contribution ID: 244
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Inertial measurement system for upper limb joints tracking

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This work presents a system of tracking and analysis of upper limb movement through the use of inertial sensors. The designed system uses four inertial sensors, which are placed at the midpoint of the corresponding segments by hand, forearm, arm, and the fourth is between the scapulae at the height between vertebrae T5 and T6 (Thoracic 5 and Thoracic 6) as a reference point. The information of the four sensors was preprocessed by a microcontroller and sent wirelessly to a computer. The data of each sensor was processed and the angular position of the joints was calculated. In this work the concept of quaternions was used to avoid the singularities that occur when the reference axes are aligned with the Earth's gravity axis, instead of working directly with the representation through Euler angles. In addition, a descending gradient filter was implemented to merge the accelerometer and gyroscope data in order to compensate drift errors.
To visualize the movement, a simple virtual environment was implemented with SimMechanics®. The designed system was evaluated with 10 volunteers, in flexo-extension and abduction-adduction movements, at different velocities and compared with goniometer measures. The system demonstrates good repeatability and the computed error was less than 5 degrees (4.83 ± 0.26 degrees).

Contribution ID: 255
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Role of the visual feedback on balance responses to upright stance perturbations

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In this study an evaluation of visual feedback on the balance response to upright stance perturbations through a moveable platform is proposed. To this aim, subjects underwent to translational perturbations of balance in backward direction at fixed velocity, thus eliciting forward-direct postural sway. The same kind of perturbation was administered to each volunteer in an eye-open (EO) and eye-closed (EC) condition, in order to assess the weight of the visual feedback on perturbation withstanding.
Center of pressure (CoP) and center of mass (CoM) were acquired, revealing a repeatable double-peak shape which mirrors two different response periods: a destabilizing phase and a counterbalancing phase. Thus, due to their repeatability, CoP and CoM were analyzed on the basis of their temporal and spatial features in both visual conditions. Further, also the angular displacement of lower limb joints and trunk were considered.
Results showed significative differences both of CoP- and CoM-based parameters computed in EO and EC conditions, in both response periods (destabilizing and counterbalancing phases). Moreover, angular range variations of lower limb joints and trunk seemed to indicate a different role of each joint in the two considered sensory conditions, highlighting the switch from an ankle-based strategy (EO condition) to a more complex kinematic strategy (EC condition), also with the same perturbation magnitude. Outcomes of this study could add information about: A) the suitability of considering center of pressure displacement also in perturbed posture experimental conditions, B) the role of the visual feedback in the balance maintenance, which appeared non-negligible thus leading to a more challenging condition for perturbation withstanding and balance restoration. Eventually, present results could help to design further studies about the neural pathways involved in balance maintenance, relevant for healthy as well as pathological subjects. Procedures followed in this study were in accordance with the Helsinki declaration ethical standards.

Contribution ID: 329
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Estimation of Postural Control Strategy During Continuous Perturbation

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Stability is an important aspect for every moving object and millions of people spend a good deal of their time on their feet for standing, walking, or running. Compared to static balance, dynamic balance with presence of external perturbation requires more complex strategy. The purpose of this study was to investigate the multi-segment of human postural control strategies organization in continuous perturbation balance task between ankle-hip angle as collective variable. We examined transition of ankle-hip angle pattern in moving platform balance paradigm. Five healthy young adults stood on a moving platform in anterior-posterior direction continuously within frequency range 0.2Hz to 0.8Hz with eyes opened. The Center of Mass (COM), Center of Pressure (COP), and ankle-hip angle changed from in-phase to anti-phase at a certain point frequency of support surface. From the cross-correlation coefficient calculation, higher frequency shows negative correlation between ankle-hip angle which mean these two variables were move in the different direction. These results indicate that joint angle sway also could be one of the collective variables in order to determine postural strategy determination.

Contribution ID: 351
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Position estimation of an IMU placed on pelvis through meta-heuristically optimised WFLC

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The estimation of lower trunk orientation and position during normal walking is relevant in clinical setting in order to improve the assessment of walking disorders.
In this paper we introduce a new method for the estimation of the position of an Inertial Measurement Unit (IMU) placed on pelvis, during normal walking on a treadmill. The element of innovation is the use of a meta-heuristic optimisation process to estimate the optimal parameters of a Weighted Fourier Linear Combiner (WFLC) filter, which is designed to efficiently extract periodic/pseudo-periodic components of signals. The choice of this kind of filtering technique starts from the assumption that the lower trunk displacement during walking follows a pseudo-periodic trend.
The IMU position was estimated double-integrating gravity-free accelerometer data. However, data obtained from this kind of approach is affected by drift errors, due to the integration of noise and non-constant sampling rates. To improve the position estimate, a WFLC filter has been designed to extract the pseudo-periodic components of the signal.
The WFLC approach needs a set of parameters in order to properly reconstruct the periodic part of the signal. The estimation of WFLC parameters was performed through an optimisation procedure based on the Artificial Bee Colony (ABC) algorithm, minimising the difference between the WFLC reconstructed position and the data coming from a sterophotogrammetry (SP) system which tracks a marker placed directly on the IMU.
The WFLC weights obtained from the first set of data, with different walking speeds, were then used to improve the estimation of multiple walking trials with the same measurement setup.
This approach allows to obtain useful clinical information using lightweight and low power consuming devices such as IMUs.
This method has been validated through SP data, showing an overall 20% improvement of the RMSE between IMU and SP data over the [x,y,z] axes.

Contribution ID: 370
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Assessment of postural stability using the method of postural somatooscilography

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The aim is to present measurement methodology and new method for evaluating the postural stability using oscillating platform. Proposed methods are alternative to basic methods which are usually parts of the commercial posturography systems. The method for calculating the postural

parameters have been designed in order to objectively quantify and classify the ability of postural stabilization on a standardized oscillatory platform, and determine differences in the postural stabilization of motor function in healthy people and in people with postural instability. The Posturomed (Haider Bioswing GmbH) was used for measurement the centre of pressure (CoP) coordinates during single leg stance provocation test. The postural somatooscilogram has been defined, which shows accelerations of CoP, in horizontal plane in both anteroposterior and mediolateral directions over time. The method was called postural Somatooscilography (PSOG) and the method's output postural somatooscilogram (PSOGram). The proposed method was implemented in MatLab sw. Compared to other commercial software the proposed method enable us direct use of MatLab toolboxes. Patients with postural disorders and control group of healthy subjects were measured. The aim of the measurement was to verify the new method, software and determine differences in the postural stabilization of motor function in healthy people and in people with postural instability. Statistically significant differences have been observed in postural stability between independent postural stable group and postural unstable group detectable with examination of the obtained parameters. Based on the findings, we can say that the presented method allows a complex analysis of the single leg stance in patients with postural balance disorders in clinical practice, it is a relatively low cost matter, non-invasive and low time consuming.

Contribution ID: 402
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Semiportable manually actuated system for measuring muscle spasticity

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In the article, we describe a design of a new system which provides means to quantitatively assess passive resistance of skeletal muscles, also termed muscle spasticity. New design is focused on the measurement of muscle groups which are responsible for movement of elbow joint. The semiportable system is an alternative to expensive motorized isokinetic dynamometers. System is manually actuated dynamometer. The electronic subsystem of the system is used to measure angular velocity and torque in the elbow joint. An incremental encoder is used for the measurement of angular velocity. The angular velocity of the rotational movement in a joint is a result of movement effected by manually controlled lever. The lever is controlled by a physician. During the angular movement of the upper limb segments, the elbow joint torque is measured by a strain gauge subsystem. The output from the system is a graphic dependence between the angular velocity and the torque, which is used to evaluate spasticity. From angular velocity, it is possible to determine the angle of rotation of segments and/or angular acceleration. The dependence between the passive moment of force and kinematic angular parameters allows us to study complex motion and force possibilities of the joint. The designed system could be useable and widely applicable in clinical practice, as well as research of diseases and treatment of musculoskeletal system. The article is a preview of a development of manually actuated muscle spasticity assessment system that has the advantages of not being motorized and therefore powered by high voltage, therefore, its application in clinical practice seems much simpler.

Contribution ID: 404
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Quantifying movement of the head and shoulders during quiet standing using MatLab software and promising parameters

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In this paper, we describe a software and method for quantifying movement of the head and shoulders during quiet standing. The proposed software allows to determine postural stability of head and shoulders, especially during Romberg's test, on the basis of the recording the relative angular movements. The proposed software is used to calculate the new parameters of head and shoulder movements. These parameters are: the area of the confidence ellipse of the inclination of the head versus the inclination of the shoulders and the area of the confidence ellipse of the rotation of the head versus the rotation of the shoulders, the size of the main and minor axis of the confidence ellipse of the inclination of the head versus the inclination of the shoulders and the size the main and minor axes of the confidence ellipse of the rotation of the head versus the rotation of the shoulders. The proposed method was implemented in MatLab sw. It should be noted that the method and/or parameter hasn't been used before in neurological practice for evaluation of head and shoulder movements. As a second (comparative) method, the range of motion (ROM) is employed for quantification of the relative angular movements of the head and shoulders. ROM is a term commonly used to refer to the range of measured values of the motion activity. To test the method, we compared the movements of the fourteen healthy subjects/volunteers and nine patients with viral infection of the inner ear, characterized by dizziness and nausea. Based on the results data, we found out that the parameters can be used to evaluate the postural stability in neurology. Proposed method and software are alternative to specialized software which is part of the commercial MoCap and/or posturography systems.

Contribution ID: 407
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Margin of stability analysis during gait in unilateral lower limb amputees

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The analysis of gait dynamic stability has aroused the interest of the scientific community and contributed with measures to avoid falls. It is well known that there is an increase in falls in people with lower limb amputation. The objective of this study is to evaluate the gait stability in different slopes (-8% downward, 0 and 8% upward) of unilateral amputees (12 transtibial and 13 transfemoral) compared to a control group (15 healthy subjects) through the margin of stability (MoS) descriptor. Participants walked for 4 min on a treadmill at their preferred walking speed on each inclination. Kinematic data of markers on the pelvis and feet were used to estimate the center of mass and a base of support (BoS), from which the MoS was estimated. A mixed repeated measure analysis of variance (ANOVA) was used to assess the main effects of group and treadmill inclination, since all descriptors presented a normal distribution. Both groups of amputees showed higher values for the mediolateral (ML) and backward (BW) MoS in relation to the control group. In addition, the transfemoral amputee presented greater MoS in the ML direction, but smaller in the BW direction. The main effect of inclination was significant, and MoS was smaller in upward inclination. The interaction effect between group and inclination was significant, indicating that the inclinations affected transfemoral group in a greater extension. The main effect of inclination and the interaction effect between group and inclination had greater effect size in the BW direction ($\eta^2 = 0.864$, $\eta^2 = 0.436$, respectively). The results may be due to a greater stride width and decreased step length adopted by both amputee groups, suggesting that amputees increased the stride width and decreased step length for increasing MoS, and, consequently, gait stability.

Contribution ID: 408
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Classical recurrence quantification analysis applied to the trunk displacement signal when walking at different speeds

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Since the recurrence quantifiers do not require stationary time series, it was analyzed whether the classical quantifiers of recurrence (RQA) can differentiate conditions with small variations of velocity through a kinematic time series with non-stationarities. The sensitivity of RQA quantifiers in relation to gait speed was assessed, using reconstructed state-space from medial-lateral trunk displacements. The following recurrence quantifiers were evaluated: percentage of recurrence (REC), percentage of determinism (DET), mean length of diagonal lines (AVG), Shannon entropy of the diagonal line length (ENTd), Laminarity (LAM), trapping time (TT), and entropy of the vertical line length frequency distribution (ENTv). The displacement time series was obtained with a marker positioned over the first thoracic vertebra (T1) of twenty-five healthy subjects (14♀, 11♂, 32.2±10.2 years, IMC: 24.69 ± 3.10 kg/m2). They were instructed to walk for 4 minutes on a treadmill while looking forward, at 80%, 100% and 120% of their preferred walking speed (PWS). For reconstructing the space state, we used the Takens' theorem using the algorithms: average mutual information and false nearest neighbors. It was used the Friedman test with post hoc Wilcoxon sign-rank test for pairwise comparisons, with a Bonferroni correction. The classical quantifiers of RQA were significantly sensitive to 20% gait speed changes, showing different behaviors due to their intrinsic characteristics. Therefore, the classical recurrence quantifiers were able to discriminate gait to different speeds from time series with non-stationarities, including drifts when walking on a treadmill.

Contribution ID: 409

10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Mystery of the human Th10 vertebra

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The human spinal system can be described still in a very limited way by means of a mechanical model due to its complexity and the number of bindings. It is therefore possible that the acquired experimental data will provide us with more than one great surprise. No model is known, either many-elements or nearly continuous (by the finite element method) that would be able to predict the experimentally ascertained behaviour of human spine that is described below.
Measurement was carried out with excitation frequencies of 5–180 Hz. On each spinous process from C7 to L5 accelerometers were placed that recorded the motion in the normal direction. 30 adult persons without diagnosed musculoskeletal system functional disorder were measured. On each vertebra, the acceleration component corresponding to the frequency just excited was established. As expected, several amplitudes on the vertebrae immediately following the excited C7 vertebra could be fitted with an exponential and thus ascertain the dampening of thoracic spine in this segment. In the next approximation, the amplitudes can be interpreted as antinodes and nodes of a standing wave, especially for resonance frequencies.
When measuring partially standing waves of human vertebral column in a prone position with normal excitation of C7 we come to the conclusion that maximum acceleration occurs at the Th10 vertebra. In all 30 persons measured it was found that in the C7–Th9 segment the gradual exponential damping is dominant. In 28 cases though, the amplitude is rising steeply at the following vertebra, and it reaches values comparable with the excited C7 vertebra. At several following vertebrae, the amplitude decreases again. We believe that it could be caused by the fact that the last anchored ribs are just on Th10, or also by that in this vertebra there is maximum freedom of rotation.

Contribution ID: 435
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Coherence analysis between kinematic and simulated muscular activity in upright stance: a modelling study

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Maintaining posture is important so that the human body is kept in balance against the gravity. Analysis of muscle activity and modeling of the human body as a inverted pendulum can reveal interesting mechanisms of maintenance of human posture. In this study, 25 young people participated in an experiment, in which kinematic and force plate data were collected during 4 min in a standing position. The data were acquired with the use of a motion capture system. Kinematic data were acquired at 100 Hz and kinetic data at 1000 Hz. For the acquisition of kinematic data, 39 retroreflective markers were used throughout the body. A triple inverted pendulum model was constructed using a line connecting the lateral malleolus to the lateral epicondyle of the knee to define the leg segment, a line connecting the lateral epicondyle of the knee to the hip to define the thigh segment, and a line connecting the hip to the acromion to define the trunk segment. The activation of nine muscles was simulated using the OpenSim software, from kinematic and kinetic data. A complex coherence and phase analysis was conducted between the simulated muscle activity and kinematics of the body segments. Trunk worked in phase with leg and thigh at low frequencies, and switched to anti-phase at high frequencies, and a in phase activation between the spinal erector and the gastrocnemius was observed. Thigh and leg muscles activated in phase with trunk muscles at low frequencies, suggesting a coupling between the movement of these segments. However, the trunk does not show significant coherence with any of the muscles analyzed, suggesting that it oscillates passively. In general, patterns of muscular activation in the ankle and pelvis were compatible with previous studies, acting to control the swing of the body to maintain upright stance.

Contribution ID: 543
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Changes that kinesio taping causes on walking and running motion

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Kinesio tape is used for healthy people to improve sports performance. However, its effect has not been clarified. This study aimed to clarify the influence of kinesio tape to lower limb on walking, jogging and short sprinting.

The conditions for equipping the taping were three conditions: without taping (control), with taping on knee joints and with taping on ankle joints. After taking the informed consent from the subject, the experiment was done.

Subjects were sixteen healthy adults (age: 21.81 ± 1.76) and walked and jogged. These motions were measured by using a 3-D motion analysis system. The subjects walked and jogged at a constant speed at 4 km/h and 8 km/h for 5 minutes. Regarding walking motion, there was no significant difference in stride length and walking pitch in all conditions. However, the coefficient of variation of stride length and walking pitch were significantly smaller than that in the condition of with taping on ankle joint ($p < 0.10$). Regarding jogging, there was no significant difference in stride length and jogging pace. However, the fluctuation of stride length and jogging pitch became smaller than that in condition with taping on knee joints.

For 50 meters sprint, 14 healthy adults who had exercise experience (age: 21.50 ± 0.50) were recruited and using a displacement gauge. There was no significant difference between the time and the maximum speed for short sprint. However, subjects without athletics experience and taping experience, significant differences were observed both in time and maximum speed ($p < 0.05$, $p < 0.10$).

From these facts, it was suggested that taping to the ankle stabilizes low intensity motion like walking motion. In the case of applying to the knee joint, the joint motion was changed by taping, it was suggested the possibility of improving the large performance of joint motion such as sprint.

Contribution ID: 563
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

The effect of difference posture on postural electrical myogram during walking

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Recently, many people mind their posture. Correct posture is important for not only our looks but also our health, for example improve metabolism, athletic ability, viscera function and spontaneous cure. However, most people think their posture is poor and correct posture which they assume is different in each other. Therefore, we need appropriate instruction for having correct posture. In this case, it is important to taking into account the load for postural muscle. The purpose of this research is to reveal the effect of difference posture on postural muscle by using EMG measurement. And, we identified the appropriate instruction way for having correct posture.

We set four posture condition while subjects were walking; natural posture, teaching posture, correct posture which they think and relax posture. Subjects went straight and returned for fifteen meters six times. We measured bilateral four electromyograms; Lumbar Erector Spinae Muscle, Transversus Abdominis Muscle, External Oblique Muscle and Internal Oblique Muscle.

As the result, in all EMG data showed that it was almost higher in teaching posture and correct posture which they think than other posture. Moreover, we could confirm the difference between right and left in these muscles. The difference was concerned about subject’s inclination of the center of gravity (COG) during still standing. Furthermore, it was found that EMG data included gate rhythm that was relation to the gate steps for some subjects in teaching posture and correct posture which they think. Measured muscles in this experiment were postural muscle of upper body so we assumed EMG of these muscles almost unaffected by gate motion. It meant that it might be excessive load for muscles by qualitative instruction. Thus, it is important to show the qualitative EMG data and COG about postural muscles when subject receives the correct posture instructions.

Contribution ID: 602
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Evaluating the performance of fall detection algorithms

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Falls that occur during regular daily activities are recognised as one of the major health risks for the elderly population. Since the introduction of small wearable inertial devices, researchers have proposed various algorithms for fall detection based on the measurements of inertial sensors (dominantly accelerometers). Those algorithms vary in complexity from simple one parameter threshold algorithms to complex machine learning techniques. Their common goal is to detect when a person falls in order to alert health professionals, family or friends to come on time for help.
In order to test the performance of new-developed fall detection algorithms, researchers use one dataset in order to set thresholds or train their algorithms and then report the results based on this dataset. However, when these algorithms are tested on other datasets, several papers have shown that the initial reported performances cannot be reproduced.
In this paper we present the results of a study that compared two datasets we recorded using two different sensor nodes with embedded accelerometers on the same group of subjects, performing the same actions of daily living and simulated falls. We analyse the differences between the data in

those two datasets that arise from the use of different sensors and demonstrate the effect it has on fall detection algorithms based on simple one-parameter threshold detection.

Contribution ID: 690
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

The effect of walking with preferred speed after Vo2max test on gait stability of male soccer players

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VO2max is considered an important component of aerobic endurance performance in elite soccer players, which is evaluated by Incremental Muscle Exercise Test (IMET). IMET induces general fatigue that deteriorates main mechanisms of postural and motor control (vestibular, visual and proprioception systems) in non-athletes young adults. The aim of this study was to examine gait stability of male soccer players walking with preferred speed after IMET test. Eleven semi-professional male soccer players (20.67±5.03 years, 71.2±7.52 kg, and height: 179.3±5.49 cm) participated in this study. The preferred walking speed (PWS) was evaluated before IMET test, followed by a pre-trial for 4 min of treadmill walking at PWS (PreT). Next, soccer players were submitted to IMET on treadmill with 0% of slope: The participants started 2 min running at 8 km/h, followed by progressive increases of the treadmill speed at rate of 2 km/h every 2 minute until participant exhaustion. IMET was followed by 28 min walking at PWS. A 3-dimensional inertial sensor system (3D MyoMotion, Noraxon, USA) was used to acquire the kinematic data of trunk spine (T1) at a sampling frequency of 100 Hz throughout the PreT, and every 4 min after IMET (PosT-0, 1, 2, and 3). The LDS (Local Dyamical Stability - maximal Lyapunov exponent: λ) was calculated through the Rosenstein's algorithm and used as gait stability index during walking trials. Repeated measures analysis of variance (ANOVA) was applied to assess the effects of different trials. No significant results were found (λ: 1.62±0.07, 1.64±0.06, 1.64±0.07, 1.62±0.05, 1.57±0.06, p=0.484 repeated measures ANOVA, for PreT, PosT0, PosT1, PosT2, and PosT3, respectively). Different from previous study with young non-athletes adults, IMET seems not to influence gait LDS of male soccer players, since they have higher endurance level.

Contribution ID: 1090
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Quantitative assessment of osteoarthritic knee instability: comparison with conventional imaging modalities

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Osteoarthritis (OA) is the most common musculoskeletal disorder inducing instability of the affected joint. Kinematic data provides a low-cost and non-invasive option to assess knee instability. We tested whether accelerometer data could provide information about the stage of OA comparable to currently used clinical modalities.

The right knee of 66 females (45-68 years) underwent magnetic resonance imaging (MRI), plain radiography, and goniometer measurements. Kellgren-Lawrence (KL) grade and the joint line convergence angle (JLCA) were evaluated from radiographs. A composite score was derived based on the MRI OA knee scoring (MOAKS), by summing the score of central cartilage thickness values. A ratio between lateral and medial cartilage thicknesses was calculated from the segmented average thicknesses over weight bearing area (MRI_ratio). Accelerometers attached to thigh and shank were used to record movement signals during the one-leg-stand test. The power of the acceleration signal along the anatomical longitudinal axis (P_acc) was used as a measure of knee instability. Finally, Spearman's correlations between acquired parameters and KL grade / MOAKS composite scores were computed. Leave-one-out cross-validation with logistic regression was used to discriminate OA subjects (KL ≥ 2).
All the instability parameters (P_acc, JLCA and MRI_ratio), except the goniometer angle, showed significant correlations with KL grading (rho=0.32-0.48, p<0.01) and MOAKS composite score (rho=0.35-0.56, p<0.01). Both P_acc and JLCA showed close to similar accuracy to discriminate OA based on area-under-curve (AUC=0.76 and AUC=0.78), while MRI_ratio and goniometer angle had poor accuracy (AUC=0.55 and AUC=0.56).
In this study, we showed that kinematic measurement with simple test is a promising method for OA assessment. P_acc had a high AUC and showed significant correlations both with KL grades and MOAKS based score. This study suggests that knee instability assessed during one-leg-stand can provide further insights in OA diagnostics.

Contribution ID: 1189
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Influence of head orientation on gait stability in young and older adults

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To maintain balance during walking, humans make use of a combined inflow of sensory information. The vestibular system monitors the orientation of the body with respect to gravity, which may stabilize the head and consequently gaze and which may contribute to whole-body stabilization. Since, head orientation influence vestibular information, the aim of this study was to compare gait stability of young and older adults walking with different head orientations. We measured 10 healthy and active young (18-30 years) adults (24,8 ±2,39 years; 67,42±16,05 Kg; 1,72±0,09 m) and 10 healthy and active older (60-79 years) adults (71±5,55 years; 61,58±6,94 Kg;1,58±0,06m). Participants, wore their own regular shoes and a safety harness, and walked on a treadmill at their preferred walking speed (previously measured during overground walking), during 4 min, in different head orientations and task (i: control; ii: yaw; iii: up; iv: down; v: cognitive dual-task). As a measure of gait stability, the margin of stability (MoS), given by the distance between the extrapolated center of mass and the border of the base of support, was calculated in the mediolateral (ML) and backward (BW) directions. As the data conformed to a normal distribution, a one-way repeated-measures analysis of variance was performed with SPSS software (version 23, SPSS Inc., Chicago, IL) ($p < 0.05$). BW MOS was smaller in the control condition compared to all other conditions (p<0,004). The MoS in the ML direction showed greater values for older adults across conditions as indicated by a main effect of group (F=242.601; p<0,001, η2=0,927), while in the BW direction the young adults showed significantly larger values than older adults (F=61.804; p<0,001, η2=0,765). ML results suggest that older adults prioritize stability compared to young, while both groups failed to compensate for balance challenges by increasing BW MOS.

Contribution ID: 1190
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Could postural strategies be assessed with the Microsoft Kinect v2?

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The quantification of body movement strategies to maintain balance may be useful to understand changes in postural control, which cannot be sufficiently described by body sway alone. Some methods for this purpose require special preparations, such as attachment of inertial sensors, goniometers or EMG electrodes. In this study, the capability of the Microsoft Kinect v2, a markerless motion sensor, to assess postural control strategies was tested. Forty-six young (22 ± 2 years old) healthy subjects had the trajectories of 25 "joints", provided by a Kinect v2, recorded during 60-s periods of upright stance with eyes open or close, on rigid (force platform) and soft (foam pad) surfaces. This protocol was approved by a local Ethical Committee. The postural strategies were characterized with a strategy index (SI) based on the phase difference between the accelerations of upper (trunk) and lower (hip) segments of the body, measured by the Kinect in anterior-posterior and medial-lateral direction. Ankle and hip strategies were identified by in-phase or counterphase accelerations respectively, the phase being estimated from the covariance between 2-s sliding windows of the two signals. The trajectories of center of mass (COM) and center of pressure (COP) were also computed from the Kinect v2 and the force plate, respectively. The SI and the velocities of COP and COM were significantly different between conditions (Friedman $p < 0.001$ for SI), suggesting effects of sensory information. These results are in line with other studies showing coexistence of both strategies during stance and the predominance of ankle rather than hip strategy on foam or with closed eyes instead of on rigid surface with open eyes. However, as foam differs from the sway-referenced platform used in other works, prevalence of hip strategy may differ among them. These results support using the Microsoft Kinect v2 to assess postural strategies.

Contribution ID: 1203
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Spherical angular analysis for pelvis coordination assessment on modified gait

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Pelvic coordination is a determinant factor in human gait due to its unique role of lower limbs interconnection and HAT (head, arms, trunk) support. While lower limbs dominant flexion-extension movement during gait occurs mainly at sagittal plane, gait pelvic movement presents

higher displacement amplitudes at transverse (T) and coronal (C) planes with lower amplitude at sagittal (P) plane.
People walk at lower velocities and run for higher velocities. Although at gait and running the movement of the legs occurs alternately, gait and running are different in many other aspects.
As a result of injury or pathology, people often adopt modified gait (MG) such as stiff knee gait (SKG) and slow running (SR) as an alternative to NG. Although most frequent study in human gait corresponds to 2D planar analysis, the study of pelvic movement in NG and in particular MG requires the use of 3D aggregated analysis. While most so-called 3D analysis on human movement consist of three 2D analysis, proposed method corresponds to a single analysis of the three considered dimensions.
The purpose of this work is to apply 3D spherical coordinates to analyze pelvic angular movement coordination at T-C-S planes in SKG and SR for comparison with NG.
Case study representative of a specific subject was selected during NG, SKG and SR test acquiring movement at Cartesian space from adhesive reflective marks on right/left anterior/posterior superior iliac spine (rasis/lasis/rpsis/lpsis) for inverse kinematics.
Angular displacements were analyzed at angular phase and radial distance in polar coordinates corresponding to T-C, T-S and C-S planes, as well as in spherical coordinates at azimuth, pitch angular phases and radial distance of the T-C-S angular displacements.
The application of spherical coordinates revealed a truly 3D innovative approach with integration in a single analysis of pelvic angular displacements at the T-C-S anatomical planes.

Contribution ID: 1231
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

A new generation of spine protection devices in sports

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State of the art back protectors just help against direct impact traumatas. They are useless for serious injuries that may araise if the range of movement is eceeded. Particularly excessive rotation of the spine may lead to dramandous injuries and not uncommonly to spinal paralysis.
A new spine protector device was devoloped to stop movements of the normal range of movement is reached.

Contribution ID: 1371
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Knee support and brace system for evaluation of rehabilitated patient

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Osteoarthritis is a common disease found in the elderly that results in abnormal walking patterns or abnormalities of the legs. To treat patient with such symptom, physical therapists normally required. In this research, we developed a portable device that can be used to measure and analyze the walking pattern. Unlike conventional gait analysis devices which is huge in size and requires extensive installation space, our device is compact and affordable. The device will be installed besides the patient knees. A locking mechanism is designed to limit the angle of the knee joint movement and hence prevent hazardous effect that might cause injury in the rehabilitated

patient. Installed on the device, two Inertial Measurement Units (IMU) are used to determine the extension/flexion angle of the knee. The measurement data will be sent wirelessly to interface with a well-known Unity program, ultimate game development platform. The animation of the human model can then be done corresponding to the real patient knee movement. This is to provide the clear visualization and better analysis of the walking pattern of the patient. To evaluate the rehabilitation efficiency, the series of force resistive sensors are installed on the special designed shoe. The topological pressure data is sent to the computer wirelessly to provide the real-time color -mapped pressure pattern of the patient foot plantar. The device was tested with the patient with satisfactory results.

Contribution ID: 1380
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Gait ratios and variability indices to quantify the effect of using smartphones in dual-task walking

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Smartphone use is one of the most common activities performed while walking: recent studies showed how this behaviour affected spatio-temporal, smoothness, symmetry and regularity gait parameters. In this study, we investigated a subset of additional gait parameters, potentially indicative of gait instability, to check whether concurrent smartphone activities cause deviations from stable walking. Ten young healthy adults were asked to walk outdoor normally and while performing five smartphone-based dual-task activities, with different levels of cognitive effort. Three groups of gait parameters, extracted by a single waist-mounted tri-axial inertial sensor, were analyzed: Gait Ratios group included Stride-to-Stance Time Ratio (SSTR) – equal to the golden ratio $\varphi \approx 1.618$ in normal walking – and Walk Ratio (WR) – the ratio between Step Length (SL) and cadence, roughly constant within healthy subjects –; Variability Measures group included Coefficients of Variation (CV) of SL and step time; Acceleration Ratios group composed of Root Mean Squared acceleration Ratios (RMSR) – the ratio between rms along a single direction and the total rms acceleration. When a dual-task is present, SSTR did not show significant variations from Baseline. A continuous typing activity with low cognitive engagement caused a significant decrease of WR with respect to all the other tasks. RMSR in the mediolateral direction and the CV SL showed visible yet not significant proportion with the amount of experienced cognitive effort. The resulting alterations were in general inconclusive as to their possible link with a reduced ability to adapt the locomotion structure to the context changes, even if for some parameters the observed proportion with cognitive effort and visual domain may need to be deepened on a bigger sample size, possibly including more challenging dual-task demands.

Contribution ID: 1416
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Fundamental study of a simple walking support system using smart devices

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Recently, falling accidents frequently happen (especially among elderly people). These accidents often lead to serious injuries. Therefore, it is necessary to urge people to maintain gait form of proper stride length and foot-ground clearance in daily life.

Lately, several systems for detecting falls have been proposed. However, there are few systems to prevent falls in daily life. In addition, since it is necessary to install more than one sensor or camera in many systems, there are limitations of using location and clothes for user.
Therefore, we have been developing a simple walking support system to prevent falls using smart device equipped with acceleration sensors for daily use. In this system, the smart device is worn on an arm so as not to effect on a life environment. In previous studies, it has been pointed out that the movement of the arm is influenced by the gait in terms of upper body rotation, energy expenditure and dynamic parameters. Hence, it is considered that arm accelerations are capable of use for gait classification.
In order to improve performance of the gait classification accuracy, we try to reconstruct proposed experimental system on a treadmill using each axial component of three-dimensional axes of arm acceleration data acquired at proper timing and introducing experiment support system for human subjects .

Contribution ID: 1644
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Detection of contraction patterns of the forearm muscles to estimate grip strength through electromyography signals

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Due to the high complexity of research and production, robotic prostheses become hard to find and expensive due to scarcity. This project aims at the development of an inexpensive grip strength estimator, allowing a user to control the intensity of strength of a prosthesis, without the cost rising significantly by using simple microcontrollers, operational and instrumental amplifiers and a neural network. To train the neural network, it was necessary to produce an electromyography system that captures signs of muscular activity, and an electronic dynamometer that measures the force produced by the patient's hand, both used to create a training set containing the electromyography signal along with the force produced by the patient. There were difficulties in acquiring the signals using EMG due to the noise of electrical equipment and wireless devices. The solution for noise reduction added a phase deformation to the signal and a response delay to the system, but it was possible to achieve all the proposed objectives, developing a system that can estimate strength with an error rate that does not damage the detection of slow and fast progression of strength.

Contribution ID: 1682
10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

A preliminary investigation of measuring the elbow joints angles by using the human channel gain

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This paper proposed a new method of measuring the elbow joints angles by using the variation of human channel gain, which means that a weak electrical signal was injected to the upper limbs and the response potential nearby was differentially detected. Comparing the values of the angles simultaneously collected by inertial sensors, we obtained the relationship between the changes in the joint angles and the signal gain values. The results indicated that the frequency and the size of the transmitting electrodes can affect the values of signal gain, and the values of signal gain and

joint angles are approximately linear. Thereby, we derived the formula of the relationship between the variation of receiver voltage and the value of signal gain, thus providing a new idea for developing a wearable equipment which can perceive and measure the changes of the joint angles in real time. In this way, we have provided a wearable and lightweight solution to the measurement of joint angles for the upper limb rehabilitation training. Comparing the results of the experiments we have done, we finally defined the conditions for making wearable applications, which could measure the angles of upper limb joints as follows: the size of the receiving and the transmitting electrodes is 40×40mm2; the frequency is 50kHz; the value distance between the transmitting and receiving electrodes is 14 cm, and sure enough, the two electrodes are able to cross the elbow joint.

Contribution ID: 1695

10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

An estimation method for lower-limb joint angles during the motion of standing up using an inertial measurement unit

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A motion-capture system is commonly used to measure human motion for evaluating clinical performance such as standing up or walking. However, after leaving the hospital, a motion-capture system is difficult to use in daily life. Therefore, we developed a technique that can estimate human motion using wearable sensors on the supposition that the method can be used easily in daily life. The aim of this study was to propose an estimation model for knee and ankle joint angle measurements and to locate the center of gravity (COG) of the body in the extension phase while standing up. An estimation model was proposed for the knee and ankle joint angle measurements by combining the angle and acceleration of the trunk on the basis of measurements from the inertial sensor attached on the subjects' chest, during the extension phase. Joint angles and COG position were compared with those obtained by a motion-capture system. The experimental results revealed that the joint angles and COG position demonstrated high correlation coefficients, which represent strong correlation between the proposed model and the motion-capture system. The proposed model could estimate the joint angle during the extension phase, with a maximum error of 4.58°, as well as COG position in the horizontal and vertical directions with maximum errors of 4.48 cm and 3.19 cm, respectively. In conclusion, our proposed system could be used instead of the motion-capture system to estimate knee and ankle joint angles; however, the estimation of the COG position was insufficient because of inaccuracy.

Contribution ID: 1833

10. Biomechanics, Rehabilitation and Prosthetics
10.06. Human movement biomechanics

Head tilt rate during equine therapy training

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Equine therapy is a therapeutic method that uses the horse gait in order to favor postural control processes of patients that have different syndromes. Current methods, such as Timed Up and Go, Wilcoxon and Whitney tests, usually analyze patient's gait and balance before and after the therapy session, but do not analyze it while patients are on horse's back. Therefore, we measured the balance of patients during the session using a quantitative measurement device, minimizing subjectivity in the evaluation process. The Research Ethics Committee of PUCPR authorized the clinical essay through the registration number 50724215.8.0000.0020. The session consisted of three walking laps on a horse's back. Participated in the study volunteers with microcephaly (1), spinal cord injury (2), cerebral palsy (2), stroke (1), hydrocephalus (1) as well as two healthy subjects. A portable actimeter was fixed on top of volunteer's head and consisted of a triaxial gyroscope, an Arduino and a SD card for data storage (30 Hz sampling rate). Balance was analysed in terms of head tilt rate. The average standard deviation from the starting position was determined for each gyroscope axis (X, Y, and Z). During the walking laps, the heads of healthy subjects tilted at ±13.3914, ±20.4349, ±17.4726 degrees/s whereas volunteers' heads tilted at ±18.6149, ±24.9386, ±29.9520 degrees/s. One can notice a lower postural control for patients, because they performed higher head tilt rate in comparison with healthy individuals. All in all, Z axis head inclination of patients almost doubled the one of healthy subjects, demonstrating a significant profile change regarding the tilt axis. The actimeter device was successful in quantifying the head tilt rate during the equine therapy session. In future work, we will obtain a higher device's acquisition rate and apply it in a larger sample.

Contribution ID: 1841

10. Biomechanics, Rehabilitation and Prosthetics

10.06. Human movement biomechanics

Interface based on inertial sensors for the application of the trunk control scale on patients with spinal cord injury

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Patients with spinal cord injury (SCI) suffer from a deficiency of trunk control (TC), this affects their independence and hinders their daily life activities. As part of the rehabilitation process, the National Institute of Rehabilitation (NIR) applies to SCI patients the clinical TC scale that consists of 13 items: 7 statics and 6 dynamics. TC scale allows to obtain a numeric evaluation of TC. However, this is a subjective test since physicians rate patients based on observation. Therefore the purpose of this work is to develop an objective tool to evaluate TC based in inertial sensors (IMUs) situated on specific body segments, that complements the clinical TC scale. In this work two interfaces were developed to capture data based on IMUs during the application of clinical TC scale. The first interface was done in MATLAB R2015a (MathWorks) using a laptop with external IMUs shimmer3 (shimmer sensing). The second interface was develop in Android Studio using the sensors of a commercial tablet. Both interfaces capture 3D acceleration data during each item of TC scale. On the Matlab interface the IMUs were configured with a sampling rate of 512Hz, and an acceleration range of 16g. On the Android interface a sampling rate of 100Hz was obtained. The developed interfaces allow to capture and manage patient's data and objective information related to TC scale.

Contribution ID: 1810

10. Biomechanics, Rehabilitation and Prosthetics
10.07. Biofluids

In vitro hemodynamic assessment of bicuspidization repair to treat functional tricuspid regurgitation: a stereo-scopic PIV study

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The heightened interest in right heart diseases has led to more aggressive treatment recommendations to manage severe functional tricuspid regurgitation (FTR). Nevertheless, most current therapies were originally catered for the left side, and their clinical results are still far from reaching satisfaction. Unlike an established literature on the performance of different valvular therapies in the left circulation, those done on the right side of the heart are currently lacking. At the same time, intra-ventricular fluid dynamics has emerged as an important diagnosis tool and a potential target in therapy-design. In this new perspective, flow alterations owning to different cardiac procedures can influence their long-term outcomes and should be of consideration in clinical practice. In this study, we designed and fabricated a novel in vitro mock circulatory system capable of emulating the pathological condition of severe FTR. A realistic porcine tricuspid valve was incorporated in a patient-specific silicon right ventricle on which bicuspidization repair was performed surgically. Flow conditions were evaluated pre- and post-procedural by 3D particle imaging velocimetry to assess the hemodynamic performance of this repair method. The results provide insights on the hemodynamic efficacy of bicuspidization surgical approach which could potentially impact the corresponding treatment outcome. Moreover, the novel experimental setup could be utilized to evaluate other treatment options and study in-depth right ventricular hemodynamics in other clinical settings.

Contribution ID: 528
10. Biomechanics, Rehabilitation and Prosthetics
10.08. Tissue biomechanics

Biphasic rheology of different artificial degenerated intervertebral discs

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Simulation of the intervertebral disc (IVD) degeneration in animal models is of great interest for evaluation of the potential regenerative therapeutics. Hence, the objective of this study was to investigate the biphaisc response of IVD for different artificial degeneration models. Fifty motion segments were dissected from juvenile sheep lumbar spines. The specimens were assigned equally to 5 groups (i.e., (1) intact (I), (2) punctured with a 16-G needle (P), (3) punctured with a 16-G needle combined with fatigue loading (PF), (4) denatured by injecting 0.5 ml 0.25% trypsin solution (T), and (5) denatured by injecting 0.5 ml 0.25% trypsin solution combined with fatigue loading (TF)). All specimens were mounted in a chamber filled with PBS and underwent a stress-relaxation test using a mechanical testing apparatus (Zwick/Roell, Ulm-Germany). Based on linear biphasic theory, a code was developed in MATLAB to calculate the aggregate modulus (HA) and permeability (k). One-way ANOVA test was used to compare the calculated parameters among different groups. Aggregate modulus decreased in P and T discs but increased in PF discs compared to intact ones. The difference of aggregate modulus between TF and intact discs were not significant. Permeability decreased in T, PF and TF discs. The permeability of both PF and TF discs were significantly lower than F and T discs, respectively. Loss of fiber integrity and looseness

of the fiber tissue may happen in punctured and denatured IVDs which decrease the aggregate modulus. In reverse, the fissures, clefts or tears produced by fatigue loading after needle puncture can increase the aggregate modulus. The collapsed disc structure hinders the fluid flow capability, hence, the fluid loss decreases for the T, PF and TF discs, which was reflected as lower permeability. It is concluded that proposed artificial degeneration models can be used to investigate potential regenerative therapeutics.

Contribution ID: 737

10. Biomechanics, Rehabilitation and Prosthetics
10.08. Tissue biomechanics

Micro-destructive testing evaluation of mechanical properties in regenerative medicine

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Regenerative medicine is a rapidly evolving multidisciplinary, translational research field whose explicit purpose is to create solutions for the repair and replacement of damaged cells, tissues, and organs. These engineering materials should have the basic mechanical properties of the damaged tissues to restore because they act as tissue substitutes. Destructive mechanical testing methods are currently employed to establish mechanical properties of a tissue
For example, Hydrogels are biomaterials that have attracted the attention of biomaterials scientists for cartilage and bone tissue-engineering applications, particularly for their use as scaffolds in cartilage and bone tissue regeneration. Injectable hydrogels are minimally invasive and can assume any desired shape. Various biomaterials have been tested for the fabrication of injectable hydrogel scaffolds, including natural biomaterials and synthetic biomaterials.
To replace damaged cartilage or bone tissue, hydrogels will be required to provide appropriate stiffness or deformation properties as well as resistance to fracture. However, despite the importance of mechanical properties when manufacturing materials for implantation, little evidence has focused on characterizing the mechanical properties of different human tissues.
Currently, the most common evaluation of tissue mechanical properties is through compressive test measurement. However, failure properties, such as the resistance to fracture , must be evaluated by fracture toughness techniques.
The application of the micro-destructive indentation test for fracture toughness determination in tissue materials can become widespread because of the simplicity of the test. The undoubted advantages of this technique are counterbalanced by the complex models and related equations reported in the literature. In this paper, a simplified and more realistic approach for estimating fracture toughness in tisuue materials is presented.

Contribution ID: 834

10. Biomechanics, Rehabilitation and Prosthetics
10.08. Tissue biomechanics

Finite Element Analysis of an Improved Suture Configuration for Mitigating Tendon Pull-through

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Typical tendon sutures are carried out to repair and permit postoperative activation and mobilization of a transferred muscle. This study was designed to test the strength and outcome of two suture configurations, namely the original suture configuration and a proposed modified new suture configuration. Both static and dynamic loading conditions have been simulated. The main intention is to simulate the condition in which a patient quickly flexes his finger, thereby placing a dynamic load on the suture. The typical six stress components – S11, S22, S33, S12, S13 and S23, were extracted from the analysis, with the first three representing axial stresses and the last three representing shear stresses in the corresponding planes. Although the combination of all components would undoubtedly have an effect on the tendon, S11 appears to be the most significant component that might influence tendon tear-through due to its alignment with the direction of the suture pull. Form the numerical finite element simulations using ABAQUS, the new suture configuration generally elicits lower stresses, with the exception of S33 and S23, in both static and dynamic analyses. In particular, the proposed new suture configuration is found to elicit a lower S11, which is the major contributor to a suture pulling through a tendon. Therefore, if a lower S11 is elicited, the probability of a pull-through tendon will be lowered.

Contribution ID: 905
10. Biomechanics, Rehabilitation and Prosthetics
10.08. Tissue biomechanics

Are micro back markers on thin film of scaffold effective to evaluate contractive movement of myotube?

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The myotube can be made from myoblasts by the cell culture technique in vitro. For the application to regenerative medicine, the quality of myotube should be evaluated in vitro. The photolithography technique enables micro machining of makers on the thin film of scaffold. The scaffold of the transparent film with micro markers has been designed to evaluate the contractive movement of myotube under the electric pulse stimulations in vitro. The scaffold of a thin film (6 μm of thickness) of polydimethylsiloxane was made with ten million micro markers: 4 μm of diameter, 2 μm of height, and 30 μm of interval. Ten million markers were made on the backside of the scaffold by the photolithography technique. The scaffold of the film was exposed to the oxygen gas to be characterized as hydrophilic before the cell culture. C2C12 (mouse myoblast cell line) was seeded on the film at the counter surface to the markers at the density of 5000 cells/cm2. The cells were cultured for 12 days in the medium containing 10% fetal bovine serum and 1% penicillin/ streptomycin at 310 K with 5% of CO2 content. The electric pulses (1 s of pulse cycle, 1 ms of pulse width) were applied between platinum electrodes dipped in the medium. The myoblasts were able to be cultured on the film to be differentiated into myotubes. The thin film with micro markers was successively made of polydimethylsiloxane, and had enough transparency for observation of myotubes by the microscope. The myotube was contracted synchronously with the stimulation of electric pulses. The contractile force of myotube of 10 μN at the electric stimulation was estimated by the deformation of the film of the scaffold. The micro back markers on thin film of scaffold are effective to evaluate contractive movement of the myotube.

Contribution ID: 1493
10. Biomechanics, Rehabilitation and Prosthetics
10.08. Tissue biomechanics

Optical measurements of integrity of silicone coating at self-expandable esophageal nitinol stents

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A stent is a mesh tube inserted into a natural passage in the body to prevent a disease-induced. A self-expandable nitinol stent is the metal alloy NiTiNol with specific properties as shape memory, hyperelasticity, superelasticity and biocompatibility esefil for the medical applications, especially for long time use. Esophageal nitinol stents can be indicated for palliation of malignant esophageal strictures, also for the treatment of benign esophageal strictures which are refractory to standard therapy and for the treatment of the esophagorespiratory fistulas. A silicone stent coating is used for tumor in-growth prevention and esophagorespiratory fistulas occlusion. There is difficult check the quality of silicone coating during the process of manufacture of this type of covering the stent by silicone layer. The Silicone layer is very thin and flexible. Whole coating of the stent must be ensured around all mesh wires even in areas with higher mechanical stress (wire crossing). This challenge led the team of the Medical biophysics at Faculty of Medicine in Hradec Kralove, Charles University to devise a method of testing the presence of the sufficient silicone coverage at self-expandable esophageal nitinol stents. The method is based on three basic steps. The preparation of a sample by potting of the stent is in the first part. There is used a multi-component epoxy resin (a mixture of Epon and Durcupan ACM) as a supporting fixative medium. In second part the method describes the CNC technology for high-pressure water jet material division of the stent without destroying the silicone layer. The last, most important part, describes the process of measurement integrity of the silicone coating by an optical motorized advanced research microscope. The primary outcomes are measured data processed by descriptive statistic, evaluation of results at the laboratory protocol and verifying the accuracy of the manufacturing process.

Contribution ID: 148
10. Biomechanics, Rehabilitation and Prosthetics
10.09. Cellular and molecular mechanics

Caveolin-1 expression regulates amoeboid-like cell migration by controlling mitochondrial fission/fusion dynamics and cellular biomechanics

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As metabolic factories, mitochondria generate ATP locally in high energy-consuming regions of metastatic breast cancer cells to sustain subcellular energy demands, and this process is heavily dependent on mitochondrial mobility as well as fission/fusion dynamics. Here, we assess the hypothesis that caveolin-1 (Cav-1), a cholesterol-enriched membrane-associated scaffolding protein, negatively regulates mitochondrial dynamics by controlling critical proteins of the mitochondrial fission and fusion machinery, Dynamin-related protein 1 (Drp1) and Mitofusin 2 (Mfn2), respectively. Depletion of Cav-1 lead to an increase in fusion/fission events and both fragmented and elongated mitochondria. Live cell imaging of individual mitochondria revealed an increase in mean trafficking velocity after downregulation of Cav-1, and there were fewer stress

fibers in Cav-1 depleted cells grown in 2D, whereas in 3D Matrigel cultures, F-actin accumulation co-localized with aggregating mitochondria at the trailing end of Cav-1 depleted cells. Using an ATP biosensor, we observed ATP production at cell boundaries in cells with reduced Cav-1 expression. Moreover, the number of cells with a rounded morphology in 3D culture was amplified after knockdown of Cav-1. In contrast to spreading cells, rounded cells exhibited a distinct amoeboid motion pattern thought to contribute to an increase in migration and invasion rate, whereas overexpression of Cav-1 rendered mitochondria immobile, blocked amoeboid movement, and decreased cell migration and invasion. Taken together, Cav-1 inhibits mitochondrial fision/fusion dynamics and trafficking by regulating Drp1 and Mfn2 recruitment to mitochondria, thereby reducing ATP supply in high energy-consuming regions. On the other hand, Cav-1 regulation of cellular biomechanics prevents cell rounding and mobility by promoting the formation of actin stress fibers. In conclusion, Cav-1 is a central regulator of cellular amoeboid-like motion, migration, and invasion.

Contribution ID: 193
10. Biomechanics, Rehabilitation and Prosthetics
10.09. Cellular and molecular mechanics

Plasma membrane cholesterol mediates the differential mechanotransduction of shear stress and stretch in vascular endothelial cells

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Vascular endothelial cells (ECs) maintain the circulatory system homeostasis by changing their functions in response to changes in hemodynamic forces, including the shear stress generated by flowing blood and the stretch produced by blood pressure. However, it has remained unclear how ECs sense changes in shear stress and stretch differentially and transduce the changes into biochemical signals. Our recent studies have revealed that the plasma membranes of ECs respond differentially to shear stress and stretch by rapidly changing their lipid order and fluidity in opposite directions. These changes in membrane physical properties are involved in the activation of the membrane receptors and cell responses specific to each force. Among the membrane lipids, cholesterol plays a dominant role in determining the physical properties of the plasma membranes. This study was undertaken to examine the effects of shear stress and stretch on the plasma membrane cholesterol in ECs, and to examine how the membrane cholesterol dynamics is linked to mechanotransduction by ECs. Cultured human pulmonary artery ECs were subjected to shear stress in a flow-loading device, and to stretch induced by uniaxial stretching in a mechanical strain-loading device, and the cholesterol content of the plasma membrane was assayed by flow cytometry using EGFP-tagged D4 (domain four of the theta-toxin) which binds selectively to cholesterol, and liquid chromatography-mass spectrometry. The flow-cytometric analysis and the mass spectrometry showed that shear stress decreased the membrane cholesterol content, whereas stretch increased it. Addition of cholesterol to the cells prevented the shear-induced decreases in the membrane cholesterol content and significantly inhibited the shear-induced activation of VEGF receptors. Treatment of the cells with methyl-beta-cyclodextrin abrogated the stretch-induced increases in the membrane cholesterol content and significantly suppressed the stretch-induced activation of PDGF receptors. These results indicate that plasma membrane cholesterol plays crucial roles in mechanotransduction by ECs.

Contribution ID: 366
10. Biomechanics, Rehabilitation and Prosthetics
10.09. Cellular and molecular mechanics

Mechano-biological coupling of cell-cell interactions in liver

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Liver sinusoid consists of multiple types of cells including liver sinusoid endothelial cells (LSECs), Kuppfer cells (KCs), hepatic stellate cells (HSCs), and hepatocytes (HCs). Polymorphonuclear leukocyte (PMN) recruitment in sinusoid contributes to pathogen clearance or tissue damage in liver diseases. While Mac-1 or CD44 is assumed to play dominant roles in vivo, the regulating mechanisms of PMN adhesion and crawling dynamics remains unclear in sinusoids. Here we developed in vitro 2D and 3D models to recapitulate key features of liver sinusoids and to elucidate the roles of distinct adhesive molecules and cellular interactions in liver-specific PMN recruitment.
Using a 2D sinusoid model, fMLF-activated PMN adhesion on TNF-α-stimulated LSECs was reduced significantly by LFA-1 blocking. PMN crawling speed was highly enhanced by Mac-1 blocking. PMN crawling directness was randomized in the presence of KCs but this finding disappeared by LFA-1 blocking. With a 3D sinusoid model, shear flow enhanced dramatically albumin secretion and CYP1A2 activity when HCs were cultured alone or co-cultured with NPCs, while co-culture with NPCs alone had effects on albumin secretion only. Under LPS stimulations, co-culture of LSECs with HSCs, KCs or HCs increased PMN accumulation independently. Moreover, the evolution dynamics of LSEC fenestrae was tested using total internal reflection fluorescence structured-illumination microscopy (TIRF-SIM). The fenestrae number decreased with culture time, which could be rescued by HC co-culture. PMN adhesion was reduced after fenestrae degeneration, suggesting an additional role of fenestrae in PMN recruitment. Thus, these models help to analyze the molecular mechanisms of PMN recruitment in the liver sinusoids and the distinct impacts of each type of hepatic cells.
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Contribution ID: 906
10. Biomechanics, Rehabilitation and Prosthetics
10.09. Cellular and molecular mechanics

How does cell deform through micro slit made by photolithography technique?

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The deformability is important for the biological cell in vivo. An erythrocyte, for example, deforms and passes through capillary. Some cells deforms and passes through a slit in vivo. Several systems sorts cells according to the deformability in vivo. The photolithography technique is useful to make a micro-channel. A micro slit (0.87 mm of width, 0.010 mm height) was newly designed between a micro ridge on a transparent polydimethylsiloxane plate and micro ridges on a borosilicate glass plate. These ridges make contact each other in the perpendicular position to make the slit between the ridges. The dimension of the surface micro morphology on the plate was confirmed with a laser microscope. A one-way flow system was designed to observe each cell passing through the slit in vitro. Four kinds of cells were used in the test: C2C12 (mouse myoblast cell), HUVEC (human umbilical vein endothelial cell), Hepa1-6 (mouse hepatoma cell), and Neuro-2a (mouse neural crest-derived cell). The suspension of each kind of cells was injected to the slits. The deformation of each cell passing through the slit was observed with an inverted phase-contrast

microscope. At the microscopic images, the outline of each cell was traced, and the area (A) was calculated. The deformation ratio was calculated as the ratio (A2 / A1) of the projected area of each cell before the slit (A1) and that in the slit (A2). The velocity of the cell passing through the slit was calculated by the trace at the microscopic movie. The experimental results show that each cell deforms to the flat circular disk and passes through the micro slit. Hepa1-6 is flattened with the increase of the passing velocity, and HUVEC is elongated along the flow. The designed slit between micro ridges is effective to evaluate the deformability of cells.

Contribution ID: 970
10. Biomechanics, Rehabilitation and Prosthetics
10.09. Cellular and molecular mechanics

Can be minimization of membrane bending energy used for simulation of the nanoparticle-cell interaction?

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Nanoparticles and nanotechnologies are being used in an increasing number of diverse industries, mainly medicine and pharmacy sectors. Unfortunately, there is still insufficient knownledge about the impact of nanoparticles on the environment as well as on the human body and its soft tissues. The cell is the cornerstone of any living organism, and in order to determine the impact of nanoparticles on the living organisms, it is necessary to study the interactions between the nanoparticles and the cells. The penetration of the cell membrane by nanoparticle is fundamental and very important in nanoparticle-cell interaction. The simulation of this interaction is aim of this work.
From mechanical point of viewthe cell membrane is deformable body and can be imposed to variety types of loading.
If the area of the cell membrane is larger that the area corresponding to the sphere of the cell volume, the primary type of loading is bending. The bending energy may be expressed as the Helfirch free energy (HFE), which is defined using the membrane rigidity and its curvature. The optimal shape could be determined as the shape corresponding to minimum free energy. Through minimization HFE of cell membrane, we are able to compute cell membrane geometry through the obtained curvature.
Our pilot model allows to determine the cell membrane geometry based on information about the depth of particle penetration into the membrane. This approach can be used for development of model which can be used for determination of cell membrane mechanical properties (based on AFM experiments), as well as for analyses of the nanoparticle shape and size effect on the cell membrane penetration.

Contribution ID: 984
10. Biomechanics, Rehabilitation and Prosthetics
10.09. Cellular and molecular mechanics

Mechanobiological roles of microRNA-33 in neointimal hyperplasia induced by the vein graft

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Mechanical factors play significant roles in neointimal hyperplasia after vein grafting, but the mechanisms are not fully understood. Using microRNA (miR) sequencing, we detected the differentially expressed miRs between grafted veins and the contralateral control. Then we focused on miR-33, one significantly changed miR in grafts, and further investigated the roles of it in neointimal hyperplasia induced by arterial mechanical stretch after vein grafting. The results revealed that neointimal hyperplasia and cell proliferation was significantly increased, and miR-33 expression was decreased after 1-, 2-, and 4-week grafts. In contrast, the expression of bone morphogenetic protein 3 (BMP3), which is a putative target of miR-33, and the phosphorylation of smad2 and smad5, which are potential downstream targets of BMP3, were increased in the grafted veins. miR-33 mimics/inhibitor and dual luciferase reporter assay confirmed the interaction of miR-33 and BMP3. miR-33 mimics attenuated, while miR-33 inhibitor accelerated, proliferation of venous smooth muscle cells (SMCs). Moreover, recombinant BMP3 increased SMC proliferation and P-smad2 and P-smad5 levels, whereas BMP3-directed siRNAs had the opposite effect. Then, venous SMCs were exposed to a 10%-1.25 Hz cyclic stretch (arterial stretch) by using the FX4000 cyclic stretch loading system in vitro to mimic arterial mechanical conditions. The arterial stretch increased venous SMC proliferation and repressed miR-33 expression, but enhanced BMP3 expression and smad2 and smad5 phosphorylation. Furthermore, perivascular multi-point injection in vivo demonstrated that agomiR-33 not only attenuates BMP3 expression and smad2 and smad5 phosphorylation, but also slows neointimal formation and cell proliferation in grafted veins. These effects of agomiR-33 on grafted veins could be reversed by local injection of BMP3 lentivirus.
The miR-33-BMP3-smad signaling pathway protects against venous SMC proliferation in response to the arterial stretch. miR-33 is a target that attenuates neointimal hyperplasia in grafted vessels and may have potential clinical applications.

Contribution ID: 1093
10. Biomechanics, Rehabilitation and Prosthetics
10.09. Cellular and molecular mechanics

Functional classification of dendritic cells in mouse: based on single cell technology

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Dendritic cells (DCs) play important roles in immune system. They have a broad distribution in both lymphoid and non-lymphoid tissues, like spleen, lung, dermis and intestine. Interestedly, in aorta, DCs appear mainly in pro-atherosclerotic area and accumulate in atherosclerotic lesions which were characterized as low shear stress application. However, DCs are a rare group of cells and show an obvious heterogeneity, which brings great challenge for traditional methods to analyze. Here we dissected functional classification of mouse DCs based on single cell techniques.
Mouse liver, spleen and aortae were flushed with PBS and excised into small pieces to isolate single cell suspensions. After using respective antibody for CD11c PE-Cy7 and MHCII APC, samples were analyzed using a FACS Aria II and single CD11c+MHCII+ DCs were sorted into lysis buffer and performed reversed transcription. 48 target genes, including housekeeping genes, adhesins, co-stimulatory molecules, Toll-like receptors, scavenger receptors, chemokine receptors and cytokines. M48 qPCR Dynamic Array microfluidics chips and Biomark high-throughput gene analysis system (Fluidigm) were then used to detect 48 target genes in single sorted DCs. Expressions of these 48 genes of sorted single DC were analyzed by Biomark, and displayed by heat maps for hierarchical clustering and principal component analysis. The Biomark data showed a high correlation with the RT-qPCR data, with a correlation coefficient r = 0.972.
In this study, we successfully developed a method to investigate functional classification of DCs based on analysis of the gene-expression repertoire at single cell level. Using high-throughput

gene analysis for single-cell data, profiles of DCs showed variations among different tissues. Functional classification of mouse DCs lays a foundation for pathogenesis of atherosclerosis and contributes to new clinical therapies. (NSFC No. 11222223 and 11625209)

Contribution ID: 1223

10. Biomechanics, Rehabilitation and Prosthetics
10.09. Cellular and molecular mechanics

Exprimental analysis of cellular membrane mechanical properties

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The study of cell-environment can reveal the possibilities of using nanoparticles in biomedicine. The condition of the cell membrane can tell about the condition of the cell. The membranes as the outer envelope of the cell have a semi-fluid character, and the proteins and lipid molecules are in constant motion. The work is focused on creating and verification of methodology for measuring mechanical properties (Young's modulus) of living cells. Atomic force microscopy and force spectroscopy were selected for contact between a tip of cantilever and a cell. This work presents achieved results of comparison using different tips of cantilevers and verification on several types of cells. Dependence between Young's modulus of a cell membrane and surface attachment is next part of this work. Different surfaces are creating by coating of glass. Coating can be used for adjustment of tip of cantilever. The thesis discusses with the possibilities of a protein binding on the tip of cantilever and measurement of adhesion of membrane and the protein. Working with living cells claims specific approach in all parts of the research. The result will be a comparison of a set of healthy cells with a set of diseased cells. Based on the findings from this work, we should be able to tell if the disease affects the membrane itself and vice versa.

Contribution ID: 1508

10. Biomechanics, Rehabilitation and Prosthetics
10.09. Cellular and molecular mechanics

Distinct binding kinetics and dynamic force spectrum for LFA-1 and Mac-1 in neutrophil recruitment

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Lymphocyte function-associated antigen-1 (LFA-1) and macrophage-1 antigen (Mac-1), two β2 integrin members constitutively expressed on neutrophils (PMNs), mediate PMN recruitment cascade by binding to their counter-receptors such as intercellular cell adhesion molecule (ICAM)-1 and ICAM-2, junctional adhesion molecule (JAM)-A, JAM-C and receptor for advanced glycation end products (RAGE). The slow rolling and firm adhesion of leukocytes rely on LFA-1 while the cell crawling is dependent on Mac-1. Their distinct functions are assumed to be governed by the binding kinetics and mechanical strength of these receptor-ligand interactions. We applied an adhesion frequency approach to compare their kinetics in the resting and activated states using

optical tweezers. Data indicate that the binding affinity for LFA-1-ICAM-1 complexes is much higher than Mac-1-ICAM-1 complexes mainly due to the highly enhanced on-rate. Structural analyses reveal that such the kinetics difference is likely attributed to the distinct conformations at the interface of Mac-1 or LFA-1 and ICAM-1. We also compared the dynamic force spectrum for various LFA-1/Mac-1-ligand bonds using single molecule atomic force microscopy (AFM) and tested their functions to mediate PMN recruitment under in vitro shear flow. Distinct features of bond rupture forces and lifetimes were uncovered for these ligands, implying their diversity in regulating PMN adhesion on endothelium. LFA-1 dominates PMN adhesion on ICAM-1 and ICAM-2 while Mac-1 mediates PMN adhesion on RAGE, JAM-A and JAM-C, which is consistent with their bond strength. All ligands can trigger PMN spreading and polarization, in which Mac-1 seems to induce outside-in signaling more effectively. LFA-1-ICAM-1 and LFA-1/Mac-1-JAM-C bonds can accelerate PMN crawling under high shear stress, presumably due to their high mechanical strength. This work provides a new insight in understanding basic molecular mechanisms of physiological ligands of β2 integrins in PMN recruitment.
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Contribution ID: 66
11. Minimum Invasive Surgery, Robotics, Image Guided Therapies, Endoscopy
11.01. Minimal invasive surgery and instruments

Tractography delineates microstructural changes in the trigeminal nerve after gamma knife radiosurgery

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Purpose: Focal radiosurgery is a common treatment modality for trigeminal neuralgia (TN), a neuropathic facial pain condition. Assessment of treatment effectiveness is primarily clinical, given the paucity of investigational tools to assess trigeminal nerve changes. The efficiency of radiosurgery is related to its highly precise targeting. We assessed clinically the targeting accuracy of radiosurgery with Gamma knife. We hypothesized that trigeminal tractography provides more information than 2D-MR imaging, allowing detection of unique, focal changes in the target area after radiosurgery.
Methods: Sixteen TN patients (2 females, 4 male, average age 65.3 years) treated with Gamma Knife radiosurgery, 40 Gy/50% isodose line underwent 1.5Tesla MR trigeminal nerve . Target accuracy was assessed from deviation of the coordinates of the target compared with the center of enhancement on post MRI. Radiation dose delivered at the borders of contrast enhancement was evaluated.
Results: The median deviation of the coordinates between the intended target and the center of contrast enhancement was within 1mm. The radiation doses fitting within the borders of the contrast enhancement the target ranged from 37.5 to 40 Gy. Trigeminal tractography accurately detected the radiosurgical target. Radiosurgery resulted in 47% drop in FA values at the target with no significant change in FA outside the target, suggesting that radiosurgery primarily affects myelin. Tractography was more sensitive, since FA changes were detected regardless of trigeminal nerve enhancement.
Conclusion: The median deviation found in clinical assessment of gamma knife treatment for TN Is low and compatible with its high rate of efficiency. DTI parameters accurately detect the effects of focal radiosurgery on the trigeminal nerve, serving as an in vivo imaging tool to study TN. This study is a proof of principle for further assessment of DTI parameters to understand the pathophysiology of TN and treatment effects.

Contribution ID: 199
11. Minimum Invasive Surgery, Robotics, Image Guided Therapies, Endoscopy
11.01. Minimal invasive surgery and instruments

Pressure dependence of cancer detection in tissue using high-frequency ultrasound

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High-frequency ultrasound (20-80 MHz) has been used in the medical field for many years, and has myriad applications. The Biomedical and Cancer Research Laboratory (BCRL) at Utah Valley University has pioneered a noninvasive and nondestructive technique using high-frequency ultrasound to detect cancer ex vivo in resected tissue specimens and in vivo using ultrasound instrumented forceps. By propagating high-frequency ultrasound through tissue, the “peak density” parameter can be calculated using Fourier analysis. The peak density measurement was developed because of its direct correlation to the size of the nucleus of a cell. Because cancerous cell nuclei have a greater diameter than healthy cell nuclei, peak density can be used to determine the malignancy of tissue samples. Previous studies have measured the temperature dependence of peak density in tissue specimens, but not the pressure dependence.
The objective of this study was to determine the correlation between pressure placed on a tissue during testing and the calculated peak density value. Preliminary results show that higher pressures change the peak density in a complex, nonlinear fashion. Therefore, a more systematic and comprehensive analysis was undertaken to determine the optimum pressure required for data collection through tissue. Results from this analysis will be shown, as well as its application to the ultrasonic forceps, which are being developed as a “smart” surgical device for testing the pathology of tissue in vivo during surgical procedures.

Contribution ID: 479
11. Minimum Invasive Surgery, Robotics, Image Guided Therapies, Endoscopy
11.01. Minimal invasive surgery and instruments

High-frequency (10-100 MHz) ultrasonic forceps for precision cancer surgery

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A critical issue for the surgical resection of soft tissue cancers is ensuring that all malignant tissue is removed while preserving as much unaffected tissue as possible. For example, failure to obtain clean (negative) margins during breast conservation surgery (BCS) results in 20-60% re-excisions across the U.S. Additionally, the inability to detect malignant lymph nodes during BCS often results in the unnecessary removal of negative, uninvolved nodes. A minimally invasive technique for detecting residual or metastatic cancer in vivo would therefore significantly improve the precision and efficacy of cancer surgery. The objective of this project was to develop an ultrasonic microprobe in the form of “smart” forceps, with ultrasonic sensors located at the tips of the forceps

to guide surgeons during operations, to provide instant diagnostic information, to enable more precise and complete resection of malignant tissue, and to conserve as much unaffected tissue as possible. The microprobe template was based on Martin forceps, modified to include two ultrasonic sensors (4x6-mm polyvinylidene difluoride film), a tissue thickness sensor (rotary potentiometer), sensor wires, and a spring to control the manual stiffness of the forceps. The body of the forceps was constructed from plastic with 3D printing. A high-frequency pulser-receiver was used to excite the transmitting sensor element at 50 MHz, and to amplify through-transmission signals from the receiving sensor element. The forceps were tested with agarose phantoms embedded with polyethylene microspheres of different diameters (58-550 micrometers) to vary attenuation. The phantoms were also tested with standard 50-MHz immersion transducers for comparison. The results showed that the performance of the forceps were equal to standard transducers, with comparable sensitivity for ultrasonic attenuation and superior accuracy for ultrasonic wave speed. Further validation of the forceps' capabilities will include testing of surgically excised BCS margins and lymph nodes at the Huntsman Cancer Institute.

Contribution ID: 1247

11. Minimum Invasive Surgery, Robotics, Image Guided Therapies, Endoscopy
11.01. Minimal invasive surgery and instruments

Time series prediction of surgical progress using logistic regression modelling

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Depending on the skill of the surgeon, and potentially unforeseen adverse events, many surgical procedures run over time, resulting in the cancellation of impending operations. This, in turn, has an effect on the patients and overall scheduling of the ward. In this paper, we have implemented a logistic regression model to determine whether or not a cholecystectomy surgery is running over time or not based on the time of the operating phases recorded during the procedure, with the aim of improving the workflow and efficiency within the operating theatre.
The classification process can be summarised in three stages. The first stage involves constructing an average surgery using the phase annotations in the Cholec80 dataset, allowing a threshold for the total procedure duration to be set. Secondly, binary labels are assigned to surgeries exceeding this threshold and to those scheduled 'on time'. The final stage uses the binary labels and 7 phase times as inputs to train the model and test its predictive ability on new surgeries. To evaluate the robustness of the model, the split for training and testing surgeries was randomised 80 times and the computed accuracies averaged. Furthermore, to better understand the relevancy of each phase for predicting, and to configure the model for real-time online applications, the accuracy was computed for stepwise increases in the input space size.
Overall we achieved accuracies of 74.4%, 83.7%, 81.2%, 93.4%, 92.3%, 94.3% and 93.0% when increasing the number of phase times from 1 to 7 respectively.
This study shows that a simple statistical model can be implemented for predicting the temporal progress of laparoscopic cholecystectomies with an accuracy of 93.4% when using only the first four phases. Currently the approach is being extended by incorporating a recurrent neural network into the regression model for automatic phase and progress classification.

Contribution ID: 383

11. Minimum Invasive Surgery, Robotics, Image Guided Therapies, Endoscopy

11.02. Image-guided devices and systems

Live image processing and visualization for point-of-care ultrasound by using a tablet PC

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One of the recent hot topics in clinical approach is point-of-care ultrasound (POCUS), which is an initial diagnosis and treatment of a patient in any places (i.e. an ER, ICU, bedside, ambulance, etc.) using ultrasound. For this purpose, several portable ultrasound machines have been introduced in the commercial market. However, the machines have still limited features for procedures such as 3D visualization and navigation, which features are effective for safe and proper treatment. Meanwhile, medical image processing and visualization have also studied and introduced to the market for surgical navigation; however, conventional navigation systems are needed a high spec workstation with a graphics card. Therefore, more practical navigation systems using a small computer such as a tablet, laptop, or smartphone are desired for POCUS. On the other hands, such a small computer is significantly improved in performance of both CPU and GPU, which is generally embedded or integrated with CPU. So, a small computer has an enough potential for live image processing and visualization for a navigation system. In this study, we developed a tablet-based navigation system with live image processing and reconstruction for POCUS using GPGPU technology to clarify the performance in clinical use.
We employed a windows tablet (Surface Pro 4, Microsoft) with an integrated graphics processor (Intel HD Graphics 520) which has 24 execution units and supports OpenCL 2.0 for GPGPU. For 3D ultrasound reconstruction and visualization, freehand 3D ultrasound algorithm was implemented by using OpenCL.
To confirm practicality, phantom volume reconstruction was performed. A 3D ultrasound volume was reconstructed from the phantom echograms and positions prepared in advance. Then the processing time was measured. In this test, framerate of volume reconstruction was approximately 20 fps.
From the result, we confirmed the tablet based navigation system has great potential for practical clinical application.

Contribution ID: 831
11. Minimum Invasive Surgery, Robotics, Image Guided Therapies, Endoscopy
11.02. Image-guided devices and systems

Assessing a small field of view hybrid gamma camera for perioperative radioactive seed localisation

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The use of iodine-125 (125I) in radioactive seed localisation (RSL) technique for guiding breast conserving surgery of non-palpable breast lesion has been increasing rapidly. The current standard method for detecting the embedded 125I seed is using a gamma probe. The aim of the study was to assess the potential use of a handheld hybrid gamma camera (HGC) in ex vivo simulations of RSL.

A newly developed HGC fitted with 1 mm diameter pinhole collimator was characterised and used to acquire images of OncoSeed™ (6711C, Oncura, GE Healthcare, USA) with activity ranging between 2 and 7 MBq. The performance of the gamma imaging was assessed quantitatively (contrast-to-noise ratio, CNR) and qualitatively at different source depths and source to camera surface distances (SSD), utilising bespoke phantoms to simulate patient anatomy and position. Hybrid optical-gamma images were obtained and assessed.
The system sensitivity and spatial resolution of the HGC for 125I was 1.69 cps/MBq (at SSD of 48 mm) and 1.99 ± 0.23 mm respectively. The CNR values of the seed (2.43 MBq) at depths between 0 mm and 25 mm ranged from 1 to 22. Subjective assessment of gamma images acquired with the phantom showed the capabilities of the HGC in localising 125I seed in the clinical simulation. Visual examination of images revealed the detectability limits of the HGC (positioned at the surface of the scattering material) for seed located at depths up to 20 mm beneath tissue equivalent scattering material. The camera was able to detect the seed (6.4 MBq) at SSD 25 mm (no scattering material in place) within a one-minute acquisition time.
This preliminary study demonstrates that the HGC is capable of detecting 125I seeds and could be a useful tool in RSL with the added benefit of providing hybrid optical gamma images for guiding breast conserving surgery.

Contribution ID: 1153
11. Minimum Invasive Surgery, Robotics, Image Guided Therapies, Endoscopy
11.02. Image-guided devices and systems

Design of augmented-reality surgical navigation system for better healthcare visualization

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Nowadays, good medical services are located in the high-level hospitals. The uneven regional distribution and the unbalanced medical quality between different hospitals bring obstacles to patients for better healthcare. In the community hospital, surgeons may lack advanced surgical skills. Considering the clinical needs, we present an augmented-reality (AR) navigation system using 3-D image overlay technology for better healthcare visualization. Autostereoscopic 3-D images of anatomic structures, which are reproduced by employing integral videography technology, are superimposed on the patient via a half-silvered mirror to form an AR navigation scene. The proposed system can generate the vivid autostereoscopic 3-D medical images and realize in-situ image overlay, which eliminates the hand-eye coordination problem. By using our system, surgeons can intuitively observe the operative area, the marked high-risky tissue, surgical tools and surgical planning pathway, which make the surgical operation more convenient and intuitive. To consider the demands of clinical applications, we design a new semi-streamlined prototype combining adjustment mechanism and servo-motors, which can broaden the visual field. Results illustrate that the navigation system can enhance the surgeons' operation of the facilitation, as well as the design is more integrated and commercialized, which are more suitable for clinical applications. This AR system can assist to transfer the decision of the experienced surgeons to inexperienced surgeons in the less developed areas through internet, which enables them to get the intuitive surgical guidance. It is advanced to realize remote visual display and intuitive guidance to solve the uneven distribution of medical resources. With the assistance of the proposed AR system, even the inexperienced surgeons can easily perform a high quality surgery. What's more, the system can be used for surgical skill training under the guidance of 3-D image. Thus, the AR system is beneficial to healthcare especially in the resource-scare communities.

Contribution ID: 1161

11. Minimum Invasive Surgery, Robotics, Image Guided Therapies, Endoscopy
11.02. Image-guided devices and systems

Stereotactic Brain Tumor Optical Biopsy

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Tissue samples from tumors located deep in the brain are harvested using a biopsy needle. The procedure is based on pre-calculated stereotactic positions from radiologic images. To provide guidance for targeting diagnostic tumor tissue and to avoid vessel rupture during the biopsy procedure an application specific fiber optic probe was devel-oped. The setup incorporated an in-house developed fluorescence spectroscopy system for 5-aminolevulinic acid (5-ALA) induced protopophyrin IX (PpIX) for detection in the tumor, and laser Doppler flowmeter (LDF) system for measurement of blood perfusion. The probe was used together with a Leksell® stereotactic frame and a mechanical insertion device for being placed precisely at the pre-calculated position. Fluorescence and blood flow were recorded millimeter-wise towards the pre-calculated target. The methods has been used in nine patients. All together 127 fluo-rescence and 182 LDF signals have been analyzed in three patients (2015/138-32). The patients were given 20 mg/kg 5-ALA prior to the surgery. The recorded signals were compared to the histopathology of the tissue samples (n = 12).
On all occasions, strong PpIX fluorescence was visible during real-time guidance. All tumors were diagnosed as glioma. Comparing the tumor with its marginal zone, the ratio of PpIX to autofluorescence (17.3 vs. 0.9 a.u., $p < 0.05$) was significantly higher in tumor. The autofluorescence was smaller than the surrounding normal brain and the blood perfusion did not show any remarkable trend in the tumor compared to the surrounding tissue, however, some highly perfused spots were detected. In conclusion, the optical probe made real-time detection of tumor possible and has a potential for vessel detection during the biopsy procedures. Moreover, the PpIX fluorescence, autofluorescence and blood flow in the tumor could be studied at precise positions in the brain and the tumor. In the next step, further anal-ysis will be added.

Contribution ID: 1352
11. Minimum Invasive Surgery, Robotics, Image Guided Therapies, Endoscopy
11.02. Image-guided devices and systems

An Automatic Preoperative Path-Planning Algorithm for Brainstem Tumor Surgery Using Combined MRI and DTI

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Background: Brainstem damage is a very serious and often life-threatening problem. The structure of brainstem is very complex, and the surgical path planning for surgical navigation system can reduce the evasion of the important tissue. We proposed an automatic preoperative path planning method based on combined magnetic resonance imaging (MRI) and diffusion tensor imaging (DTI) for determining optimal surgical paths in brain stem tumor surgery, which can effectively circumvent the important tissues and reduce the disability rate. Methods: Our algorithm can automatically obtain the preoperative path (the determination of optimal entry point and path) by optimizing the cost function, which is associated with candidate entry point and candidate path between entry point and the target point. The cost function is always influenced by the results of

image registration and segmentation. Therefore, we register the DTI into the MRI by comprehensive considering three types information of trace, fractional anisotropy and relative anisotropy to achieve more accurate DTI location information. After that, the optimal solution model of the preoperative path which computes a cost function associated with each point on the outer brain boundary and instrument entry path, is constructed by the gravitational repulsion model and spline interpolation using the segmented model of brainstem and fiber bundle. Furthermore, the preoperative path can be achieved automatically by optimizing the solution of the cost function, and the results are evaluated by comparing the cost of a particular path associated with each critical structure, as well as the total number of examining all the cross-sectional images orthogonal to this path. Results: Our method could complete automatic preoperative path planning and avoid important tissue damage with less cross-sectional images orthogonal to our path.
Keywords: Diffusion tensor imaging, brainstem tumor, image registration, path planning

Contribution ID: 986
11. Minimum Invasive Surgery, Robotics, Image Guided Therapies, Endoscopy
11.05. Robots and manipulators in therapy

Multi-DoF surgical endoscopic robot system with soft end-effector and flexible manipulator

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In minimally-invasive surgery (MIS), surgeons often suffer from occlusion region problem because of the limited operating space and rigid traditional surgical instrument. Although a variety of manipulators have been devel-oped, most of them are rigid mechanical structure, which lacks of softness and robustness. For extending the bending scale and manipulation capabilities, we present a multi-DoF surgical endoscopic robot system with soft end-effector and flexible manipulator for minimally-invasive robotic surgery. Our proposed system consists of automatic driven unit, soft end-effector and flexible dual manipulator. The end-effector realizes a larger and safer bending motion by using the two-DoF pneumatically actuated soft actuator, which implies endoscopic function and flexible manipulation function on the effector tip by using a mini endoscope and two wire-driven compact continuum forceps manipulators. What's more, a channel is reserved for the extended diagnosis or therapic function. Pilot results show that the pneumatically actuated soft actuator increases the safety and flexibility of the end-effector, which can bend and elongate in the three-dimensional space. The reserved channel aligned with the longitudinal axis of end-effector can equip with other probes (laser ablation probe, magnetic sensor, and etc.). And the two continuum flexible forceps manipulators on the effector tip imply two degrees of freedom by using the minimized wire-driven mechanism, which can adjust their gestures under the compact size and realize cooperative work under the dual-continuum manipulator arm. Experimental outcomes demonstrate that the proposed robot system has extended bending capability, excellent softness and manipulation flexibility. Therefore, it has promising prospects for future clinical applications such as single-port surgery (SPL) and Laryngeal surgery.

Contribution ID: 1916
12. Diagnostic and Therapeutic Instrumentation
12.10. Keynote lecture

KEYNOTE LECTURE: Additive manufacturing in medicine and tissue engineering

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Nowadays, additive manufacturing otherwise known as three-dimensional (3D) printing is fully implemented into the production of hard tissue replacements. Department of Biomedical Engineering and Measurement together with CEIT Biomedical Engineering company designed and produced more than 45 implants made of titanium alloy using additive technologies, which were subsequently implanted by Slovak and foreign surgeons. 3D printing of PEEK, bioceramic and magnesium alloys implants is recently tested to offer alternative materials to titanium for cranioplasties or biodegradable impalnts. 3D bioprinting is being applied to regenerative medicine to address the need for tissues and organs suitable for transplantation. Compared with non-biological printing, 3D bioprinting involves additional complexities, such as the choice of materials, cell types, growth and differentiation factors, and technical challenges related to the sensitivities of living cells and the construction of tissues. The 3D bioplotter was used to prepare tubular structures made of PLA + PHB polymer for substitutes of human urethra. Tubular structures were tested from geometrical point of view to assure required precision, repeatability and possibility to print porous structures for application of epithelial and muscle cells and their growth. Several studies on PEEK spinal implants manufactured by 3D printing were realized, where mechanical testing, simulations and testing of biocompatibility were implemented. Presented research covers selected case studies of patient specific implants made by additive manufacturing and research in medical 3D bioprinting and tissue engineering.

Contribution ID: 530
12. Diagnostic and Therapeutic Instrumentation
12.02. Injection and infusion systems

An engineering model of an air-powered needle-free skin treatment system

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Needle-free injection systems are non-invasive drug delivery systems and are gaining much popularity in cosmetic field as a pain-free treatment for wrinkles and scars. A high-pressure micro-jet delivers certain drugs or healing agents to a particular depth inside the dermal layer for attaining therapeutic healing. Among the various types of needle-free injection systems, air-powered needle-free systems are the favourite in this field. Although many studies were done in understanding the mechanism involved in these systems an extensive study in identifying all the parameters haven't been done so far. In a typical air-powered needle-free injection system, compressed air drives the liquid in the injection chamber to a high-speed micro-jet through a micro-nozzle. The present study aims at identifying the key parameters in the process and study their effect on microjet characteristics.
The investigation was carried out using both experimental and computational tools to evaluate the micro-jet from an air-powered needle-free injection system.The dispersion characteristics of the jet in skin tissue were studied using visualization studies in 15% polyacrylamide gels, widely used as a skin phantom. Impact force on the skin surface was also measured with the help of a force sensor and a digital oscilloscope. A commercially available CFD code (FLUENT 18.1, ANSYS) was used as the tool for computational studies. The piston movement was successfully simulated using Eulerian/VOF approach coupled with dynamic mesh and moving boundary method.
Visualization studies helped in obtaining a better understanding of the dispersion characteristics of micro-jet in soft materials. It was also found that the initial penetration depth was found maximum in 50% filling volume in the injection chamber. The micro-jet characteristics depend upon the piston dynamics and could be studied with the help of CFD computations. Total pressure and area of

impinging micro-jet determines its penetration capabilities and was monitored experimentally and numerically.

Contribution ID: 180
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

Impedance spectroscopy method to detect pelvic floor muscle damage – a feasibility study

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Impairment of the pelvic floor muscles and fecal incontinence affect 5-10% of the adult populations of European states. The most common cause is perinatal obstetrical anal sphincter injury (OASI) resulting from vaginal delivery. There is no method for screening in the period immediately after delivery. Diagnosis is limited to physical examination. The gold standard, transanal ultrasonography and manometry, can be performed after a few weeks, whereas clinical practice requires that injury be detected as early as possible for optimal treatment. Therefore, we would like to validate an alternative technique, impedance spectroscopy. The aim of the study is to analyze the accuracy of problem detection within the 3-1000kHz frequency range in 3 radial positions. 22 females (10 issued and 12 included in a control group) were engaged. Impedance moduli and phase shifts were estimated using a bipolar impedance spectrometer along with a specific anal probe. We calculated parameters assessing different subranges of analyzed frequencies and treated them as input vectors for detection. Accuracies were estimated for Naïve Bayes, Random Forest, Support Vector Machine and Quinlay's C5.0 models. We performed recursive feature elimination to find the most significant subranges of frequencies. An accuracy of 86.4% was observed for the Random Forest technique and entire set of considered parameters. It appears that impedance spectroscopy allows assessment of problems with pelvic floor muscle (particularly OASI), directly after vaginal delivery and faster and easier than gold standard methods.

Contribution ID: 191
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

Cardiorespiratory profiling during simulated moon mission

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Manned spaceflight requires diverse research, including in neuropsychology and human physiology. For these subjects, the Lunares Analog Research Station (www.lunares.space, Pila, Poland) was established. It allows testing of crew participants under space-like conditions. One experiment, Lunar Expedition I, was performed on a group of 6 would-be astronauts over 14 days. All were asked to carry out mission-specific activities, like digging or repairing a rover during an extravehicular activity (EVA). The aim was to evaluate the possibility of measuring cardiorespiratory signals (before EVA after donning a helmet, and while operating), to analyze

them, and to assess the subjects' adaptation and the reproducibility of results. The respiratory-related impedance pneumography, single-lead ECG and 3-axis accelerometer signals were acquired using our prototype, Pneumonitor 2. Due to problems with detachment of electrodes (due to sweating or physical activity), we ultimately collected 10 full registrations (out of 15 attempts) from 5 astronauts (4 males, 1 female), ages 24-33. All signals were preprocessed and annotated. The set of cardiorespiratory parameters for the time, frequency and information domains was calculated for 4 states: at rest, doing squats, holding breath and EVA. We compared the results with normative values collected from athletes. The considered parameters were found to be in the normal range, typically slightly worse than average for elite athletes. The physiological responses are in line with expectations. Because of the small amount of data, we did not draw general conclusions and reproducibility was assessed only qualitatively. Impedance pneumography makes it possible to establish an astronaut's cardiorespiratory profile and adaptation during a mission, but we need to develop a wearable electronic textile solution for the target electrodes.

Contribution ID: 422
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

Analyzing rheoophthalmic signals in glaucoma by nonlinear dynamics methods

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We assess the possibility to analyze signals of transpalpebral rheoophthalmography (TP ROG) by methods of nonlinear dynamics and find out how informative this technique is in examining patients with various stages of primary open-angle glaucoma (POAG).
The technique was verified on the basis of TP ROG signals obtained in examining 4 groups of subjects: 1) control group (10 eyes with no ocular pathology); 2) stage I of POAG (15 nonoperated eyes), 3) stage II of POAG (7 eyes), and 4) stage III of POAG (4 eyes). In all, 36 eyes of 28 subjects aged 25 to 84 (average age 62.1±7.1 years) were examined.
The analysis of TP ROG signals included determining the rheographic index (RI), calculating the RI average in each group, and finding out how RI depends on POAG stage. Alternatively, we used the nonlinear dynamics method with the signal's attractor reconstruction, where we chose the time delay, determined the embedding dimension, and constructed the attractor in the space of the chosen coordinates. After the barycenters of each reconstructed attractor were found, we analyzed TP ROG signals graphically in the attractors' representation plane.
The analysis of TP ROG signals by nonlinear dynamics methods demonstrated that a more distinct differentiation of POAG stages as compared to traditional signal processing becomes possible. As the stage of the diseases advances, the location of the barycenter of the reconstructed attractor is changing significantly. It shifts rightward and upward in the space of the chosen coordinates. Due to this fact, it becomes possible to separate TP ROG signals into POAG stages by simple geometric figures and to increase the accuracy of the diagnosis at early stages of the disease, which may be used for further study of the link between the hemodynamic state of the eye and glaucoma stages.

Contribution ID: 456
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

Measuring glucoselevel non-invasively using bio-impedance technique

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The number of diabetic patients in the world increases every year. According to International Diabetes Federation (IDF)
statistics shows that in 2015, diabetes prevalence of 17.6% in Saudi Arabia. This project aims to provide technique that can
measure blood glucose level without the need to puncturing the skin. This study presents the basic principle of bio
impedance of the body along with its application in measuring blood glucose level and the effect of frequency changing on impedance values. Bio-impedance signal is picked from the human body using electrodes. The current will be from the integrated circuit AD5933 for impedance measurement. AD5933 is then interfaced with microcontroller using 12C bus to display the reading. The resulting impedance signal will be correlated with blood glucose level using the relationship found from the experiment applied on a blood plasma samples with different glucose concentrations. This study will prove that when glucose level increase the body bio-impedance also increase. Using this technique is very helpful in estimating the blood glucose level with eliminating the risk of infection and the pain of puncturing the skin.

Contribution ID: 519
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

A New Approach for Indirect Validation of Fat Mass and Fluid Content using Segmental Multiple Frequency Bioimpedance Analyzer

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At present, bioelectrical impedance analysis (BIA) is widely recognized as a simple, cheap and non-invasive method to estimate human body composition. The human body composition comprises of mass distribution, water compartment and electrical conductivity. The most common BIA approach is the whole body bioimpedance measurement. However, the whole body bioimpedance measurement has several disadvantages such as lower estimation of human body composition and strict placement of electrodes. To overcome these drawbacks, a segmental multiple frequency bioimpedance analyzer (MFBIA) was designed and evaluated for the estimation of fat mass and fluid content changes using biological phantom. The indirect assessment of fat mass and fluid content using biological phantom is to validate the designed segmental MFBIA. Following the validation method described in our previous work, a fresh hollowed-out cucumber filled with different concentrations of oil and saline was used as biological phantom. Surface impedance measurements were obtained at five applied frequencies (5, 50, 100, 150 and 200 kHz) using the designed segmental MFBIA and commercial bioimpedance analyzer (Quadscan 4000) as reference standard. A linear regression model was used to determine the correlation of oil and saline content between both bioimpedance analyzers. The regression analysis obtained for oil and saline at different frequencies showed high correlation between the commercial and designed segmental MFBIA. The designed segmental MFBIA can be used to estimate the changes in fat and fluid contents using a biological phantom.

Contribution ID: 588
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

Skin-penetrating microelectrode arrays as a minimally invasive device for cutaneous melanoma diagnosis

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Melanoma remains one of the leading deadly cancers in the world. Current diagnosis relies on dermatological examination and biopsy, which can be time-consuming, error-prone and uncomfortable. The process is further complicated when benign moles resemble malignant melanomas, leading to unnecessary biopsies and increased costs. Electrical impedance, which describes the opposition to alternating current flow, has been explored as a diagnostic tool. When measured in biological tissues at relevant frequencies, it provides tissue health information such as water content and cellular integrity. While this method shows promise in skin cancer diagnosis, previous works utilised electrodes placed on the skin surface, which presents high contact impedance and limits measurements into the deeper dermal layers, where melanocytic growths populate.
Here, we discuss an alternative electrode design - a microelectrode array (MEA) with discrete sensing zones that allow for impedance measurements at precise depths within the skin layers where transformed melanocytic cells reside. NRAS-mutated mouse skins were applied MEAs, through which a small current was injected from a Howland current source and impedance measured from 10 Hz to 100 kHz. Each skin site was then excised, fixed and sectioned for H&E and SOX10 immunohistochemistry staining to confirm melanocytic growths.
Histological data revealed that the MEAs came in contact with the dermis (depth 164.1±58.2 μm), where most melanocytic growths were found. Compared to albino controls (no melanocytic presence) and NRAS controls (no apparent melanocytic clustering), late-stage melanocytic growths showed lower impedance magnitude across most measured frequencies, likely due to the loss of membrane capacitance in these structurally compromised cells. Correlating histopathology with impedance data, the overall trend suggests that increase in density of melanocytic growths leads to reduced tissue impedance. Results demonstrate that our MEAs are able to measure impedance at precise tissue depths, offering potentially more accurate melanoma assessment compared to conventional surface electrodes.

Contribution ID: 763
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

Electrode optimization for impedance based central aortic pressure estimation

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Evidence suggests that assessment of the central aortic pressure (CAP) is vital for accurate detection of cardiovascular events and for making treatment decisions. Direct CAP measurement is possible and is used in clinical environment, however it is both costly and carries increased risk, therefore it is not suitable for preliminary screening and monitoring. Indirect noninvasive

assessment of CAP has been around for several years. Applanation tonometry which is largely based on research by O'Rourke et al is method of choice and sometimes even described as gold standard for noninvasive assessment of central pressures, pulse wave velocity and heart rate variability. Pressure sensor is typically placed on radial artery, and central aortic pressure is estimated by generalized mathematical transformation of the recorded waveform. While widely used the method has serious drawback – strong dependence on operator skills. In search for measurement methods with better repeatability an electrical bioimpedance has emerged as viable alternative. Its applicability has been confirmed in several studies involving simultaneous invasive CAP measurement, and comparative measurements with AtCor Medical SphygmoCor device. Further refinement of the method is considered in proposed abstract. It is assessed that perhaps 85% of the problems in bioimpedance measurement can be tracked down to the most vulnerable part of the system – the electrodes. Several experiments have been conducted for the assessment of the electrical interface between measurement apparatus and the living tissue. Different electrode configurations were used over the radial artery along with different electrode materials. Measurements were conducted on several frequencies to verify literature suggestions. One of the main research questions was assessment of the impact of the electrode pressure onto radial artery to the measurement results, as it may vary when sensors are strapped around the wrist. Novel pressure control method is suggested as the result, allowing also multimodal readout.

Contribution ID: 809
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

Application of garment – embedded textile electrodes for EIT based respiratory monitoring

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Electrical impedance tomography (EIT) is one of the alternative techniques, capable to replace spirometry both in medicine and non-medical fields - sport, fitness, singer training etc. The advantage of EIT is the ability to evaluate changes in volumes of separate lung segments. This makes EIT method functionally superior to spirometry. EIT measurements required an array of conventional bio-potential electrodes, attached to the patient’s chest. The electrode arrays usually either are bulky belts, or require time – consuming procedure for electrode attachment. The potential solution is to replace conventional electrodes with ones made of conductive knitted textile. Textile electrodes, integrate in a patient’s underwear, could provide wearables for daily respiratory monitoring in hospitals, at home, during physical activity etc. The goal of the present paper was to demonstrate usability of textile electrodes for EIT measurements. For this, the conductive textile fragments were integrated in the chest of the long sleeves thermal underwear t-shirt to form three rows, each containing 16 circumstantially placed electrodes. The textile electrode network was connected to the commercial EIT monitoring system Dräger® Infinity C500. Two healthy male volunteers aged 45 – 50 performed series of breathing maneuvers (tidal breathing, deep breathing, FRC maneuver). The breathing volume ad FRC was measured using spirometer, integrated into total body plethysmograph. EIT measurements were made using either conventional or textile electrodes. The course of measurements demonstrated, that textile electrodes has too loose contact with the skin, due to this electrodes electric impedance exceeded the range, suitable for operation of the Infinity C500 EIT machine. Application of additional pressure to electrodes and use of electrolyte spray reduced impedance of textile electrodes to acceptable values. Under such conditions, there were no difference in correlation coefficient between spirometry volumes and ETI volumes, obtained using either by conventional, or textile electrodes

Contribution ID: 908
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

The study of continuous measurement system for biomaterial in body by electrical impedance

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About 60% weight in human body is fluid which consists of various solutions. These concentration of solutions are important parameter for diagnosis and treatment. Especially, concentration of electrolytes are controlled severely, but there are very few continuous quantitative measurement system.
So it is well known that electric conductiivity is different amoung tissue. And the conductiivity is concern with electrolytes and biomaterials. And electrical measurement has an advantage of measuring continiously. But it is less used as a clinical system. We tried to study for clinical application to measure electric conductiivity in a living body.

Contribution ID: 967
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

Changes of body composition and bioimpedance during pregnancy – pilot study in Czech Republic

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Monitoring of specific physiological values during gestation process is a very important process. Body composition values and directly measured bioimpedance values however are currently not included into this monitoring although these values can help to track healthy process of gestation. In this work we are presenting new possible measurements of progress of body composition and electrical values during whole gestation process in Czech population. Bioelectrical resistance, reactance and body composition values were measured by BIA device Tanita MC 180 MA on 5, 50, 250 and 500 kHz. BIA measurements from 10 women were evaluated during second and third trimester of pregnancy. We discovered changes in directly measured electrical values and calculated values during a gestation period. Statistically significant increase was discovered in calculated body composition values: Weight (kg) ($P=0.005$), Fat mass (kg) ($P=0.01$), TBW (kg) ($P=0.005$). Statistical significant ($P=0.05$) decrease on all used frequencies was discovered in resistance and reactance values. Average decrease of resistance across all frequencies was $73.17 \pm 7.62\ \Omega$ which presented $11.92 \pm 0.07\%$. Results suggest that body composition values and especially directly measured values that are not equation dependent can give precise description for gestation process and can be used as one of the markers of healthy gestation process in future. Hence this measuring and evaluating of directly measured electrical values and body composition values can give us more information about gestation process.
Keywords: pregnancy, bioimpedance, body composition, fat mass, TBW, weight, resistance

Contribution ID: 1031
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

Finite element mapping for efficient image reconstruction in rotational electrical impedance tomography

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Electrical impedance tomography (EIT) is a label free harmless imaging method capable of imaging differences in electrical conductivity of a sample. In EIT, a low frequency current is injected into the sample, voltage differences on sample surface are measured, and from these measurements, interior conductivity distribution is reconstructed. To increase the accuracy of reconstruction, rotational EIT (rEIT) has been proposed where independent measurements are taken from multiple rotational positions around the sample. However, the benefit of conventional electrode configurations are limited to small amount of rotational positions. We present an approach called Limited Angle Full Revolution rEIT (LAFR-rEIT) that uses a small number of electrodes and large number of rotational measurement position measurements over 360-degrees. Results are comparable results to previous rotational EIT implementations, and furthermore, the limited EIT boundary access provides space for simultaneous attachment of other measurement modalities. On the other hand, the increased number of measurement positions cause an increase in computational complexity, and optimization is required until 3D applications are feasible. This work discusses modifications into finite element mesh presentation of the imaging domain and outlines numerically sufficiently light reconstruction method for 3D LAFR-rEIT.

Contribution ID: 1141
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

Behavior of electrical resistance of rats gastrocnemius muscle during contractions with different intensities

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According to the literature changes on muscle electrical resistance during contraction are related to changes in morphological and physiological features of muscle and both features changes during a muscle contraction. The morphological changes mean any structural modification of muscle, e.g. length, cross sectional area and volume. Physiological changes refer to any event which can result on modification at muscle impedititivity and that occur as consequence of biochemistry processes associated to muscle contraction. Even the studies reporting that both features contribute for changes on electrical impedance, they did not discuss deeply how these features may influence the muscle impedance. Other literature contradiction is about the direction of muscle impedance changes during contraction, some studies pointed out increases and other ones decreases on electrical impedance parameters. This paper aimed to investigate the behavior of real part of

electrical impedance, i.e. the resistance, of the gastrocnemius muscle of wistar rats during muscle contraction at different levels of muscle strength. Four needle invasive electrodes were placed in the animal muscle for impedance measurement while two others needles were placed on muscle extremity and were used for the neuromuscular electrical stimulation to evoke the contraction. The stimulation signal was a biphasic square wave with 1V of amplitude and ten different frequencies ranging 2 - 150 Hz were used, in order to provoke different muscle strength. The experimental protocol consisted at ten pulse trains with 1s duration and 40s rest and each pulse trains had different frequencies. The experimental protocol were submitted and approved for the Ethics Committee for Research with Animals of Federal University of Rio de Janeiro under the decision number 019/15. Results show a decrease up to 10% at muscle resistance from the basal level to the maximum contraction level and that such behavior can be influenced by metabolic processes.

Contribution ID: 1409
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

Microwave and impedance spectroscopy as a useful tool for testing dielectric properties of glucose solutions

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Diabetes is one of the most common social disease in the world. One of its basic symptom is increased level of blood glucose concentration. Conventional electrochemical and optical detection techniques, based on fingerpricking are inconvenient, expensive and unpleasant, from the viewpoint of the multiple puncture per day. Therefore, there is a need of blood sugar measuring device which may provide continuous monitoring of blood glucose concentration non-invasively. Promising techniques are based on the correlation between glucose-induced variations and blood dielectric properties. This report presents two possible methods showing the variations of impedance modulus and relative permeability values in glucose-sodium chloride (0,9%) and glucose-bovine plasma solutions at different concentrations, ranging from 50 mg/dl to 400 mg/dl, occurring in human blood. It is worth noticing, that in each sample the dielectric properties depend on the glucose concentration of the sample over the whole studied range, that is 1 kHz to 2 MHz for impedance measurements and 100 MHz to 5,5 GHz for microwave spectroscopy. These findings may be the basis for investigation of electrical and dielectric properties of examined glucose solutions.

Contribution ID: 1673
12. Diagnostic and Therapeutic Instrumentation
12.03. Bioimpedance

A bioimpedance-based cardiovascular measurement system

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Bioimpedance measurement is a biomedical technique to determine the electrical behavior of living tissue. It is well known for estimating the body composition or for the electrical impedance tomography. Additionally to these major research topics, there are applications with completely different system requirements for the signal acquisition. These applications are for example respiration monitoring or heart rate measurements. In these cases, very high resolution

bioimpedance measurements with high sample rates are necessary. Additionally, simultaneous multi-channel measurements are desirable.
This work is about the hardware and software development of a 4-channel bioimpedance measurement system, whereat all channels are galvanically decoupled from each other. It is capable of measuring 1000 impedance magnitudes per second and per channel. Depending on the chosen measurement configuration, impedance changes down to mΩ ranges are feasible to be detected. To enable the usage in a variety of different research applications, further biosignals like photoplethysmography, electrocardiography or heart sounds can be acquired simultaneously. For electrical safety purposes, an implemented galvanically isolated USB interface transmits the data to a host PC. The impedance measurements can be analyzed in real-time with a graphical user interface. Additionally, the measurement configuration can easily be changed via this GUI.
To demonstrate the system's usability, exemplary measurements from human subjects are presented.

Contribution ID: 172
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Presence of stochastic resonance in isolated mouse heart

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The heart is an organ with a continuous activity whose heart rate and strength contractions are modulated by several mechanisms including the autonomic nervous system, the renin-angiotensin system, vasopressin, among others. In particular, the nervous system transmits electrical signals to the heart through neurons. Neurons are essentially noisy. During the past years, several researchers have suggested that the nervous and cardiovascular systems appear to leverage the noise to improve information transfer.
Stochastic resonance (SR) is a phenomenon observed when increases in levels of noise cause an increase in any metric of the quality of signal transmission or detection performance, rather than a decrease. In the cardiovascular system, some researchers have suggested that SR could enhance the homeostatic function of the human blood pressure regulatory system, and also SR is present within the baroreflex human center. However, few researchers have addressed in the fact that the noise can enhance contractile response in the whole heart.
This study focuses on the electrical stimulation-contractile response coupling and demonstrates experimentally that the noise can enhance the contractile response in the whole heart. Experiments were conducted in isolated mouse hearts (0.040kg, n=7) where the contractile response due to an electrical stimulation (2-7V, 6-17Hz) perturbed with Gaussian noise was recorded. A Langendorff preparation was used to obtain two variables: the heart rate driven by the pacemaker in the sinoatrial node, and the contraction force since the force is measured through a suture and a force-transducer placed at the apex of the heart.
To the best of our knowledge, this is the first experimental test in whole heart focused on analyzing the contractile response due to electrical stimulation perturbed with Gaussian white noise. We found that the best performance was obtained with 10% induced noise. We have experimentally demonstrated the SR in isolated mouse heart.

Contribution ID: 233
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Personalization of the oscillometric blood-pressure measurement

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Oscillometric blood-pressure measurement might result in substantial error depending on the physiological parameters of the tested person. Especially the rigidity of the arteries can influence the oscillometric amplitudes. Personalization can greatly improve the accuracy and reproducibility of the measurement. The personalization process requires several measurements taken from a person applying special cuff pressure (CP) – time functions. A blood pressure measuring device was developed to generate different CP – time functions. It is able to sustain the CP at a constant value during both inflation and deflation. The device also measures ECG in Einthoven I lead and photoplethysmographic (PPG) signal at the fingertip. This makes possible to calculate the pulse-wave transit time (PWTT). The sampling frequency is 1 ksample/s thus PWTT values are calculated with 1 ms resolution. Recordings were taken from ten healthy subjects, both senior and young ones. The deflation was stopped and the CP was held constant at 90 mmHg and then at 60 mmHg for 60 seconds each. The subjects were at rest. Pulse wave transit times were determined from the heart to the cuff (PWTTHC) and to the fingertip (PWTTHF). Mean value and standard deviation as well as the trend of change of PWTTHC and PWTTHF over the 60 s intervals with constant CP are person specific, not age-group specific. The change in PPG signal amplitude resulting from cuff occlusion was found to be substantially smaller for senior than for young persons. Based on the personalization it is possible to define for each person a specific CP – time function providing information not only on actual blood pressure but also on the rigidity of the brachial artery. The recordings taken with constant CP parts help also compensate the effect of breathing.

Contribution ID: 306
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

A novel portable ultrasonic device for detecting the local pulse wave velocity of carotid artery

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It is well known that the majority of acute cardiovascular events is precipitated by the rupture of a vulnerable atherosclerotic plaque in the blood circulation system, and subsequent thrombogenesis. Even minimally or moderately stenotic atherosclerotic plaques can cause acute myocardial infarction and sudden cardiac death. Measurement of the stiffness of vessel plays an important role in detecting the cardiovascular diseases. Recently, measurement of pulse wave velocity (PWV) has been confirmed to be related to the stiffness of vessel. PWV is defined as the velocity at which the pressure waves, generated by the systolic contraction of the heart, propagate along the arterial tree. The regional PWV assessment is usually done in two different arteries (commonly the carotid and femoral arteries). However, many studies have shown that measurement of local PWV is important rather than regional PWV. In this study, a portable ultrasonic device was developed for measuring the PWV of carotid artery. A ultrasound transducer with 8-element was made for detecting the vessel motions, synchronously. The whole system including 8 channels pulser-receivers, FPGA chip as a core unit, and ADC. After the echo signals were digitized and be fed into a micro-computer, the PWV was calculated by a regression algorithm. Experiments were carried out from 10 subjects. The regional PWV was also measured by using traditional approach to confirm our local PWV data. All the results showed that the novel ultrasound device exhibits a good performance to assess the stiffness of carotid artery

Contribution ID: 357
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Wearable pulse wave monitor resistant to motion artifacts

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The aim of this study is to create a wearable device for long-term pulse wave monitoring as well as to investigate the possibility of using adaptive noise cancellation approach for reducing motion artifacts occurred during the real life recording. In our study wearable monitoring device have acquired pulse wave by using photoplethysmography approach and human movement with triaxial accelerometer. The electrical design of wearable device was based on synchronous demodulation and using 24 bits sigma-delta analog-to-digital converter.
To achieve effective and robust motion artifacts reduction we create the pulse wave signal processing method based on band-pass filtering and adaptive noise cancellation. Pulse wave signals were initially pass-band filtered at 0.5–10 Hz to remove noise, electrical and physiological interferences, using a zero-phase forward and reverse digital filter, which first filtered the raw signal in the forward direction, and subsequently filtered the reversed signal, thus the resultant signal has zero-phase distortion.
Adaptive noise cancellation was implemented by using a recursive least squares algorithm based on the solution of the Wiener-Hopf equation. Our studies have shown that the best results of pulse wave signal processing are achieved for the following parameters of the algorithm: the forgetting factor of 0.99; filter order of 16.
Performance of proposed processing technique was evaluated by assessing signal-to-noise ratio of the filtered signal and compared with other approaches such as wavelet multiresolution decomposition and moving average filtering. For correct estimation of SNR we used robust approach based on the eigenvalues of signal autocorrelation matrix.
This study indicates that designed wearable device based on principles of photoplethysmography for unobtrusive and noninvasive recording of pulse waves and using advanced digital processing technique for removing motion artifacts could provide an effective and performance tool for improving the long-term healthcare monitoring of human vital signs.

Contribution ID: 360
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Advances in cardiac Holter monitoring

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The 12 lead ECG and Holter monitor, HM, remains the most common tools for examining the heart rhythm. Norman Holter’s ambulatory ECG recording has been a mainstay of clinical practice to diagnose cardiac rhythm disorders since 1961, traditionally recording every heartbeat for 24 hours. The HM requires multiple electrodes on the chest and a recording system, usually worn on a belt or on a holster strap. Even today, these systems can still be bulky and difficult to conceal in public.
The electrodes often disconnect, especially during sleep and cannot be worn during showering. Exercising can also result in electrode disconnection due to perspiration and activity. Multiple views of the cardiac signal and large inter-electrode spacing should allow P-wave detection, but unfortunately the data yield is poor

Patch monitors, PM, have been developed recently in attempts to overcome shortcomings of the conventional HM systems. PMs allow for longer duration monitoring and, consequently, have matched or outperformed HM yields, although the comparison, is merely one of compensating for lower diagnostic yield on a daily basis by increasing the duration of recording.
The key to improving diagnostic yield is the quality of the P-wave, regardless of the specific duration of recording. P-wave clarity, its morphology and relationship and timing to the QRS is crucial for defining an arrhythmia's specific mechanism. Patch systems, with their short vector(s) make the ECG's P-wave signal detection relatively difficult, but they compensate partially by being easier to wear and adhering for longer periods. One patch system placed on the sternal mid-line, with a noise floor of 2 micro Volts, is P-wave centric and is the first to outperform the conventional HM over a 24-hour recording period, giving 46% actionable data cf.12% from HM in 50 pts.

Contribution ID: 367
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Influence of artificial microgravity on human arterial vessels

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The main goal of this work is to study the alterations occurred in human vascular system under artificially simulated microgravity by using special short-arm centrifuge. Artificial gravity produced by short-arm centrifuge along the head-to-feet axis induces gravity gradients and causes hemodynamic alterations. We have used arterial blood pressure measurements, pulse wave contour analysis, and accelerated photoplethysmography to determine the effects of artificially simulated microgravity on human vascular system. The group of 30 healthy male and 50 female volunteers was studied in a short-arm human centrifuge at two levels of gravity gradients along head-to-foot direction (Gz): normal gravity gradient of 1 Gz and so called microgravity mode of 0.7 Gz during 10 minutes at supine position lying at the nacelle.

Contribution ID: 453
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Design and implementation of digital telestethoscope

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Our project relates to Tele-stethoscope which is specially designed to provide state of art technology to medical and health professionals to provide best possible practices to the seniors, people with disabilities, and people in distant areas who may have difficulties to grab a proper health care facility. Initial stage of this project was to consult our professors, health professionals and sketch a concept design. Even though, electronic stethoscopes are available in market but they are out of reach of a common man. We revisited the cost and put up a cost analysis which has turned this instrument more economical. Research was completed to identity the frequencies of head sound which stethoscope needed to filter. The concept includes all the attributes that a Tele-stethoscope should include. Next step was to design analog circuit which comprises pre-amp and post amp stages and then the interfaced to Pc via a free open source. Project was then tested

with the help of Skype voice call messenger and we successfully transmitted cardiac sounds with such high quality and precision.

Contribution ID: 502
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Skin tissue circulation monitoring system using wearable multi-functional sensor array

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Potential risk of compromised circulation after free tissue transplant surgery requires one-week skin tissue observation in postoperative period by physicians. Monitoring skin circulation provides physician objective basis and relieves burden of them. Current devices with camera or big data processor restrict movement of patients thus failing in one-week monitoring. Using wearable devices on skin tissue monitoring could solve the problem mentioned, but the feasibility of using this approach has not been proved yet. Our purpose is to develop a wearable and multi-functional monitoring system to detect skin circulation and verify the feasibility of the device. We implement pulse wave sensors, color sensors, and temperature sensors on a flexible substrate to make the sensor probe. Those three parameters are on-site indications for judging compromised circulation, and all data could be checked on a tablet device. To verify feasibility of the device, we designed a protocol that applying pressure on forearm of human using sphygmomanometer and then releasing the pressure to make ischemia skin blood-flow and refill of blood-flow. We attached the sensor probe on palm of five healthy volunteers and obtained three signals during normal condition, during ischemia condition, and during blood refill. According to the result of t-test among all volunteers, the pulse wave power between ischemia and other 2 states got a significance level at 0.05. Color signals during ischemia, although showed lower value than other states, failed to get a good significance level. Temperature remained stable throughout the experiment because of the limited ischemia time. We developed a wearable skin circulation monitoring device using sensor array and verified that the device is feasible to distinguish compromised circulation. Our multi-functional sensors have high potential to obtain unrecognizable data due to several artifacts, and are suitable for monitoring in hospital circumstances.

Contribution ID: 541
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Multifunctional photoplethysmography sensor design for respiratory and cardiovascular diagnosis

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Photoplethysmography (PPG) is an optical signal acquisition method to monitor blood volume variations to assess cardiovascular health, using a light source and a photodetector. For the estimation of vital parameters like respiratory and heart rate, different properties of PPG signals need to be further analyzed, which offers a vast application area. This demands the utilization of different sensor techniques to be used such as motion sensors, skin temperature monitoring and

different wavelengths of light sources. This paper presents the proposed multipurpose PPG sensor design, called SmartPPG, which is able to measure multi-wavelength PPG as well as skin temperature while providing motion tracking via an accelerometer. Photocurrents created on photodiodes are digitalized and can be read using peripheral communication protocols. Including I2C communication pins to the voltage supply pins, the sensor unit has a 4-pin connector. Sampling frequencies of different sensors are adjustable and the total system has a power consumption of 19 mW at a sampling rate of 100Hz. The SmartPPG system is portable and broadens the field of PPG-based applications. Time multiplexed multi-wavelength PPG measurements can be used for arterial diagnostics, whereas the selection of different photodiodes leads to different penetration depths, therefore, allows monitoring of deeper skin layers. Skin temperature measurement in combination with PPG may allow the automated detection of local inflammation or edema. The motion sensor enables motion artifact reduction algorithms. The manufactured prototype was tested on a small group of participants for different applications such as blood oxygen saturation (arterial and venous), venous muscle pump test and respiratory rate estimations. This paper does not aim to evaluate different PPG modalities but the success of the proposed design. Therefore, tests of cardiovascular diagnostics were conducted additionally. For respiratory rate estimation, a fusion algorithm is proposed and tested on the measurements recorded using the prototype.

Contribution ID: 639
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

The effect of LED direction in measuring multi-wavelength PPG waveform on wrist

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This study aims to investigate the optimal sensor positioning in measuring Photoplethysmography(PPG) on wrist. For this purpose, we developed multi-wavelength optical sensor, including infrared (940nm), red (660 nm), green (530 nm), and blue (450 nm) LED, and we investigate the PPG waveform by changing the direction of LEDs.
PPG signal was obtained from a participant, and it was measured on left wrist in sitting position.We used two LEDs of developed sensor located on same line across the photo detector, and LEDs were placed on longitudinal or transversal direction of wrist to compare the directional effect. Experimental results showed that the green and blue PPG have similar waveform regardless of the direction of LEDs. However, in infrared and red PPG showed different aspects. In PPG waveform obtained from the transversal direction, the amplitude of the AC component was reduced compared with the PPG obtained from longitudinal direction.
The result of this study could be understood from the structure of the blood vessel. The artery on the wrist stretch parallel with longtudinal axis of wrist, however, capillaries are uniformly distributed throughout the entire skin.
For more generalized result, additional studies including wide-range of population need to be carried out.

Contribution ID: 733
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Greater effectiveness of transthoracic delivery of multidirectional monophasic shocks for cardiac defibrillation

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Background: Electrical defibrillation is the only effective treatment for termination of ventricular fibrillation (VF). Cardiomyocytes are most sensitive to stimulation with longitudinally-applied electric fields (E). However, as cell bundles are oriented in different directions, high-intensity E required for successful defibrillation may cause myocardial injury. Previous studies with isolated cardiomyocytes and direct defibrillation indicate greater efficiency of multidirectional vs. unidirectional stimulation. The aim of this study was to explore the multidirectional approach for transthoracic defibrillation.
Methods: A multidirectional defibrillator was developed to apply 3 identical monophasic truncated exponential voltage shocks within 30 ms to 3 pairs of electrodes disposed 60 degrees apart in paddles designed for transthoracic defibrillation. VF was induced in anesthetized, artificially-ventilated swine by intraventricular low-energy DC stimulation. Defibrillation trials were performed with the up-and-down protocol, alternating the unidirectional and multidirectional approaches. The relationship between the probability of defibrillation and shock energy was determined by survival analysis. The protocols were approved by the institutional Committee of Ethics in Animal Use (CEUA/IB/UNICAMP, No. 4261-1).
Results: Circulatory stability was maintained throughout the experiment, judging from the low (<5%) difference between initial and final arterial pressure values. The energy intensity required for 50% success in defibrillation was markedly lower for the multidirectional (27.3±0.2 J) than for the conventional, unidirectional approach (70.2±0.8 J; p< 0.001; N= 5).
Conclusion: The results confirm that the superiority of multidirectional stimulation holds also for transthoracic shocks, which is expected to contribute to patient safety in emergency defibrillation.
Patent required.
Financial support: CNPq/Brazil.

Contribution ID: 756
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

The implications of the lead theory on the patch ECG devices positioning and measurement

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Currently we are witnessing fast development of patch ECG devices, some of which have already been extensively evaluated and shown to be useful for detecting arrhythmias. The research about using the patch ECG devices for purposes other than arrhythmia detection has been scarce. The efficiency of patch electrocardiography for a specific purpose can depend on the devices' location on the body surface. It is still an open question where to position the ECG patch devices, and should the position depend on the specific purpose and perhaps even be personalized. We present the lead theory of differential leads (ECG leads obtained by patch devices with small inter-electrode distance) and discuss its implications on the patch ECG devices' positioning on the body surface. The theoretical considerations are practically illustrated by comparing ECG features

between leads of the standard 12-lead ECG and a set of experimental differential leads obtained by taking differences of the leads from a 35-lead ECG.

Contribution ID: 1111
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Comparison of home blood pressure measurement devices on artificial signals

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Cardiovascular diseases are well known as leading causes of death in developed countries. At the same time, the prevalence of arterial hypertension is about 44 % in European countries and about 30 % in the United States. The hypertension is a significant danger and should be monitor carefully. Many studies in recent years show that a proper technique for the blood pressure monitoring is a self-measurement in home conditions. In recent 20 or 30 years, auscultatory and oscillometric methods become as widely used for blood pressure measurement. In clinical practice, blood pressure measuring devices are evaluated according to validating protocols published by American Association for the Advancement of Medical Instrumentation or by British Hypertension Society. Despite these protocols, a market with the automatic devices for home self-measurement of the blood pressure is flooded by a lot of cheap devices with doubtful accuracy.
The aim of this study is to compare selected devices for the self-measurement in home conditions. The devices available in global market with the different methods of the measurement have been selected – one electronic tonometer which uses oscillometric method during the deflation of the cuff (Hartmann Digital HG160), one with oscillometric method during the inflation of the cuff (HuBDIC HPB-1520), one device for measurement on the wrist (Omron R7). The devices were evaluated using the blood pressure simulators (Fluke BP Pump 2 and Fluke ProSim 8).
For each device and each type of blood pressure signal (22 different simulated signals), the absolute and the relative errors of the diastolic and the systolic pressures were evaluated. The obtained results show that the measurement error of these devices could be frequently higher than 5 mmHg and it is necessary to concern with the accuracy of the devices. The detailed results and their interpretation will be presented in the paper.

Contribution ID: 1125
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

The possible approach of the synchronous ECG and PPG measurement

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Electrocardiography and photopletysmography are basic in- vestigative methods used in healthcare. As the ECG and the PPG are non-invasive methods. The principle consists in ECG recording of electrical activity of the heart and the result of this sensing is a graph plotting - electrocardiogram. PPG is one of the main methods of measurement plethysmography when the result is a graphic record of the pulse wave. The main function of PPG is the volumetric flow measurement of blood (e.g. in atherosclerosis, which is possible by vascular permeability derive their rigidity). Both of these methods are used for monitoring of cardiovascular system. It would be advantageous to have possibility to measure ECG and PPG from one place on the human body. It

would be also advantageous to have only one device and reduce the number or size of sensors or electrodes. In this paper, we describe developing such system and also investigation the ideal place for placing of sensors for satisfactory mea- surement.

Contribution ID: 1184
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

A dynamic oscillometric approach to assess impaired orthostatic heart rate control

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Impaired orthostatic heart rate (HR) control is a risk factor for autonomic dysfunction and increased mortality. State-of-the-art methods which combine both blood pressure(BP) and HR measurements are expensive, complex and require significant expertise to use and interpret. Our aim was to develop and clinically validate a dynamic oscillometric system to measure transient HR changes during standing as a prerequisite for development of a dynamic BP measurement system.
A physiological measurement system was developed to capture transient HR (HROSC) changes from the dynamic oscillogram occurring in a pressurised upper arm cuff worn during standing. A validation study was conducted in 43 participants recruited through a National Falls and Syncope Unit to determine the accuracy of HROSC compared to a gold standard ECG derived HR measurement (HRECG) captured simultaneously during standing. Linear regression, cross-correlation (CC) and Bland-Altman (BA) analyses were performed to compare HROSC and HRECG measurements. Clinical parameters (baseline, min-max HR difference, speed of HR recovery (HRR) and Ewing's ratio) were derived and agreement between approaches evaluated with the intra-class correlation (ICC) coefficient.
Complete data was available in 20 non-patients and 18 patients (median age 50(27-72) years; 39.5% females). In non-patients, the R2, Spearman coefficient and CC coefficient were all greater than 0.99, while in patients these values were lower ranging from 0.204 to 0.786. In non-patients the BA bias and limits of agreement (LOA) were 0.011bpm and (1.857 to -1.842)bpm respectively while in the patient group a bias of 0.278 bpm and LOA of -22 to 171bpm was measured. Agreement was high (>0.8) for Ewing's ratio (ICC=0.997) and speed of HRR (ICC= 0.859) in non-patients only.
Dynamic oscillometry is a promising, low-cost, user friendly and accurate approach for assessing impaired orthostatic HR control in non-patient cohorts (aged<60). Future methodological refinements are necessary to improve its accuracy in older patient cohorts.

Contribution ID: 1213
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Multichannel 24-bit bioinstrumentation for bioelectrical signals detection using Arduino technology

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In this work is to develop a bioinstrumentation for the automatic detection of biopotential signals. Currently, detecting bioelectric signals generated by physiological activity of excitable cells is one of the most attractive research topics in the fields of medical physics and biomedical engineering; especially in the theme of brain-computer interface in order to control the upper and/or lower ends of prostheses using only the brain. A high-performance 24 bits, based-Arduino technology bioamplifier with 16 channels, was built and calibrated to automatically measurement bioelectrical signals from muscle, cardiac and brain activity. In order to obtain the digital multichannel electric biosignals, a computational routine was developed in Python. Experiments performed in a volunteer showed the bioamplifier can satisfactorily measure multichannel bioelectric signals generated by biceps, triceps, heart and brain tissues. These preliminary results provide that this bioinstrumentation can be useful for studying physiology activities in research area.

Contribution ID: 1217

12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

A novel method for an accurate noninvasive measurement of pulse wave velocity

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Background
This paper presents a novel method for a pulse wave velocity (PWV) measurement. PWV is one of a few parameters, which is used to predict an arterial stiffness. The term 'arterial stiffness' means a change in mechanical properties of arterial walls and is associated with higher cardiovascular risks. The purpose of this study was to develop a noninvasive method to simply and quickly determine PWV.
Method
The solution is a usage of a brachial arm cuff, which is pressurized (35-40) mm Hg above systolic pressure (suprasystolic pressure), and a differential pressure sensor, which can detect even very weak pulsations at that pressure. That is an advantage over current devices on the market, which use pulse wave for their calculation of PWV. The method is already patented and according to this solution was developed a device. Measurements were provided in cooperation with General University Hospital in Prague and within the created methodology was measured the same group of subjects with the 'gold standard' SphygmoCor VX device (AtCor Medical, Sydney, Australia). For this purposes were measured 31 subjects (21 men, 10 women), aged 21-66 (mean 37 ± 12) and nobody took medicine for cardiovascular diseases.
Results
The calculated PWV by created algorithms for analyzing and processing pulse wave in MATLAB software was ((6.34 ± 1.33) m/s) and the PWV determined by SphygmoCor VX was ((6.43 ± 1.25) m/s). The regression and correlation analysis demonstrated, that there is a correlation (0.8) between novel method and SphygmoCor VX. Also the measurement by the novel method is much more faster than measurement by SphygmoCor device.
Conclusions
The results demonstrate, that the novel method could be a new one as an accurate noninvasive evaluation of PWV and prediction of cardiovascular risks.

Contribution ID: 1273

12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Pulsed transmission protocol for improving the skin-temperature stability in transcutaneous wireless energy supply systems for high-power rated medical implants

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Introduction: Therapeutic options in end stage heart failure include cardiac transplantation or implanting a Total Artificial Heart (TAH) or a Left Ventricular Assist Device (LVAD). These are devices with relatively high-power requirements (5W to 80W). Existing power supplies to TAH/LVAD are via percutaneous drivelines, with a high incidence (20%) of infection. We have developed a high-power rated wireless Transcutaneous Energy Transfer System (TETS) concept for addressing the main clinical drawbacks that available TETS have not solved in practice: skin-temperature (< 1 degree centigrade offset) and system robustness
Methods: Coupled coils RF transmissions of 30 ms pulse bursts provided up to 20 J energy packs to re-charge a super-capacitor at the secondary circuit every 20 seconds, allowing sufficient time for natural dermis blood irrigation to stabilise the skin temperature between the coupled coils (external primary coil and subcutaneously implanted secondary coil). The energy associated with every transmitted micro-pulse was calculated from voltage and current probes measured and computed; using a 200 kHz RF power transmission. The efficiency of the system was computed in terms of percentage by taking the ratio of the energy of the micro-pulses at the receiver capacitive load to the energy of the micro-pulses at the transmitter side.
Results: The transmission efficiency on the capacitive load with an operating pre-charge above 25V, was of 76.6%, during the 30 ms super-capacitor charging time. The reason for the improved efficiency was mainly due to the capacitive load driven nature associated to the particular transmission protocol, rather than a resistive load driven; which is the case in conventional TETS.
Conclusion: The proposed pulsed transmission protocol offers two main advantages for LVAD/TAH implanted devices TETS solutions: sufficient skin-cooling time by natural blood circulation, and keeping a high-standard transmission efficiency driving a capacitive load.

Contribution ID: 1364
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Basic study of quantitative evaluation method for pulse diagnosis based on medical engineering

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The pulse diagnosis is one of the pulse wave diagnosis technique in the traditional Kampo medicine. In the diagnosis technique, the radial artery of the left and right wrists is examined by the three fingers. However, it depends on tradition and experience, and there is lacks medical evidence. We have been developed the pulse diagnostic device, with three pressure sensors in

series and the manchette as a quantitatively change external pressure load. In this study, we measured the pulse diagnosis pressure waveform by using non-invasively pulse diagnostic device on the radial artery in a healthy subject. To a healthy subject who got informed consent, The pressure sensor was placed on the radial artery skin at the traditional pulse diagnosis position, under the guidance of Chinese medicine doctor with the approval of the Ethics Committee in Tohoku university. The pulse waveform was changed by external load pressure at each of the three srensors portion. In addition, the pulse wave velocity was calculated from the pulse waveform of each sensor, and the pulse wave propagation speed tended to increase at the psychological burden. Pulse wave measurement in a healthy subject was performed by using a pulse diagnosis device. The possibility of quantitative diagnosis in the traditional pulse diagnosis was suggested.

Contribution ID: 1509
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Effects of nitroglycerin to ballistocardiography measurement by EMFi

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The purpose of this work was to study the effect of nitroglycerin (glyceryl trinitrate) to ballistocardiographic signal (BCG) recorded in sitting position by using Electromechanical Film (EMFi) sensors. BCG, electrocardiogram, ankle pulse and carotid pulse (CP) signals were recorded from a single person and duration of the signal components according to R wave of the ECG and amplitudes of the signals were studied. In the first study, the effect of 1 nitroglycerin pill (0.5mg) was studied and in the second study, the effect of exercise and the intake of 2 nitroglycerin pills were examined.
The time domain properties of BCG, CP and ankle pulse signals stayed almost stable due to the nitroglycerin intake. Increase was observed in systolic signal amplitudes. Diastolic signal amplitudes mainly decreased. Signal traces became smoother and the fluctuation of the ballistic signals decreased. Temporary effect on the heart-vasculature system caused by the nitroglycerin intake can be observed by EMFi based BCG measurement.

Contribution ID: 1674
12. Diagnostic and Therapeutic Instrumentation
12.04. Cardiovascular systems

Aortic pulse wave velocity measurement via heart sounds and impedance plethysmography

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The determination of the physical characteristic of the human arterial system, especially the stiffness of the aorta, is of major interest for estimating the risk of cardiovascular diseases. The most common measurement technique to get information about the state of the arterial system is the pulse wave analysis. It includes the measurement of the pulse wave velocity inside the arteries as well as its morphologically changes when propagating through the arteries. Since it is difficult to detect the pulse wave directly at the aorta, most available devices acquire the pulse wave at the extremities instead. Afterwards, complex models and algorithms are often utilized to estimate the original behavior of the pulse wave inside the aorta.

This work presents an impedance plethysmography based technique to determine the aortic pulse wave velocity. By measuring the starting time of the pulse wave directly at its origin by the acquisition of heart sounds and the arrival time at the end of the aorta non-invasively via skin electrodes, unreliable complex models or algorithms aren't necessary anymore to determine the pulse wave velocity.
After describing the measurement setup and the problem-specific hardware system, first measurements from a human subject are analyzed and discussed.

Contribution ID: 52
12. Diagnostic and Therapeutic Instrumentation
12.05. Neuromodulation systems

Stereotactic neurosurgical manipulator

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Head injuries are becoming a challenging clinical entity for most of the doctors as it requires high level expertise and involves lot of risk.To overcome this issue, medical and robotics field were combined to improve the quality of surgery which resulted in emerging of stereotactic neurosurgery. The main task here is to place the instrument accurately and precisely over the surgical target above the human skull for performing action such as tumor therapy, tissue biopsy etc, thus minimizing brain damage when compared to an open head surgery. Presently a manually controlled stereotactic frame fitted with the tool or a robotic arm is used to perform the surgery at a specific point.
In the present work, the manipulator will be completly automated. Objective of this project is to develop an ergonomic stereotactic frame which can be fixed on the patients head. Coordinates of the target within the brain specifeid by the surgeon from the 3D model obtained from CT or MRI images will be fed to the control systems. This point is then fed to motor control drives which drive the tool accurately and precisely over the head above the surgical location.

Contribution ID: 1130
12. Diagnostic and Therapeutic Instrumentation
12.05. Neuromodulation systems

Stroke and trauma diagnostics for ambulances and helicopters

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This paper reports on the development and testing of of novel, compact, portable diagnostics system for stroke and trauma for use in ambulances and helicopters. Portable diagnostics for the pre-hospital setting remains a major challenge for the 30 million individuals who each year sufferers a stroke or brain trauma. When an ambulance arrives at the scene of an accident or a suspected stroke the objective is to reduce the risk for death and provide optimal care of the patient. The patient is evaluated and decisions made, with limited information,
on which hospital the patient needs to be transported to and on whether to initiate some form of treatment. Both these groups of patients, which are subject to these life and death decisions, would clearly benefit if medical personal had access to the additional support of diagnostic tools. No such tools are today available in clinical praxis but as the the first group in the world and have, with our clinical partners, started to evaluate the first generations in clinical trials. The latest from ongoing clinical and biomedical engineering research will be presented.

Contribution ID: 1317
12. Diagnostic and Therapeutic Instrumentation
12.05. Neuromodulation systems

Suitable stimulating technique to record visual evoked potential in migraine with aura patients

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Aim: Migraine with aura is a headache that strikes after or along with sensory disturbances. To deal with some patients different diagnostic techniques maybe used. Visual Evoked Potential (VEP) is one of useful technique in this connection. Flash and Pattern Reversal Checkerboard (PRC) are two stimulating techniques to record VEP. The aim of present work is to compare these two techniques in migraine with aura patients & look for optimum one.
Material & Method: Flash & PRC VEP were recorded in 20 migraine with aura patients. Latency (msec) and amplitude (μV) of VEP, P100 peaked were noted for each patient. The results obtained was compared together.
Results: The mean ±S.D. for latencies were 98 ± 5.28 & 102 ± 8.33 for PRC & flash stimulations respectively. On other hand, the mean ± S.D. for amplitudes were 6.12 ± 1.86 & 4.38 ± 2.86 for PRC and flash stimulations respectively. The differences for two techniques are not significant (P>0.05)
Conclusion: From the result of present work, one can conclude that PRC is a suitable technique to record VEP in migraine with aura patients, which will be discussed in full paper.
Keywords: Migraine with aura, Pattern reversal checkerboard and flash visual evoked potential

Contribution ID: 1375
12. Diagnostic and Therapeutic Instrumentation
12.05. Neuromodulation systems

Association between nerve conduction study and tendon reflex among diabetic patients

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Introduction: Diabetes mellitus (DM) is one of the most chronic diseases all over the world. Diabetic neuropathy is one of the commonest long term complications of DM. Hence, this study aimed to determine the peripheral neuropathy and pattern of nerve involvement on nerve conduction study (NCS) neuropathy in DM and its correlation with tendon reflexes.
Methods: This study was performed on the 77 DM patients aged 14-70 years who were admitted to Shariati Hospital, Tehran, Iran. Patients with autoimmune diseases, hypo or hyper thyroid, collagen vascular disease and drug or/and alcohol intake were excluded. All the patients were examined by an expert neurologist and nerve conduction study (NCS) including nerve conduction velocity (NCV), distal latency (DL) and amplitude in the Median, Ulnar, peroneal and sural nerves were measured. Then, patients with normal and abnormal both physical and NCS were considered as control and case group, respectively. Afterward, neurological examination includes temperature sensation, vibration sensation (128-Hz diapason), ankle jerk and knee reflexes were assessed.
Results: The mean age was 50.5±7.5 years and 48 patients were female. 41.2% and 44.2% were received oral and insulin therapy, respectively. Paresthesia in 66.2%, weakness in 11.7 and pain in 2.6% were observed. According to NCS and physical examination (PE) patients were divide into 3 group: normal (3.9%), neuropathic (70.1%) and subclinical neuropathy (26%). Also, NCV in 88% and 12 % was abnormal and normal, respectively. Indeed, abnormal NCV in motor median (24.7), sensory median (57.1%), motor ulnar (18.2%), motor peroneal (11.8%) and sensory sural (46.8%)

was observed. Knee jerk in 1(1.3%) was absent, in 13 (16.9%) was decreased and in 63(81.8%) was normal. The same results were seen in the term on ankle jerk.
Conclusion: Based on results of this study, abnormal tendon reflex has a significant association with decreased NCV.
Keywords: Diabetes mellitus; Neuropathy;

Contribution ID: 938
12. Diagnostic and Therapeutic Instrumentation
12.06. Dialysis and apheresis systems

Removal of vascular calcification inducer phosphate in different dialysis treatment modalities

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Approximately 8-10% of the adult population suffers from kidney damage. Cardiovascular complications are the leading cause of death in chronic kidney disease (CKD) patients and vascular calcification is prevalent. One key trigger of higher prevalence of vascular calcification in CKD is high serum phosphate (P) level. During the renal replacement therapy, dialysis, phosphate is removed from the blood regularly.
The paper aims to evaluate the calcification capability of phosphate and compare the removal of phosphate during the different dialysis modalities.
Human vascular smooth muscle cells and rat aortic rings were incubated in high inorganic phosphate media. Both, calcium content measurements (o-cresolphthalein complexone method) and histochemical staining (von Kossa) proofed significantly increased calcification.
Ten uremic patients, five males, and five females mean age 59 ± 16 years, were followed during 40 chronic midweek hemodialysis sessions in Centre of Nephrology, North Estonian Medical Centre, Estonia. Four dialysis modality with different settings were used once for each patient:
1. Hemodialysis (HD) with low-flux dialyzer (FX8), blood flow (BF) 300 mL/min and dialysate flow (DF) 500 mL/min
2. High-flux hemodialysis (HF) 1, BF 300mL/min, DF 800 mL/min
3. HF2, BF 350mL/min, DF 500 mL/min
4. Postdilutional online hemodiafiltration (HDF), BF 350mL/min, DF 800 mL/min.
All treatments lasted 240 min. Patients mean pre-dialysis serum phosphate levels were 1.72 ± 0.57 mmol/L which is higher than in healthy subjects (0.81-1.45 mmol/L). Total removed phosphate (TRP) was calculated for each session, and the results for different dialysis modality groups were compared using 1-way ANOVA test.
The mean TRP for HD was 33.6±9.9 mmol, which differed significantly ($p<0.009$) from TRP values (43.9-45.8 ± 8.1-15.3 mmol) of other modalities (HF1, HF2, and HDF). TRP values of other modalities were not significantly different.
The results are indicating the possibility to remove phosphate more effectively by adjusting the dialysis treatment parameters.

Contribution ID: 1528
12. Diagnostic and Therapeutic Instrumentation
12.06. Dialysis and apheresis systems

New Bioactive Particles for the Removal of Bilirubin in Hemodialyzed Patients in Critical State

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The mortality of dialyzed patients with critical health situations consequence of liver failures are unacceptably high. The existing systems for the hepatic dialysis and bilirubin removal shows serious limitations as its cost, complexity and limited effectivity. With a panorama of about 1 million people dying annually from kidney failure, more than two million patients in the world receiving some type of dialysis and approximately 73000 dialysis machines working worldwide and growing, the need of an effective, selective and fast system for the removal of bilirubin in extremely jaundiced dialyzed patients is vital.
A polymeric particulated biomaterial highly effective in bilirubin depletion and compatible with the blood tissue complexity has been developed. These particles can be allocated in a cartridge connected on line with the dialysis systems for treatment of dialyzed patients with high levels of bilirubin in critical state.
Particles with narrow size distributions and size around 500 microns has been created by suspension copolymerization of styrene (Sty) and methyl-methacrylate (MMA). At a certain point of the polymerization process a surface attachment of a linear polyethylenglycol is carried out. The incorporation of the linear PEG at the surface of the microparticles improves compatibility of the material with the human blood and permits the attachment of the albumin to the particle surface. After that, the attachment of bovine serum albumin (BSA) to the particles is carried out.
The efficiency of these particles for the removal of bilirubin from human blood with a high level of bilirubin has been tested. The new particles demonstrated that was possible to reduce the bilirubin level in blood from 10.2 to 1.8 mg/dL in a closed circuit device in less than 8 h.

Contribution ID: 700
12. Diagnostic and Therapeutic Instrumentation
12.07. Pulmonary systems

Monitoring of breathing volume using textile strain gauges

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Spirometry, being the golden standard method in respiratory monitoring, require measurement device to be attached to the patient mouth. This is inconvenient for patient and hospital staff and make use of spirometry difficult for continuous breathing volume monitoring in non-hospital applications. There were number of attempt to replace spirometry with measurements of the chest of trunk volume. One of the potential solutions is evaluation of the chest volume using set of respiratory belts, placed at the various levels. Such belts could be manufactured of the highly strain - sensitive knitted resistive fabric. Such fabric, integrated into tight underwear, like t-shirt or compressive body, could be used to measure changes in trunk circumference. The objective of the present research was to check usability of the t¬-shirt integrated knitted strain gauges for evaluation of the breathing volume. The breathing monitoring garment was made in a form of t-shirt with seven knitted resistive stretch sensing ribbons, sewn around the t-shirt trunk. The electric resistance of the ribbons were measured using BioRadio® data logger. Ribbons, calibrated to measure circumference, demonstrating slight non-linearity. Circumferences, measured by individual ribbons, were used to estimate trunk volume of four healthy volunteers (2 male 2

female). Alongside, volunteers breathing volume was measured using commercial spirometer SpiroUSB. Comparison of the results demonstrated, that t-shirt allows evaluate breathing volume with the uncertainty of 0.5 l, given all 7 ribbons are used for calculation of volume. The uncertainty was higher for female volunteers; this could take place because t-shirt was calibrated on the male individual. For this individual, the uncertainty was as low as 0.15 l. The results indicates that multi – ribbon t-shirt could be used for reasonable estimation of breathing volume, but required personal calibration for each individual.

Contribution ID: 991
12. Diagnostic and Therapeutic Instrumentation
12.07. Pulmonary systems

Research of impedance characteristics with a negative pressure breathing using rheocardiographic and rheoencephalographic signals

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Negative pressure breathing (NPB) is a spontaneous breathing with negative (relative to external, atmospheric) pressure in airways and lungs during the complete respiratory cycle or at certain phase. Our study was aimed at evaluation changes in cardiovascular system caused by applying negative pressure during inspiration (NPBin). Negative pressure was produced by enhanced inspiratory valve in standard valve box connected to mouthpiece. Mouth pressure was registered and further used as a mark of current phase of respiration. Mouth pressure was measured by Honeywell differential pressure transducer connected to mouthpiece.
Seven healthy normal male volunteers participated in the study. An age of the volunteers was from 19 to 34 years, the mean +-SD was 25.7+-6.3. All measurements were made with a subject in supine position. The study included five series conducted on the same protocol with each volunteer. Value of applied negative pressure was the only difference between series (0, -10, -15, -20, -25 cm H2O). Series were conducted in random sequence. Each volunteer participated only in one series per day. Each series was divided into three stages: 15 minutes before applying NPBin, 25 minutes of NPBin, 15 minutes after NPBin. Physiological parameters were recorded continuously during all three stages.
Researches of a basic impedance changes are conducted with a negative pressure breathing using rheocardiographic and rheoencephalographic signals.

Contribution ID: 1147
12. Diagnostic and Therapeutic Instrumentation
12.07. Pulmonary systems

Cooperative automation of extracorporeal gas exchange and artificial ventilation

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At present long term extracorporeal lung assist and ventilation are only tuned manually by the supervising personnel. The adaption takes place only in care intervals or in alarm situation. In previous work we reported on an automatic control system for the extracorporeal circuit. For this

automation problem, gas exchange by ventilation causes disturbances. On the other hand, ventilation should be set as to provide maximum possible level of protective ventilation while assisting to gas transfer as required. As lung mechanics and gas exchange are constantly changing frequent readjustments are necessary to maintain the optimal clinical regime. To integrate this in our automation system we combined control of the extracorporeal gas exchange with an expert based system for ventilation settings. The expert system is based on a formalised treatment protocol which is based on the treatment strategies of the daily routine of our clinical partners. The rule set was later reviewed by several experts. From there, the rule set was implement in a stateflow chart adding further strategies on how to handle timing (intervals of state changes) and definition of hysteresis to prevent switching cycles in a near steady state. Further extensions were required to resolve contradictory settings created by the primary control goals of oxygenation, protective ventilation and de-carboxylisation. This was achieved by prioritisation.
At first we performed design verification on simulation models. After achieving satisfying performance, the setup was tested in an animal in vivo model of an acute respiratory distress syndrome created by combined lung lavage and forced ventilation. After establishing lung failure indicated by a Horovitz-quotient (PaO_2 / FiO_2) of less than 100mmHg we started automatic control. Subsequently the automation system was able to maintain arterial oxygenation and venous CO_2 at desired levels as well as adjusting ventilation to least possible protective ventilation

Contribution ID: 1171
12. Diagnostic and Therapeutic Instrumentation
12.07. Pulmonary systems

Motion based monitoring of respiratory mechanics in spontaneously breathing subjects

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Different research groups tried to correlate the surface motion of the human upper body with lung activity and respira-tory mechanics. Though accessing the respiratory mechanics via the upper body surface motion would be beneficial in different fields of medical applications, an optimal system with sufficient accuracy still does not exist. Nowadays the gold standard to measure lung function is spirometry where a mouth piece/ face mask is needed. But in some applica-tions these conditions are unconvenient for the patients, for example in case of sleep apnoe or during the respiratory analysis of athlets in high level sports.
By the synchronous measurement of optoelectronic plethysmography (OEP) and body plethysmography the surface motion could be mapped to human lung activity. A smart compression shirt was loaded with 64 OEP markers at differ-ent locations of the upper body and was worn by three different volunteers (two male and one female) during body ple-thysmography. Various respiratory maneuvers were performed to cover most of the common scenarious of respiration like normal or deep breathing, and to obtain additional lung parameters such as the total lung volume. Using the de-launey triangulation tidal volumes were determined in an accuracy with an adjusted R^2 of 99%. Further investigations using the delauney triangulation showed that a reduction of the number of sensors is possible, and therefore the com-plexity of the measurement system could be reduced considerably. The use of more than 20 sensors in the smart com-pression shirt did not improve the mean error of the measurement significantly and with 15 sensors the mean error of the tidal volume was less than 15ml, which is in line with the clinical guidelines of spirometry.

Contribution ID: 335
12. Diagnostic and Therapeutic Instrumentation

12.08. Sleep systems

Feasibility study of evaluation of therapeutic effect for sleep apnea syndrome using mental healthiness evaluated from voice

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Dealing with sleep apnea syndrome (SAS) is important because of its unignorable social burden, however current standard diagnosis requires a costly examination (polysomnography, PSG). Therefore, strong demand for easy screening methods for SAS exists. There is also a need for evaluation of therapeutic effect by continuous positive airway pressure (CPAP). Because CPAP requires adjustment of parameters (titration), or CPAP used with inadequate parameters will not improve a patient's symptom. Considering quality of life, evaluation of therapeutic effect requires monitoring of mental and physical conditions in daytime.
We already reported that mental healthiness evaluated from voice showed some correlation with severity of SAS. In this study we examined feasibility of mental healthiness evaluated from voice as an index of therapeutic effect by CPAP.
We recorded voices from patients of SAS when they were examined by PSG for first diagnosis and for titration of CPAP, just before and just after each examination. Then we analyzed the voices to evaluate mental healthiness of the subjects at the recording. The subjects were categorized into two groups; subjects of a group had not used CPAP before their titration, and subjects of another group had started their therapy by CPAP in advance of their titration.
As a result, direction of change of mental healthiness in the former group varied by subjects at their titration, while mental healthiness in the latter group showed tendency of improvement concerning its baseline. Within the latter group, the degree of improvement in mental healthiness tends to get larger as ratio of days used to whole term in CPAP usage before titration is higher.
This result suggests that mental healthiness evaluated from voice has a potential for an easy method to evaluate therapeutic effect for SAS, and that it is important for effective treatment to use CPAP as many days as possible.

Contribution ID: 774
12. Diagnostic and Therapeutic Instrumentation
12.08. Sleep systems

Validation of a wireless and portable EEG acquisition system with dry electrodes

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The Electroencephalogram (EEG) is the record of electrical cerebral activity. It is very important, in the clinical field is used commonly in sleep studies and to diagnose brain diseases and injuries. On the other hand, in research it is applied in brain computer interfaces (BCI), detection of drowsiness and fatigue, neurorobotics, etc.
The EEG signal has a low amplitude voltage (10μV to 100μV) and it main frequency range is between 0.1Hz to 100Hz. These characteristics make the EEG very susceptible to the noise produced by the electrode-skin interface, electromagnetic interference and movements in the

environment. It is also very affected by the artifacts introduced by other biosignals (EOG, ECG, EMG, respiration, etc).
In order to reduce noise in the acquisition and enable new EEG applications such as BCI and home polysomnography studies, we carry out the design and manufacture of a portable wireless system for acquisition of EEG signals. In this paper, we carried out the validation of the system designed by comparing signals acquired with commercial EEG equipment from the AKONIC and GRASS companies in the frequency and temporal domain. Different EEG recordings were obtained in 4 healthy subjects using standard Ag / Au cup electrodes and dry electrodes TDE-200 from Florida Research Instruments. Also, we performed the analysis of the acquired signals in eyes-closed and eyes-open resting condition.
We conclude that the designed system has low noise levels (CMRR> 80db) and a signal quality comparable to that of commercial equipment, which allows its use in research tasks and portable studies. On the other hand, we observe that the quality of the signal obtained with the dry electrodes is worse, due to the high skin-electrode impedance, but even so it is good enough to detect the eyes-closed and eyes-open resting condition, allowing a more comfortable use of the system.

Contribution ID: 110
12. Diagnostic and Therapeutic Instrumentation
12.09. Therapeutic systems

Synergistic antifungal activity of amphotericin B, essential oils, and low-frequency ultrasound on Rhizopus oryzae biofilm

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Fungal infections have gained clinical importance in the last decade. These serious and sometimes fatal infections are often associated with biofilm formation, which can increase resistance to antifungal agents when compared to free living colonies. This increased resistance makes it vital to test antifungal susceptibility using biofilms and not planktonic cells. Amphotericin B has been used as the first line of treatment for mucormycosis since the 1950's. However, it can have many adverse side effects including chills, fever, headaches, and muscle pain as well as the fatal syndromes of hepato and nephrotoxicity. These side effects, in conjunction with mortality rates of 97% (untreated) and 39% (treated with amphotericin B) demonstrate the need for alternative treatment options.
An intriguing treatment possibility is the combination therapy of amphotericin B with essential oils. The antifungal activity in essential oils originate from plant secondary metabolites, which can be classified by their phytochemical constituents. Another treatment possibility is the combination therapy of amphotericin B with continuous- or pulsed-wave low-frequency ultrasound (LFUS). LFUS treatment in combination with antibiotics has proven to be promising for biofilm removal and treatment of chronic rhinosinusitis. Ultrasound facilitates transport of antibiotics across biofilms, increases sensitivity of biofilm-growing bacteria to antibiotics, and could conceivably be used in tandem with any one or more anti-biofilm agents.
This study aims to investigate fungal biofilm disruption using LFUS alone, and in combination with amphotericin B and various essential oils, to determine if LFUS and essential oils enhance the effectiveness of current treatments. Essential oils from thyme, oregano, cinnamon, lemongrass and clove were chosen specifically due to their potent antifungal properties. To date, results from this study indicate that essential oils improve amphotericin B permeation through Rhizopus oryzae biofilms. Current experiments are in progress to determine if LFUS enhances essential oil and amphotericin B permeation.

Contribution ID: 820
12. Diagnostic and Therapeutic Instrumentation
12.09. Therapeutic systems

Plantar pressure measurements data transformation framework

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Pedobarography measurements of pressure distribution across the plantar surface and ground reaction force can be a source of valuable information for gait analysis in context of injury prevention, improvement in balance control, diagnosing disease, and sports performance analysis.
Different applications demand different measurement types: platforms in the gait labs or in-shoe smart soles, and also subsequent analysis approaches and methods applied vary with the application domain. Although the pedobarography is considered experimental, technology advancements in the field of Internet of Things, and popularity of collecting different data linked to human activities and behavior, are contributing to increase in pedobarography research. Comprehensive analysis of research results is impeded with the fact that data collected are not standardized, and different in volume and structure, thus not facilitating comparative analyses, as it is a case with other biomedical signals as ECG or EEG. In our research we have implemented software framework in Python language with objective to ed to extract relevant pedobarography information using foot segmentation and data aggregation algorithms. Implemented algorithms are generic and associated with specific parameters aimed to produce data sets with desired time and space pressure resolutions.
In order to validate our solution we processed data from public plantar pressure data set with foot profile matrix of dimension 56x128 and sampling rate of 100Hz and transformed it in data sets comprising pressure signals covering selected number of foot segments, down to one sensor signal. In the process of transformation we have retained information relevant for gait analysis and identification of gait cycle events. The proposed data transformation application can help in data sharing and comparison of different approaches in pedobarography.

Contribution ID: 1011
12. Diagnostic and Therapeutic Instrumentation
12.09. Therapeutic systems

Study of the induction of alpha brain waves through virtual reality therapy

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This research determines the interaction of visual and auditory factors, which are specifically designed in a controlled virtual reality environment. These influence the increase of the number of Alpha brain waves in order to induce body relaxation and a psychic state of serenity and calmness.
The clinical trial examined 62 previously prepared test subjects, in the facilities of the Tecnologico de Estudios Superiores de Ixtapaluca, in a room conditioned by the Department of Psychology with the following characteristics: external sound isolation (environmental), ambient temperature of 23 °C and armchair adaptable to the user.
The study was performed with an electroencephalogram (EEG) exclusively developed for this investigation. The control group that received the Virtual Reality Therapy (VRT) vs the comparative group (which was subjected to conventional psychological therapy) was examined. The data collected from both groups along the therapies were conjugated by software that compared the EEG patterns of each group. The study determined more favorable results for TRV than conventional therapy.

Contribution ID: 1012
12. Diagnostic and Therapeutic Instrumentation
12.09. Therapeutic systems

Computed Tomography-Based Thermometry for Temperature Mapping during Percutaneous Radiofrequency Ablation: An Ex-Vivo Study Using Bovine Liver

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Background:
Computed tomography (CT)-guided radiofrequency ablation (RFA) is a common hyperthermia therapy for hepatocellular carcinoma. The current post-ablation evaluation relies on visual inspection of the non-enhancing tissues on the contrasted CT images. This study aimed to investigate the correlation between CT number shift (dHU) and tissue temperature change (dT) in order to produce thermal maps for more objective assessment of ablation adequacy.
Methodology:
RFA was performed on ex-vivo bovine liver samples (n=15) using single RFA electrode (Covidien, Massachusetts, USA). Standard 3 cm liver ablation protocol (impedance-controlled mode, 12 min ablation followed by 15 min cooling) was used. Fiber Bragg Grating (FBG) optical laser sensors were placed inside the bovine liver at 5, 10, 15 and 20 mm away from the RFA electrode. A sequential CT scan was performed at 3 min interval throughout the ablation and cooling process. The CT numbers adjacent to the FBG sensors were measured and correlated to the tissue temperature measured by the sensors.
Results:
A significant decrease in the CT number during heating phase and subsequent recovery in CT number as temperature decreased during the cool-down period was observed in all samples. A negative linear relationship ($y = -1.6347x - 3.1135$, R2=0.780) between dHU and dT was observed. Spearman's rho correlation analysis showed a significant strong negative correlation ($r=-0.820$, $p=0.001$) between dHU and dT, with average 1.6 HU change per degree Celsius.
Conclusion:
The strong correlation between dHU and dT during RFA could be used to estimate tissue temperature based on the CT number measured during real-time CT-guided RFA. This approach would help the interventionalist in determining the ablation efficacy hence improving treatment outcomes.

Contribution ID: 1030
12. Diagnostic and Therapeutic Instrumentation
12.09. Therapeutic systems

Diffuse control system for the treatment of phobias using virtual reality

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In this research, Virtual Reality Therapy is used to treat the following phobias: arachnophobia, coulrophobia and acrophobia. The study groups was treated with sessions of gradual exposure to virtual worlds of 5 minutes per session, which were monitored by an electrocardiograph (ECG) and a portable electroencephalogram (EEG) systems that interpreted the Alpha signals of the frontal lobe, the Beta waves of the occipital lobe and signals of the heart. This process was applied to 10 people for each phobia.
Taking the bioelectric reactions of the brain and the heart as an input to a diffuse controller, we obtained the membership function (MF) that served as a mediator for the virtual environment in relation to the phobia. This was adapted to a relaxation environment with audio modules at a frequency of 20KHZ to induce beta-low waves and acquire positive progress in the results of each test subject.
This method of control allows to find the best environment for therapy according to the electrical reactions recorded by the ECG and EEG.

Contribution ID: 1372
12. Diagnostic and Therapeutic Instrumentation
12.09. Therapeutic systems

Independent lung ventilation – current state of the art

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The aim of this study is to analyze pros and cons of different ventilatory techniques for independent lung ventilation (ILV). ILV is typically employed for mechanically-ventilated patients, when there is a need to control the ventilation of each lung separately. It happens in numerous clinical situations (lung cancer, accidents, surgeries), while the mechanical properties of the lungs differ from each other considerably. In such cases, standard methods of ventilation (both lungs simultaneously) may lead to unwanted side effects like baro- and volutrauma, hypoventilation, etc. To avoid such situations, in the 70ies of 20th century, it was proposed to employ two synchronized respirators, each connected with one lung only, by double lumen endotracheal tube. It allows to separate and control ventilation of both lungs. However, the method is not commonly applied because of lack of respirators which may be effectively synchronized. Besides, setting ventilation parameters for each lung separately, while using two respirators, is a complex problem and requires a lot of effort from the medical staff. Equally important seems to be a significant cost of such a solution (two respirators) and a greater number of devices and tubes around the ventilated patient. In clinical practice there are also used other ILV techniques, such as e.g. intubation of endotracheal tubes with a blocker of selected bronchia. Nevertheless, this procedure requires the introduction to the lungs some mechanical elements, and on the other hand, it gives no possibility to control the ventilation effectively. Consequently, a common clinical practice is to use a conventional ventilation, which however, frequently leads to mentioned adverse health effects and serious damage to one lung. Therefore, better approach seems to be use a device with a ventilatory flow divider, that allows to set the ventilatory parameters for each lung independently.
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Contribution ID: 1386
12. Diagnostic and Therapeutic Instrumentation
12.09. Therapeutic systems

Use of magnetic probe for detection of hook-wire in the extracted tissue from breast biopsy

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Over past few decades, the breast conserving surgery to treat breast cancer has increased. Once the tissue is removed, it is sent to have an X-ray to check the margin. This process requires longer time and radiology expert to do so. In this paper, we propose a method of using a magnetic probe for detection of hook-wire localization. The hook-wire commonly used in breast cancer biopsy surgery is having magnetic property. In this paper, magnetic probe with a permanent magnet and hall sensor placed inside (Ookubo et.al, 2013) was used for detection of location of the hook-wire in three dimensional directions (Kuwahata et.al, 2017).
During the experiments, the hook-wire was placed inside the phantom which was like the extracted tissue from breast biopsy. The probe was moved around the phantom and every 30°magnetic sensitivity was recorded. This process was repeated for the distance till 50 mm in between the hook-wire and probe and the result was recorded.
The experimental data evidently had shown that magnetic sensitivity is the maximum when hook-wire's asymmetry part was facing the probe and as the distance or the angle changes, the sensitivity changes as well. Symmetry was found in the pattern of the sensitivity as the angle changes. Henceforth, variation due to hook-wire's asymmetric part was calculated for different distance from the probe and it was found that variation in magnetic sensitivity was increased as the distance between the probe and hook-wire increases.
We investigated the sensitivity obtained from the magnetic probe in presence of the hook-wire psensitivity varies with distance away from hook-wire and further experiments are required to be conducted in order to consider more practical situations during surgery. Hence, proposed probe can be used for locating the hook-wire in the extracted tissue.

Contribution ID: 1413
12. Diagnostic and Therapeutic Instrumentation
12.09. Therapeutic systems

Techniques to deliver inhalable drugs to mechanically-ventilated patients

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Techniques to deliver inhalable drugs to mechanically-ventilated patients have been used since the invention of modern mechanical ventilators. Although many new devices are available for ventilator-dependent patients, successful aerosol therapy still depends on thorough understanding of drug delivery techniques and their proper use. This work presents a short review on the types of aerosol devices currently available on the market and provides strategies for choosing the right strategy for optimal treatment of mechanically-ventilated patients.
Nowadays, nebulizers and pMDIs with in-line spacers are the devices which are most commonly used to administer inhaled medications during mechanical ventilation. Both nebulizers and pMDIs produce similar therapeutic effects in mechanically-ventilated patients. The therapeutic aim and availability of the drug generally determine which aerosol device to use. pMDIs are preferred for

inhalation therapy in ventilator-dependent patients because of problems associated with use of nebulizers and the advantages of pMDI, such as convenience, lower cost and decreased risk of damaging the flow sensor. However, only a few drug formulations are available as pMDIs. Therefore, they are mainly used to deliver bronchodilators and corticosteroids for ventilator-supported patients with airway obstruction, while nebulizers are used to deliver a variety of drugs such as bronchodilators, corticosteroids, antibiotics, prostaglandins, surfactant, mucolytic agents and other formulations that are not available for pMDIs.
Summarizing, there has been a significant progress in aerosol drug delivery for ventilator-dependent patients for the past several years. However, aerosol therapy during mechanical ventilation is still complex because of challenges associated with the aerosol devices, inhaled medications, device selection and administration technique. Therefore, there is a constant need to broaden knowledge on potential problems and factors influencing drug delivery to mechanically-ventilated patients and to seek new technical solutions to them.

Contribution ID: 1432
12. Diagnostic and Therapeutic Instrumentation
12.09. Therapeutic systems

A novel conception of coupling independent lung ventilation with inhalable drug delivery

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This work presents a description of a novel medical device, which will broaden the potential application of a single respirator. This medical device is going to enable performance of independent mechanical lung ventilation with or without simultaneous inhalable drug delivery to selected lung of one patient, as well as a conventional mechanical lung ventilation with or without simultaneous inhalable drug delivery of two patients. In both cases, only one respirator will be utilized. In numerous clinical cases (lung cancer, accidents, surgeries), independent lung ventilation with simultaneous drug administration by inhalation is desired. To obtain this goal, instead of using two respirators, the novel medical device as a ventilatory divider may be used, which allows to deliver ventilatory parameters (tidal volume, assistance pressure etc.) independently to each lung. This novel device will employ only one respirator. In addition, it will enable a dose control of therapeutic aerosol, delivered to one or two lungs. As a result, the device will maintain required amount of inhalable drug, declared by a medical stuff. Increasing the precision of inhalable drug delivery, only to the diseased lung, will reduce amount of the drug. Consequently, adverse health effects, which may appear after prolonged contact of therapeutic substances with health lung tissue, can be limited. Positive economic impact of the proposed solution will be the considerable treatment costs reduction of patients demanding independent mechanical lung ventilation with simultaneous inhalable drug delivery. This reduction will be expected in terms of required medical equipment (amount of utilized respirators) as well as patient monitoring time and effort devoted by a medical personnel. Finally, estimated cost of the novel developed device is planned to be several times lower than ordinary market price of a respirator.
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Contribution ID: 1672

12. Diagnostic and Therapeutic Instrumentation
12.09. Therapeutic systems

Tactile resonance technology and Raman spectroscopy for ex vivo detection of prostate cancer

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The most common cancer form for men is prostate cancer and a curative treatment is radical prostatectomy that can give erectile problems and incontinence. Thus, there is a need for an instrument that can provide decision support to the surgeon during surgery on the presence of cancer cells. A probe, combining Raman spectroscopy and tactile resonance technology, was used for detecting cancer in fresh human prostate tissue. Tactile resonance measures the tissue stiffness and Raman spectroscopy depicts the molecular content in tissue, both related to cancer. This study investigated the potential of the combined probe by testing its ability to differentiate between normal and cancerous prostate tissue ex vivo. Ten patients with prostate cancer took part in the study after giving informed consent. Each prostate was transported from surgery on ice to the pathology department where it was sliced in 1 cm thick slices. The centre slice was used for measurement. Measurements were done on about 20 sites on the surface of the prostate slice and was then transported back to the pathology department for histological analysis. The measurement probe was mounted on a motorized 3D stand in order to quickly scan the surface and at the same time register the position, that were also photographed with a CCD-camera ensuring that the probe measurements could be compared with the histological pictures. The statistical analysis was based on 148 sites with non-cancer and 40 sites with cancer. Using a generalized linear mixed model (GLMM) for the stiffness data resulted in statistically significant prediction of cancer ($p=0.004$). The Raman data was more difficult to analyse due to oversaturation but will be processed further. Although promising data for the stiffness parameter in detecting prostate cancer, more measurements including more prostates must be performed before the full value of the instrument can be established.

Contribution ID: 1808
12. Diagnostic and Therapeutic Instrumentation
12.09. Therapeutic systems

GPU-based fast imaging technique during boron neutron capture therapy (BNCT): Monte Carlo simulation study for S-PET operation

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Purpose of this study was to show the graphics processing unit (GPU) based fast prompt gamma ray imaging technique during boron neutron capture therapy (BNCT) using the Monte Carlo simulation. The 478 keV prompt ray is emitted from the reaction between boron and neutron as the single photon. To acquire the prompt gamma ray image in a single step, positron emission tomography with an insertable specific collimator for single photon detection (S-PET) was simulated. Prompt gamma ray images according to the treatment fraction were acquired almost immediately after the acquisition of projection data. We could confirm the application feasibility of the fast prompt gamma ray technique for BNCT.

Contribution ID: 1922
13. Micro- and Nanosystems, Active Implants, Biosensors
13.06. Keynote lecture

KEYNOTE LECTURE: Next generation multi-electrode array technologies for neuroscience and cardiology: challenges, progress and opportunities

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The academic and clinical impact of extracellular microelectrode-arrays (MEA) neuroengineering technologies exceeded all expectations. Today's brain-machines interface technologies (BMIs) enable to replace sensory organs, connect robotic parts to the PNS or CNS, link disrupted neuronal pathways, sense pathological firing patterns and generate stimuli to modulate them, inject drugs and suppress pain. Under in vitro conditions similar technologies are used to screen drugs using cultured human pluripotent stem cells taken from healthy subjects and patients to develop advanced personalized medicine.
Nevertheless, even the most sophisticated MEA used nowadays suffer from critical drawbacks such as poor signal to noise ratio, inadequate source resolution and instabilities overtime. These sever shortcomings are attributed mainly to the nature of the interfaces formed between living cells and the MEA devises.
In the presentation I will review the field focusing on novel breakthrough bioengineering approaches to generate the next generation neurons/cardiomyocytes-MEA interfaces to overcome the present shortcomings.

Contribution ID: 441
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

Determination of vascular contrast of hemoglobin within quantum dots using near infra read

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Introduction: Early detection and treatment of breast cancer may be helping to save the lives of patients. Many new techniques have been urban to detect breast cancer. One of them is the use of nano-particles for accuracy and early diagnosis after photo transfer. In this study, we used Quantum dot which can change light source transfer intensity. we have used two types of quantum dots with and without silver coatings to compare the degree of disparity in image quality.
Material and methods: quantum dots nano particles and four types of bloods with 0,1, 2, 4 hemoglobin concentrations used to simulate breast cancerous conditions. Nanoparticles with each concentrations of hemoglobin injected into the breast phantom including vessels and transmitted light intensity measured by power meter. Light source was near infrared At 635 wavelength.
Results: The intensity of the passing lights from hemoglobin concentrations of 0, 1, 2, and 4 were 9.31mw, 4.73mw, 3.36mw and 2.86mw, respectively in without nanoparticle condition. When the nanoparticles were blended with hemoglobin concentrations of 0, 1, 2, and 4, the intensity of the passing light with cadmium selenium quantum dot were 6.14mw, 3.34mw, 2.73mw and 1.92mw, respectively. And in the quantum dot of Cadmium Selenium with silver coating The intensity of the passing light are 1.22mw,1.83,mw,2.52mw and 3.31mw.
Conclusions: This study showed that addition of Cadmium Selenium with and without silver coating to different concentration of hemoglobin provides an effective decline on the light transferring

intensity. Also in cadmium selenium with silver coating, the intensity of light passing through the phantom increases with increasing hemoglobin concentration, which can produce a good visual contrast with the increase in hemoglobin.

Contribution ID: 513
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

Noninvasive blood glucose monitoring system with skin-like biosensors via electrochemical twin channels

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Diabetes is a worldwide chronic disease that threatens human health and lives. Millions of lives have been lost because of poorly controlled blood glucose. Regulated and continuous glucose monitoring of diabetes patients can provide better monitoring and control of blood glucose and prevent complications. Glucose monitoring with commercially available products relies on invasive lancet approaches. Repeated finger pricks not only hinder patient compliance because of pain but also result in skin irritation and bacterial infections. Currently, noninvasive glucose monitoring is not widely appreciated because of its uncertain measurement accuracy, weak blood glucose correlation and its inability to detect hyper/hypoglycaemia during sleep. Here, we present a strategy to design and fabricate a skin-like biosensor system for noninvasive, in situ and highly accurate intravascular blood glucose monitoring. The system integrates an ultrathin skin-like biosensor with paper-battery-powered electrochemical twin channels (ETCs). The designed subcutaneous ETCs promote intravascular blood glucose re-filtration at the arterial ends and reduce the re-absorption at the venous ends. As a result, the intravascular glucose is driven out of the vessel and transport it to the skin surface. The skin-like ultrathin (~3 μm) nanostructured biosensor, with high sensitivity (130.4 μA/mM), fully absorbs and measures the glucose, owing to its extreme conformability to the skin surface. We conducted in vivo human clinical trials which were approved by the PLA Air Force Hospital medical ethics committee. The noninvasive measurement results for intravascular blood glucose showed a high correlation (>0.9) with clinically measured blood glucose levels. The system opens up new prospects for clinical-grade noninvasive continuous glucose monitoring (CGM).

Contribution ID: 706
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

UWB platform for vital signs detection and monitoring

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In this paper, a non-invasive method for vital signs (heart and respiratory rate) detection and monitoring employing ultra-wide bandwidth (UWB) technology is proposed. Custom hardware and software platforms based on Decawave DW1000M module were developed, and used for data acquisition with high update rate. For validation of the proposed measurement model all supported channel settings were used.
In the experiment the developed transmitter and receiver modules were placed on the chest in various positions. The transmitter generates UWB ultra-short pulses with a minimum bandwidth of 500 MHz. The impulse responses of the UWB channel measured at the receiver contain

information about the heart muscle contraction and respiration. Since the heart and lung movements are periodic, they can be extracted from the received signals. We applied an algorithm for extracting features from the signal frequency spectrum, in order to estimate the heart rate (HR) and respiratory rate (RR). The obtained results have been evaluated by using reference commercial ECG and respiratory device.

Contribution ID: 721
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

Synthesis and Characterization of Fluorescent Gold Nanoclusters as Free Radical Scavengers

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Fluorescent Gold nanoclusters have raised great interest for unique quantum-sized fluorescent properties and more other applications are explored in recently. Here we observed the DHLA-protected gold nanoclusters can be an efficient free radicals scavenger similar to vitamin C. Fluorescent gold nanoclusters have narrow size distribution smaller than 2 nm and intensive emission ranging from 600-850 nm. The highly negative-charged surface of nanoclusters have also been characterized by gel electrophoresis, which comparing with large plasmonic gold nanoparticles. The anti-radical activities of fluorescent gold nanoclusters were determined using the free radical, 2,2-Diphenyl-1-picrylhydrazyl (DPPH*).The strong absorption band of its radical form of DPPH* at 515 nm disappeared upon reduction by the gold nanoclusters, accompanying with fluorescent quenching of gold nanoclusters. The interaction between the gold nanoclusters and free radicals was also investigated in this study. We envision that the detail investigation of fluorescence as well as the redox properties can be fundamental knowledge for future biosensor design. The research work was financially supported by Ministry of Science and Technology (MOST 105-2622-E-033 -008 -CC3 and MOST 106-2112-M-033 -008) from Taiwan (R.O.C.).

Contribution ID: 857
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

Fragile electrical potential along the roots of the elaecorpus ganitrus (“rudraksh tree”)

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Nowadays there is a huge crisis all over the world. Our traditional energy resources pollute the planet by generating large amount of fossil-fuels carbon dioxide (Co2) or they perish the nonrenewable resource. Consequently, there is need of new form of energy that is renewable and sustainable and most important that is easily available to all. After the rise of solar, wind and hydro electric power – hydro energy, here introducing a new type of sustainable energy, that is, energy from elaeoarpus-ganitrus (called “Roxb”) normally called “Rudraksha (Sanskrit rudrākṣa)” is a tree having great spiritual and medicinal-value in India and now all over the world. However, the interesting thing is that it can also generate feeble-current from its roots, and this current-potential can be further used as a power-source. We harvest the energy by embedding electrodes near roots and through biological amplifiers which allows the flow-of-electrons.

Circa~1.4 billion people do not have any access to electricity in all over the world. Due to this lacuna, people have no light to read, no phone to communicate and no computer to participate in the world. Because of this lacuna they are limited in their socio-economic development. Since renewable-forms-of-energies are always considered as clean sources-of-energies and their optimal-use minimize-environmental-problems, we try to find out better ways of energy production for our sustainable—development.
Sustainable development includes several goals which “affordable and clean energy” and “good health and well being” are the key-points we are focusing upon. After the rise of solar-energy, wind-energy hydro-power, we stepped forward for a new form-of-energy that is energy from living—plants. In the past, several investigators have proposed various models and developed some technologies based on this. It started with bio fuel cells, microbial fuel cells, photo-voltaic bio-fuel cells, bacterial-fuel cells and now the latest is plant –‘e’.

Contribution ID: 1178
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

Semiconductor ethanol sensor inducted with visible light

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In the past decade semiconductor gas sensors have been rapidly developed. The sensors are cheap, easy to use, are able to detect variety of different gasses and are stable. Because of this, the sensor gained widespread use.
Modern semiconductor sensors are based on MOS (metal–oxide–semiconductor) structure. Catalytic gas sensors are not appropriate for detection of inflammable gases, therefore more often the sensors are combined with UV radia-tion. As the results evaporated gases are adhered to the MOS surface and the gases current via the MOS transistor is influenced. However, UV light is potentially harmful for humans and the environment. In this paper a system is pre-sented that can pave the way towards gas analyzers that rely on visible spectrum light.
To carry out sensor response measurement a test setup consisted of gas chamber, LEDs (light-emitting diodes) power supply and semiconductor sensor was built. For reading and processing of an output signal purposes high-precision multimeter and Arduino controller were used.
Homogenous optical irradiation on the semiconductor surface was achieved by using of LED matrix. Different wavelengths (400nm, 440nm, 530nm, 600nm) were applied separately to find the condition for the best sensor re-sponse on gas sorption.
Sensor response to different irradiation wavelength (corresponding to emission energy) under constant flux, the sensor signal rising and relaxation time were measured. An output signal was recorded in zero-level emission and in presence of the ethanol.
Sensor response to the ethanol vapor was found for each applied wavelength and it is approximated by non-linear regression curve. Different signal rise and relaxation times were detected in dependence on wavelength.

Contribution ID: 1263
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

Can Textile electrode for ECG apply to EMG measurement?

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Electromyograms (EMG) are used as not only evaluation of muscle strength and muscle fatigue in medical but also those in sports science and biomechanics fields. To monitor EMG for long terms, it needs the expert knowledge to set electrodes on a certain muscle position every day. We assumed that this problem would be solved by developing textile electrodes. In our previous study, we revealed that the stretchable conductive elastomers (COCOMI) we developed enabled to measure precise electrocardiogram (ECG) waveform compared with conventional Ag/AgCl electrodes. However, EMG measurement has not been evaluated so far. Because EMG has a wider frequency band than the ECG, we need to be clear the electrode's characteristics for EMG measurement use. The purpose of this research is to clarify whether the developed electrode can adapt to the EMG measurement from the point of view of the wide frequency bands.
Healthy eleven adults were participated in our experiment as subjects (Age: 21.4±0.8: mean ± S.D.). Electromyograms were recoded from the tibial anterior muscle. EMG signal were collected by self-making myoelectric amplifier. The frequency band of the electromyogram amplifier was 30 to 500 Hz and sampled at 1 kHz. EMG was measured isometric contraction motion of the load 0, 1.25, 2.5, 3.75 and 5 kg.
As the results, the correlation coefficients between the load and the RMS of the developed electrode and the Ag/AgCl electrode were r = 0.918 and r = 0.912, respectively. This result showed that the development electrode can be used for muscle strength evaluation.

Contribution ID: 1291
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

The relationships between distance between the connectors of electrodes and the R-wave amplitude

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The monitoring of electrocardiogram and heart rate in daily life is effective way for the early detection of some diseases. Disposable electrode is mainly used for an electrocardiogram (ECG) measurement. Disposable electrode has some problems. For example, an electrode come unstuck because of sweat and it sometimes occur the skin irritation. To solve these problems, we developed a shirt-type ECG electrode as a device suitable for measurement in daily life. In our previous study, we have been demonstrated the possibility of the ECG measurement during exercise. However, the research on ECG measurement in water has not been done sufficiently. In water, the input impedance decreases due to the presence of water around the electrodes. So, the amplitude of the electrocardiogram is attenuated. The change in the input impedance is affected by the distance and size between the electrodes. The purpose of this study is to clarify the optimum distance between the connectors of electrodes in ECG measurement for in-water use. Experiments were conducted using four shirt type electrodes with different lengths of wring parts. The subjects were ten men. Measurements of electrocardiogram and input impedance on land and underwater were performed. The results showed that attenuation rate of the amplitude in water decreased by 1.58% on average as the distance between the connectors of electrodes increased. From this result, it can be said that it is useful for ECG measurement in water if the distance between the connectors of electrodes is kept away.

Contribution ID: 1477
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

Challenges and benefits of mobile sensors applications for the purposes of diagnostics, therapy and self-management

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In the era of miniaturization and big data we experience the stormly intrusion of various mobile devices in our everyday lives. The most expanding technology area is that of the portable sensors, called wearables. The marked volume is estimated at $ 20 billion in 2015 and more than $ 70 billion in 2025, with the major bulk attributed to the medical and health sectors. Portable sensors appear in various constructions and shapes with numerous purposes – from smart patches to physiological value-capturing and energy-generating t-shirts resp. from tracking the movement behaviour and rehabilitation after joint implantations to the support in the diagnosis, therapy and self-management of life-threating illnesses such as strokes. New ideas and devices are presented daily.
However, the application in the medical sector should be subjected to very strict rules. Firstly we have the regulations regarding data security and privacy, valid in the respective countries. Secondly it is necessary to acquire long-term data with reliable quality. The highest challenge here is to assess how mobile environments generate artefacts and modify the signals and to interpret data with very sparse or no context information. Not only reliable IT-infrastructures and platforms, but also very innovative analytical methods and their resource efficient algorithmization are required at this point.
This paper is dedicated to a deeper analysis of such implicit for the wearable technologies problems. Three different scenarios for the application of wearables for medical use outside, in hospital and in home environment are analysed and the challenges and benefits for patients and geriatric users are explored.

Contribution ID: 1605
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

Proposal of electrode for measuring glucose concentration in blood

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The article deals with the design of the electrode system and the appropriate measuring circuit for the measurement of blood glucose concentration, since the determination of the level of blood glucose is an integral part of many medical procedures for determining the state of the human organism. The aim of the concept is to create two functional devices with different design of the electrode system and to perform a series of measurements to verify the functionality and the data statistically process. There was used the principle of resistive sensing of non-electric quantities, so the designed systems using gold electrodes working as electrolytic sensors. The problem relating to the measuring circuit, which is the same for both electrode systems, has been solved by a microammeter which can convert the generated signal to a suitable measured electrical signal. The signal is formed by the reaction of glucose and enzyme, the resulting value being directly proportional to the glucose concentration. At this work, created systems fully meet specified conditions and requirements. The research confirmed the functionality of the designed units. On the basis of obtained data is possible to compare and evaluate the constructed electrode systems and to make the basis for further development in the subject matter.

Contribution ID: 1659
13. Micro- and Nanosystems, Active Implants, Biosensors

13.01. Biosensors

Immunoassay inside a capillary tube for point-of-care applications

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We developed a new assay system based on a simple structure of a capillary tube with its inner diameter of 400 µ-meter and length of 3 cm, targeting C-reactive protein (CRP) and cortisol in saliva. The salivary CRP and cortisol had been reported to increase when people are under stress. A standard method to measure stress is trier social stress test (TSST), in which an examinee undergoes a series of stress-inducing procedures in front of judging group. In a clinical environment urine cortisol is collected for a day. Compared with the TSST and urine cortisol methods, measuring salivary CRP and cortisol has advantage of objectivity of the result and simplicity of the measuring process.
In order to simplify the immunoassay, which is normally processed in a series of adding proteins followed by washing steps, horseradish peroxides (HRP)-conjugated antibody was installed at one end of the capillary tube, while capture protein was immobilized at the other end of, where the optical device is equipped. In order to analyze the immunoassay occurring inside a capillary tube, home-made optical detector was manufactured with a dimension of 10 cm x 10 cm x 3 cm. Also for the purpose of using in point-of-care (POC) environment, a pen-type optical detector was manufactured.
In the case of CRP, sandwich-type assay was used while for cortisol competitive method was utilized due to the small molecular weight of cortisol. In order to find out optimum method for immobilizing cortisol for competitive assay, 4 different types of surface chemistry were compared. The limit of detection (LOD) for CRP and cortisol were 0.1 ng/mL and 0.05 ng/mL respectively. The capillary assay system with its simple structure together with high performance is highly likely to meet the general requires for POC.

Contribution ID: 1661
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

A new optical, adaptable, high-resolution 3-axis sensor for medical device navigation

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The use of sensors as an interface between man and machine is becoming increasingly important in many biomedical applications. In particular, for people with physical disabilities such as spasticity, muscular dystrophy or spinal cord injury, using an input sensor (joystick) is often a problem since the range of motion in terms of force and stroke undergoes constant changes. A new optical, adaptable, high-resolution 3-axis sensor is presented which can replace standard joysticks in medical devices such as electric wheelchairs and may also serve for navigation in the aerospace or marine sector. A laser diode is affixed to a movable axis and projects and interprets a random geometric shape on a CMOS or CCD chip. The downstream microcontroller's software identifies the geometric shape's center, distortion and size, and subsequently calculates x, y, and z coordinates, which can be processed in attached devices. Depending on the image sensor in use (e.g., 6.4 megapixels), the 3-axis sensor achives a resolution of 1544 digits from right to left and 1038 digits up and down. Through interpolation, these values increase by a factor of 100. A movement carrier is positioned in a polymer sandwich which is capable of absorbing a large spectrum of forces upon it (approximately 1g to 5kg). The carrier and thus the axis of the sensor

can be moved by <1° in any direction. The sensor features excellent reproducibility in terms of deflection to coordinates and the ability to return to its neutral position very precisely. Further properties are the high level of protection against temperature, electromagnetic and radio frequency interferences, and the adaptability and adjustability to fit a user's range of motion with respect to stroke and force. This new sensor device thus aims to revolutionize sensor systems such as joysticks for wheelchair navigation in terms of safety, usability and adaptability.

Contribution ID: 1681
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

A contact-force regulated photoplethysmography (PPG) measurement platform

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Photoplethysmograpy (PPG) platform integrated with a miniaturized force-regulator is proposed. PPG is an optical measurement technique that can be used to monitor volumetric changes in the microvascular bed of tissue. The intensity of light reflected from or transmitted to the tissue is proportional the microvascular volume, thus being used for real-time physiological status monitoring such as blood oxygen level, heart rate, blood pressure and cardiac output. PPG signals, however, are affected by a number of factors, such as optical absorption and reflection of skin tissue, motion artifact, respiratory status, environmental light, etc. Over the other factors, the contact force between the PPG probe and the tissue greatly influences on PPG signals. The thermopneumatic actuator in the present PPG platform maintains the consistent contact-force between the PPG probe and the measuring site, consistent and stable PPG signal cab be obtained. We designed and fabricated the watch-type PPG platform with an overall size of 35 x 19 mm. In the PPG measurement on a radial artery wrist while its posture is changed to extension, neutral, or flexion, the contact-force regulation provides consistent PPG measurements where a variation of PPG amplitude (PPGA) and a variation of PPG interval (PPGI) show 7.2 % and 1.0 %, respectively. The proposed PPG platform can be applied to the biosignal measurement in various fields such as PPG-based ANS monitoring for estimating nociception, sleep apnea syndrome, and psychological stress.

Contribution ID: 1758
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

Designing sensitive and robust redox probes for use in pH microsensors

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An inexpensive and scalable solid state sensor based on a custom synthesized riboflavin derivative is described. Riboflavin, vitamin B2, plays a critical role in the maintenance of health but, in recent years, it has begun to attract considerable interest as a flexible component in the design of bioelectrochemical sensor systems. The redox chemistry associated with the flavin group has

been the principle spotlight and has been shown to act as a versatile electrochemical mediator in a range of chemical, enzyme and immunosensing and microbial systems. The detection of persulfate, glutamate, human chorionic gonadotropin and hepatitis C have exploited riboflavin as redox probe. In most cases, the riboflavin is either covalently attached to the base substrate through a chemical linker or has been electropolymerized directly at the electrode. The mechanism for the latter is poorly understood and there can be considerable degradation in the signal associated with the flavin moiety. Large overpotentials are typically required to induce polymerisation and it is conceivable that the redox groups are compromised during the aggressive oxidative process. A new flavin analogue which, in contrast to riboflavin, possesses an electropolymerisable phenolic substituent distinct from the core redox centre was prepared. The latter was polymerised on carbon fibres and yielded a redox active film which was sensitive to pH. The sensor exhibits Nernstian behaviour (55mV/pH) and was found to be robust to repetitive monitoring and can offer continuous real-time pH measurements. The micron dimensions of the probe could be suitable for sensing in a wide range of biomedical contexts and a critical evaluation of the system is presented.

Contribution ID: 1762
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

Evolving approaches to pH sensing: disposable dual probe redox sensors

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The ability to measure pH is a critical factor in biochemical laboratories but it is becoming increasingly common to perform such analyses at the point of care. While the glass membrane pH probe has long been a reliable instrument for the lab based assays, there is increasing interest in the development of minimally invasive probes / disposable systems that can meet the demands of direct clinical application. There has been extensive research into solid state potentiometric pH sensors with new nano structured systems based on MnO2, IrO2, WO3 and ZnO finding some application. Voltammetric approaches enabling indirect pH measurement have also garnered interest as an alternative methodology – particularly for complex biological samples. Such systems exploit the pH dependence of redox peaks intrinsic to a particular marker compound. The pH marker compound can be a diffusing solution based species, immobilised as a single layer, polymer bound or generated directly as an intrinsic species at the electrode surface. Irrespective of the nature of the material employed, obtaining the necessary selectivity whilst providing a cost effective sensing strategy remains a considerable challenge. The design of a new, disposable pH sensing system based on a screen printed carbon strip functionalised with a dual redox probe is described. A custom designed flavin derivative (10-(4-hydroxyphenyl) benzo[g]pteridine-2,4(3H,10H)-dione) is incorporated along with ferrocyanide. The flavin provides pH sensitivity while the ferrocyanide serves as an internal reference. The ability of the film to measure pH has been demonstrated and the robustness of the internal standard evaluated. The sensor has been shown to provide a Nernstian response and enables the production of inexpensive carbon based electrode systems without the need for silver-silver chloride reference electrodes.

Contribution ID: 1803
13. Micro- and Nanosystems, Active Implants, Biosensors
13.01. Biosensors

Sub-picomolar detection of E. coli O157:H7 bacterial DNA using Au nanoparticle decorated ZnO nanoflakes reinforced eggshell membrane as a platform

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The limit of detection (LOD) of a biosensor depends on the design and engineering of a platform which in turn aid in the detection of the target DNA. Traditionally, natural and synthetic substrates were used as platforms but there LOD were always in the nanomolar range. In this study, we have developed a three dimensional nanobiocomposite which will provide enhanced and homogenous loading of capture probes thus pushing down the LOD. Herein, gold (Au) nanoparticles decorated Zinc Oxide (ZnO) nanoflakes were impregnated on the microfibers of eggshell membrane (ESM) in order to fabricate a three dimensional hierarchical structure which would act as a platform for immobilization and detection of DNA. The three dimensional morphology of the platform was confirmed using FESEM analysis and this aspect of the platform would facilitate enhanced loading of capture probes, improving the limit of detection (LOD). ATR-FTIR & XPS analysis confirmed successful decoration of Au nanoparticles on the surface of ZnO nanoflakes which acts as a probe to bind the capture DNA. In order to detect the target E. coli O157:H7 DNA, complementary capture probes with thiol functionalization were immobilized on the fabricated 3D platform. On –chip hybridization of FAM tagged target DNA solution was performed in varying concentration to determine the LOD of the as fabricated platform. All the target DNA solutions were tested in quadruplicate and the results were analyzed using fluorescence microscopy. The intensities were compared using Image J software and it was observed that the LOD for the capture probe immobilized platform was pushed down to 1 pM concentration of target E. coli O157:H7 DNA. The three dimensional architecture of the sensor platform facilitated immobilization of large number of capture probes, thus providing a cumulatively enhanced signal to noise ratio even at sub-picomolar concentration of the target DNA.

Contribution ID: 83
13. Micro- and Nanosystems, Active Implants, Biosensors
13.02. Nanotheranostics

Magnetic resonance cancer nanotheranostics

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The magnetic spin effects can game important role in chemical reactions producing or destroying radicals (Turro N. et al., 1983). It is also known that magnetic resonance imaging can induce double-strand breaks in DNA through induction of reactive oxygen species by electromagnetic field (Jaffer H. et al., 2017). Based on the foregoing, we have developed the technology of magnetic resonance for cancer nanotheranostics. The magneto-mechano-chemically synthesized magnetic

nanocomplex that consisted of the iron oxide Fe3O4 nanoparticles and the antitumor drug doxorubicin with soft ferromagnetic properties was used with saturation magnetic moment ms=8.17 emu/g. The magnetic resonance system with magnetic field intensity 1.5 T was utilized. The study was carried out on C57Bl/6 mice with Lewis lung carcinoma. The temperature inside the tumor reached up to 37.1 °C after 15 min of the electromagnetic irradiation by the magnetic resonance system. The magnetic nanocomplex administration combined with the electromagnetic radiation in the magnetic resonance system showed maximal antitumor and antimetastatic effects. The electron spin resonance spectra have been used as diagnostic markers and recorded a change in the tumor redox state based on chemical species such as NO-FeS-proteins and ubisemiquinone. The technology of magnetic resonance nanotheranostics could possibly allow to improve the antitumor effect of chemotherapeutic agents in disseminated cancer treatment.

Contribution ID: 160

13. Micro- and Nanosystems, Active Implants, Biosensors

13.02. Nanotheranostics

Active control of micro objects in blood vessel by forming tempo-spatial variation of acoustic field

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Ultrasound is widely used not only for diagnostic purposes such as echography, but also for minimally invasive therapy, which has advantages in cost and size of equipment compared with X-ray CT or MRI. We are developing other applications using acoustic radiation force, which is a physical phenomenon to propel solid object in its direction of propagation, for physical delivery of drug or gene. We have ever reported our attempts for active induction of microbubbles and thin catheter. Also, we have attempted for active control of therapeutic cells for cellular immunotherapy, which are autologous bone marrow cells for decompensated liver cirrhosis and NK (Natural killer)-cells for self-hepatocytes. Since we have already introduced two-dimensional array transducers, we are able to design and produce the shape of three-dimensional acoustic field to adopt various conditions of blood vessel shape, flow velocity, and position arrangement of ultrasound sources. By forming tempo-spatial variation of acoustic field, which varies acoustic radiation force distribution temporally and spatially, we confirmed the controllability of a thin catheter, microbubbles and therapeutic cells, which were moved according to the variation of acoustic field. We found a remarkable induction efficiency according to the sound pressure of ultrasound exposures. Also we are going to discuss for further in vivo application through multiple bifurcations in blood flow.

Contribution ID: 194

13. Micro- and Nanosystems, Active Implants, Biosensors

13.02. Nanotheranostics

Protein nanocage: a versatile molecular carrier

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Protein nanocages can be engineered to tailor their functions as carriers for health (e.g. therapeutic and diagnostic agents), molecular electronic, and consumer care (e.g. cosmetics and food) applications. They are formed by the self-assembly of multiple subunits forming hollow cage-like structures of nanometer size. Due to their proteinaceous nature, the protein nanocages allow facile modifications on its internal and external surfaces, as well as the subunit interfaces designed for the intended applications. In this presentation, I will elaborate on utilizing protein nanocages loaded with metal as MRI contrast agent or with drug as drug carrier, modifying the interface of the subunits to render the nanocages sensitive to environmental changes, such as pH. Engineering of the external surface allows for the display of targeting ligands for selective accumulation on cancer cells as well as epitopes for modulating of the immune system. Leveraging on its natural or engineered metal-chelating activities, protein nanocages serve a dual function as a reaction container and as facilitator in the deposition of monodispersed platinum nanoparticles on graphene surfaces for electrocatalysis in fuel cells. Long-range electron tunneling across metal-loaded protein nanocages has also been shown to be promising in the development of memristive devices and future molecular electronics. In the most recent works, we show that the protein nanocages are surface active with an ability to stabilize Pickering emulsion with pH-responsive behavior. Titrating the protein ratio allows for formation of gel-like structures. In summary, protein nanocages are versatile protein-based materials whose properties are tunable for various applications.

Contribution ID: 447
13. Micro- and Nanosystems, Active Implants, Biosensors
13.02. Nanotheranostics

Study of the influence of the molecular weight of the polymer used as a coating on magnetite nanoparticles

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Designing coated magnetic nanoparticles for nanotheranostics applications, such as magnetic resonance imaging (MRI) contrast enhancement, hyperthermia, and drug-delivery, has been in the focus of scientific interest for the last decade. It is possible to provide significant improvement in dispersibility and magnetic properties by careful selection of different coatings on magnetic nanoparticles. Specifically, the adhesion of PEG with magnetite nanoparticles is used for the physical and chemical properties that are very useful for biomedical applications. It is necessary to study the relationship of amount of coatings to optimize the properties of nanotheranostics materials, such as magnetite nanoparticles. The aim of this contribution was to prepare the magnetite nanoparticles stabilized with various biocompatible polymer coatings such as polyethylene glycol (PEG) 400, PEG3350, poly(ethylene glycol) methyl ether (mePEG) 550, and mePEG2000 in order to elucidate the influence of the polymer type and molecular weight on the corresponding amount of coating. The X-ray diffraction (XRD) determined inverse spinel structure of magnetite nanoparticles, and field–emission scanning electron microscopy (FE-SEM) indicated the formation of quasi-spherical nanostructures with the final average particle size of 88–136 nm depending on the type of polymer coating. The bonding status of different polymers on the surface of the magnetite nanoparticles was confirmed by the Fourier transform infrared spectroscopy (FT-IR). According to TGA analysis polymer decomposition is taking place in two steps in the case of the higher molecular weight polymer coated nanoparticles. The first step presumably due to the breakdown of organic skeleton, and the second step is attributed to the complex degradation process. By considering these weight losses, the total amount of magnetite in samples is 95.32 %. The results of this study indicate the possibility of controlling the properties of theranostics nanomaterials, starting from the molecular weight of the polymer used as a coating.

Contribution ID: 714
13. Micro- and Nanosystems, Active Implants, Biosensors

13.02. Nanotheranostics

Study of Polycaprolactone / Polypyrrole Electrospun Fibers for BSA Protein Adsorption

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Since the development of technology, proteomics has become the focus of biomedical research, so the biotechnology and pharmaceutical industry put a lot of effort to develop economic, practical, rapid separation and high purity method to purify the protein. The purpose of this study is to develop a micro-reactor with conductive electrospun for protein adsorption by their high porosity and high specific surface area. Combined electrical properties of conductive polymers with the electrospun to enhance the adsorption efficiency of proteins. The electrospinning fibers were characterized by Fourier transform infrared spectroscopy. The morphology and fibers size were observed by scanning electron microscope and transmission electron microscope. The results show that the diameter of the electrospinning fibers can be reduced and become more uniform when the rotary collector at the higher speed. The highly aligned conductive fiber structure can help current transfer, thus significantly improving its conductivity. The fibers became hydrophilic form highly hydrophobic after polymerization of the polypyrrole (PPY) on the surface. The electrospun fibers were subjected to protein adsorption experiments after potential was applied, and the adsorption efficiency was increased compared to the electrospun fibers without the potential group. The adsorption capacity of bovine serum albumin (BSA) were increased by repeat adsorption method, and the maximum adsorption can above 90% after repeatable adsorption. In view of the above, the efficiency of protein adsorption can be improved by applying the electrospinning fiber potential.

Contribution ID: 992
13. Micro- and Nanosystems, Active Implants, Biosensors
13.02. Nanotheranostics

Simulation of a novel approach for quantitative floating magnetic nanoparticle reconstruction

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Magnetic nanoparticles (MNP) offer a large variety of promising applications in medicine thanks to their exciting physical properties. For most applications it is very important to know the quantitative spatial and temporal distribution of the MNP, e.g. magnetic drug targeting and magnetic biomarkers. We developed a novel approach to gather both information simultaneously. Beyond this we can also detect particle clots and binding states. The fundamental idea is a spatial excitation field applied to floating MNP instead of a temporal excitation field applied to static MNP distributions in classical magnetorelaxometry imaging. Our simulation setup consists of a blood vessel, a static magnet and several magnetic field sensors placed around the vessel. The magnet is designed to produce a homogeneous magnetic field within a specific region of the vessel, oriented perpendicular to the vessel wall. No magnetic field is assumed outside this region. A laminar flow and the associated velocity profile are assumed for the blood and thus for the contained MNP. When the MNP reach the magnetic field they align with the field. The observable alignment process shows different dynamics, depending on the binding state of the MNP (described by Brownian and Neél relaxation). Due to their physical properties, regarding unbound MNP, only relatively large ones can be detected, depending also on the blood flow rate. When all

MNP are aligned, the static net magnetic moment is measured. When the MNP leave the externally applied magnetic field, the MNP relaxate, which again can be measured. Combining the gathered temporal data we were able to reconstruct the two-dimensional magnetic particle flow profile, and to quantify the amount of MNP in unbound and bound state in our realistic simulations. Especially magnetic nanoparticle clots and MNP-beads could be detected.

Contribution ID: 1181
13. Micro- and Nanosystems, Active Implants, Biosensors
13.02. Nanotheranostics

Surface area of graphene governs its neurotoxic activity

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Due to their unique physicochemical properties, graphene and its derivatives are widely evaluated for biomedical applications. Currently, many studies have investigated the biocompatibility and toxicity of graphene in vivo and in vitro. Generally, graphene may exert different degrees of toxicity in animals or cell models when administered with different routes and penetrated through physiological barriers, subsequently being distributed in tissues or located in cells.
In this study, in vitro neurotoxicity of graphene with different surface areas (150 and 750 m2/g) was examined on dopaminergic neuron model cells, SH-SY5Y. SH-SY5Y cells were treated with graphene with different surface areas in different concentrations between 400- 3.125 µg/mL, and the toxic effects were tested by MTT, LDH, GSH, and MDA. Both sizes of graphene have shown increased cell viability in decreasing concentrations. Graphene with a surface area of 750 m2/g is more toxic than graphene with a surface area of 150 m2/g. Cell damage is increasing parallel with surface area. But after examining LDH results, it is concluded that the viability loss of the cells are not through membrane damage. Along with that, in the MDA test, neither of the two graphene types showed damage through this oxidative stress pathway. Besides, it has been determined that graphene with a higher surface area shows less oxidative stress than the control group, which indicates that graphene might have antioxidant effect. In the GSH test, GSH values were increased in cells exposed to both graphene species within the first 24 hours and 48 hours. This increase suggests that the graphene has an antioxidant effect on the cells.
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Contribution ID: 1617
13. Micro- and Nanosystems, Active Implants, Biosensors
13.02. Nanotheranostics

Nano-photo-thermo-radiotherapy of cancer cells using core-shell nanoparticles

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In this study, gold coated iron oxide nanoparticle (Au@Fe2O3) was synthesized in a core-shell structure. Photothermal and radiosensitization effects of Au@Fe2O3 nanoparticles were investigated on human mouth epidermal carcinoma KB cell. Cell death and apoptosis were measured to study the synergistic effects of nanoparticles in combination with both radiotherapy (RT) and photothermal therapy (PTT).

The KB cells were treated with Au@Fe2O3 (20 μg/ml; 4 h) and then received different treatment regimens of PTT and/or RT using laser (808 nm, 6 W/cm2, 10 min) and/or 6MV X-ray (single dose of 2 Gy). Following the treatments, MTT assay was performed to evaluate the cell survival rate and apoptosis was determined by flow cytometry using an annexinV–fluorescein isothiocyanate/propidium iodide apoptosis detection kit.
No significant cell damage or cell apoptosis from the individual treatment by laser was observed, while viability of the cells firstly incubated with Au@Fe2O3 and then exposed to the laser was significantly decreased. Additionally, our results demonstrated that Au@Fe2O3 is a good radiosensitizer at megavoltage energies of X-ray. When nanoparticles loaded KB cells were received both laser and X-ray irradiation, the cell viability substantially decreased. Following such a combinatorial treatment, flow cytometry determined that the majority of cell death relates to apoptosis.
It may be concluded that Au@Fe2O3 nanoparticle has a great potential to be applied as a photo-thermo-radiotherapy sensitizer for treatment of head and neck tumors.

Contribution ID: 1618
13. Micro- and Nanosystems, Active Implants, Biosensors
13.02. Nanotheranostics

Significant apoptosis induction in human glioma cells using gold-coated iron oxide nanoparticles: A benefit of nano-thermo-radiotherapy

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Recently, gold coated iron oxide nanoparticles (Au@IONPs) have received a great deal of attention in cancer therapy. In this in vitro study, we aimed to investigate the anti-cancer effects of Au@IONPs core-shell nanoparticles when applied in thermo-radiotherapy. Moreover, we investigated the level of apoptosis induced in U87-MG human glioma cells after receiving a combinatorial treatment regime (Au@IONPs + Hyperthermia + Radiotherapy).
The Au@IONPs nanocomplex was firstly prepared and characterized. Cytotoxicity of the nanoparticles (various concentrations; 4 h incubation time) was investigated on U87-MG cells and finally the concentrations of 10 and 15 μg/ml were selected for further studies. After incubation of the cells with nanoparticles, they received hyperthermia (43oC; 1 h) and then were exposed to 6MV X-ray (2 and 4 Gy), immediately. Following the treatments, MTT assay was performed to study the cell viability and flow cytometry was conducted to determine the apoptosis rate induced in each treatment group.
The results revealed that nanoparticles have no significant cytotoxicity at concentrations lower than 15 μg/ml. Also, we observed that nanoparticles at the mentioned concentration have modest enhancing effects in hyperthermia or radiotherapy. This is while the nanoparticles significantly enhanced the combinatorial effects of hyperthermia and radiotherapy. It was determined the majority of cell death is occurred due to apoptosis when all the nanoparticles, hyperthermia and radiotherapy are applied to the cancer cells.
It was concluded that Au@IONP nanoparticle can be considered as a good thermos-radio-sensitizer and significantly trigger apoptosis in cancer therapy.

Contribution ID: 1619
13. Micro- and Nanosystems, Active Implants, Biosensors
13.02. Nanotheranostics

Folate conjugated Au@Fe2O3 nanoparticle as a targeted radiosensitizer

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Here, we report the effect of folic acid (FA) as an active targeting agent on enhancing the radiosensitizing efficiency of multifunctional Au@Fe 2 O 3 core–shell nanoparticles (NPs).
Au@Fe 2 O 3 NPs were firstly synthesized, then modified with FA, and finally characterized. Radiation dose enhancement studies were carried out on both human nasopharyngeal (KB) cancer cells and L929 healthy cells. NPs at the concentration of 20µg/ml were firstly incubated with both cell lines and then different doses of 6 MV X-ray radiation were examined. The end effects were evaluated through MTT assay and flow cytometry using AnnexinV/PI kit.
The obtained characterization data showed that the synthesized NPs are spherical, with a hydrodynamic size of 33 nm and also the obtained data confirmed the successful conjugation of the NPs with FA. It was indicated that viability of KB cells has a much lower rate than L929 cells when the cells were treated by {FA- Au@Fe 2 O 3 + X-ray} regimen. Cell viability was even decreased significantly when x-ray dose was increased. Furthermore, flow cytometry studies showed that FA-targeted NPs induced higher level of apoptosis for KB cancer cells than L929 healthy cells.
In conclusion, our findings provide a new perspective on high ability of the synthesized FA-targeted Au@Fe 2 O 3 NPs which may be considered as an efficient radiosensitizer in the process of targeted radiation therapy of cancer.

Contribution ID: 44
13. Micro- and Nanosystems, Active Implants, Biosensors
13.03. Body sensor networks

ASICSENSE: A Highly integrated thin and soft sensor system for ECG and bioimpedance measurement

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In 2012, we have developed Sense, a commercial wearable sensor system for athletes which measures among other signals the transthoracic bioimpedance and a single-lead ECG with medical grade. The system has been acclaimed for its simplicity of use thanks to dry (gel-free) electrodes, its ease of integration (the system is made of two active sensors connected via one single unshielded wire) and the outstanding quality of the measured signals. The wearing comfort was however worth improving, mainly due to the height of the sensors and the hard plastic of their housings.
ASICSENSE is a highly miniaturized version of Sense. Each of the two ASICSENSE sensors has a height of 5.4mm (less than half as thin as Sense) and an overall volume of only 7mL. This substantial reduction in size has been mainly achieved by integrating the measuring functions of Sense in a single ASIC. The wearing comfort has been further improved by completely molding the sensors in soft, skin-friendly silicone.
To validate the ASICSENSE system, the sensors were placed on the left and the right side of the thorax of a male test person. A Sense system was put on in parallel to record simultaneously ECG and bioimpedance signals. The subject then executed a protocol which consisted of 3-minute blocks of lying supine, sitting, standing, walking (5km/h) and running (8km/h).
The ASICSENSE sensors were perceived as very comfortable to wear (barely noticeable). The quality of the ECG and the transthoracic bioimpedance signals is good and in congruence with the

signals recorded with Sense. The different ECG waves are clearly visible, even during walking and running. Qualitatively, the signals recorded with ASICSENSE are even less noisy than those recorded with Sense. One reason for this finding may be an improved skin contact of the soft, cuddly ASICSENSE sensors with the skin.

Contribution ID: 94
13. Micro- and Nanosystems, Active Implants, Biosensors
13.03. Body sensor networks

Development of a new method to monitor shoulder girdle motion for ballerina with shoulder impingement syndrome based on Smart-Shirt application

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Development of a new method to monitor shoulder girdle motion for ballerina with shoulder impingement syndrome based on Smart Shirt application.
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Shoulder injuries of professional ballet dancers occurred in 2,5% of cases in women. Movement faults and changes in muscle function of the scapula are associated with shoulder symptoms. Shoulder impingement is the most common cause of shoulder pain.
The ability to control the orientation and movement of the scapula is essential for optimal arm function and pain reduction in young adults with shoulder impingement signs
Smart garments find wide range of healthcare applications, including rehabilitation. One of the main parts of smart garment is the sensing system which can include one or several sensing elements for posture and joint motion control.
The aim of present research was to verify the possibility of using DAid Smart shirt, developed in collaboration of Riga Technical University and Riga Stradins University to capture and monitor shoulder gridle motion during motor control exercises (Worsley et al, 2013) and during training sessions out of laboratory environment for ballerina with type I or Inferior scapular dysfunction (Kibler classification). Another aim was to develop method of this Smart shirt using in addition to conventional physiotherapy to reduce right side shoulder girdle elevation.
As a monitoring tool specially, designed smart T - shirt had been used. Specifically, embodied textile strain sensors gave possibility to capture spatiotemporally motion, but acquisition system provided visual feedback on the screen of remote electronic device.
Conclusions: Designed DAid Smart shirt can be objective and convenient, tool for shoulder motion monitoring. For both: patient and physiotherapist. Thus, it can be used as effective assisting device to conventional physiotherapy for shoulder girdle motion control.

Contribution ID: 1145
13. Micro- and Nanosystems, Active Implants, Biosensors
13.03. Body sensor networks

Classification algorithm improvement for physical activity recognition in maritime environments

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Human activity recognition using wearable sensors and classification methods provides valuable information for the assessment of user's physical activity levels and for the development of more precise energy expenditure models, which can be used to proactively prevent cardiovascular diseases and obesity. The aim of this study was to evaluate how maritime environment and sea waves affect the performance of modern physical activity recognition methods, which has not yet been investigated. Two similar test suits were conducted on land and on a small yacht where subjects performed various activities, which were grouped into five different activity types of static, transitions, walking, running and jumping. Average activity type classification sensitivity with a decision tree classifier trained using land-based signals from one tri-axial accelerometer placed on lower back and leave-one-subject-out cross-validation scheme was 0.95 ± 0.01 while classifying the activities performed on land, but decreased to 0.81 ± 0.09 while classifying the activities on sea. An additional component produced by sea waves with a frequency of 0.3 - 0.7 Hz and a peak-to-peak amplitude of 1 m/s2 was noted in sea-based signals. Additional filter was developed with the aim to remove the effect of sea waves using least amount of computational power in order to create a suitable solution for real-time activity classification. The results of this study can be used to develop more precise physical activity classification methods in maritime areas or other locations where background affects the accelerometer signals.

Contribution ID: 294

13. Micro- and Nanosystems, Active Implants, Biosensors
13.04. Active implants

Long-term implantation of an optogenetic stimulation system in a liquid crystal polymer package

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Optogenetics is an emerging technique for neural stimulation using light. It has many potential clinical applications including new treatments for Parkinson's disease, chronic pain and restoring vision. However, extensive pre-clinical animal model work in the areas of safety and efficacy is required before optogenetic treatments will be seen in the clinic. We have developed a fully implantable optogenetic stimulator which addresses this need. This study presents an injection molded liquid crystal polymer (LCP) package for the optogenetic stimulation system including features for delivering light to the external stimulation site whilst providing protection against body fluids. The lifetime of the device is predicted using a model to be 95 days, where the lifetime is defined as the time before the internal relative humidity (RH) reaches 63 %RH; a conservative level at which the risk of corrosion is minimised. The addition of 6 % w/v desiccant in the enclosure extends the lifetime to 366 days. The predictions are supported by 12 LCP packaged optogenetic implants under bench test saline at 38 °C and continues to function after 12 months. Furthermore, 4 devices implanted in Parkinsonian rats remain operational after 9 months. The optical fibre protruding the package to deliver light is at risk of moisture ingress. A mass-gain experiment shows that plasma etching of the polytetrafluoroethylene (PTFE) optical fibre improves adhesion and decreases moisture ingress into the package. The results in this study demonstrate LCP's feasibility as a packaging material for long-term optogenetic implants. This methodology can design LCP packages for other active implants intended for chronic studies with designed lifetimes ranging from months to years, thus an attractive radiofrequency compatible alternative to titanium hermetic packages.

Contribution ID: 330

13. Micro- and Nanosystems, Active Implants, Biosensors
13.04. Active implants

Titanium surface microgrooves and controlled dual release of bone morphogenic protein-2 and insulin-like growth factor-1 enhance osteoblastic differentiation of cells

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Objective: We aimed to demonstrate that controlled dual release of bone morphogenic protein-2 (BMP-2) and insulin-like growth factor-1 (IGF-1) by catechol-functionalized adhesive polymer nanoparticles on microgrooved titanium (Ti) surface enhances in vitro osteoblastic differentiation of human mesenchymal stem cells (MSCs).
Methods: Human bone marrow-derived MSCs were commercially purchased. Photolithography was used to fabricate the microgrooved Ti, and catechol-functionalized adhesive nanoparticles were immobilized onto Ti surfaces for controlled dual release of BMP-2 and IGF-1. After characterizing the release profiles of BMP-2 and IGF-1 from the nanoparticle-immobilized Ti substrata, we assessed the alkaline phoshpatase activity and osteoblastic differentiation and confirmed the result by determining the expression of major osteoblast marker genes and proteins.
Results: We demonstrate that surface microgrooves and dual growth factor releasing system synergistically promote the osteoblastic differentiation of MSCs. Also, combined microgrooves and controlled release of BMP-2 and/or IGF-1 significantly promote the relative expression of major osteoblast marker genes and proteins. The overall significant correlations between the experimental results determined by the Pearson's correlation analysis verify the validity of our study.
Conclusion: The proposed combined surface of microgrooves and growth factor release system can be used as a strong osteogenic promoter on biomaterial surfaces.
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Contribution ID: 358
13. Micro- and Nanosystems, Active Implants, Biosensors
13.04. Active implants

Powering implants by galvanic coupling: a validated analytical model predicts powers above 1 mW in injectable implants

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While galvanic coupling for intrabody communications has been proposed lately by different research groups, its use for powering electronic implants remains almost non-existent despite it is an effective method, as we have recently shown in vivo (IEEE Trans. Neural Syst. Rehabil. Eng., 25(8):1343 – 52, 2017). Reluctance to use galvanic coupling for power may arise from not recognizing two facts. First, large magnitude high frequency currents can safely flow through the human body if applied as short bursts. Second, for a sufficient voltage drop across the two pick-electrodes, the implant can be shaped as a

thin and flexible elongated body. And, such implant conformation – a thin, flexible and light weight long body – is highly beneficial in terms of minimal invasiveness. Not only because it allows percutaneous deployment but also because it minimizes tissue damage. Here we will present a simple analytical model able to estimate the attainable power by galvanic coupling. The results obtained with the analytical model, which is in vitro validated in the present study, indicate that time-averaged powers above 1 mW can be readily obtained in very thin (diameter < 1mm) and short (length < 20 mm) elongated implants when currents which comply with safety standards (SAR < 10 W/kg) flow through the tissues where the implants are located. Interestingly, the model indicates that, for a given SAR, the attainable power is independent of the tissue conductivity and of the duration and repetition frequency of the bursts. This analysis indicates that galvanic coupling can be safely used to power very thin implants, avoiding bulky components such as coils and batteries. The power obtained by the injectable devices could be employed to use them as electrical stimulators and biosensors, among other applications.

Contribution ID: 361
13. Micro- and Nanosystems, Active Implants, Biosensors
13.04. Active implants

Advances in cardiac implantable devices:cardioverter defibrillators

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The first implantable defibrillator, ICD, implanted in 1980, following the pioneering work of Mirowski and Mower, was non-programmable, shocking above 170 bpm, with a short battery life and peri-operative mortality, p-op, of 9.7%. Transvenous leads were developed with a reduction in p-op to <0.5%, systems were programmable and anti-tachy and brady pacing were available. Patients started to outlive their leads highlighting the Achilles' heel of the system, the lead itself, with approximately 30% of shocks being inappropriate. The totally subcutaneous ICD, S-ICD, was developed (1) with no leads either on or in the heart, comprising an electrode with two sensing elements, a shocking electrode and pulse generator, PG. Whilst there have been no lead failures, pocket complications surprisingly increased restricting the uptake. An intermuscular technique (2) for PG placement, between serratus anterior and latissimus dorsi, has found favour, reducing the surgical complication 10-fold compared with truly subcutaneous placement. There are >33k patients implanted with the S-ICD worldwide. A recent advance in this area is the 44 F 'string defibrillator' (3), implanted subcutaneously, high right parasternal to left dorsal positions in an arc, caudally. This system does not have a conventional PG, but has sufficient energy for approximately 1 year, depending on usage, and can be recharged at a planned outpatient follow-up in 1 hour. First-in-man study was performed in 22 patients.
Home monitoring for pacemakers and defibrillators is now recommended as 'standard of care' primarily for patient safety but also for cost reduction. MRI compatibility of implantable cardiac device is rapidly increasing.
The area of implantable cardiac devices continues to move rapidly and the new technology, once proven, will improve patient outcomes.

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3. Neuzil at al. HRS 2017. Late breakers

Contribution ID: 403

13. Micro- and Nanosystems, Active Implants, Biosensors
13.04. Active implants

Advances in cardiac implantable devices: pacemakers

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The first implantable pacemaker, 1958, in a 43-year-old patient extended his life to 86 years. The device had shortcomings especially in terms of longevity and pacing ability. Rapidly advancing technology increased longevity and allowed atrial pacing with consequential new modes including epicardial left ventricular, LV, pacing for cardiac resynchronisation therapy, CRT by 1994. Device size, lead design and battery longevity have improved. The most recent drive has been to leadless pacing commencing with Nanostim, as proof of concept, followed by Micra for right ventricular, RV, pacing, however not complication free. There is reluctance to implant widely due to concerns regarding extraction. Advancement in CRT is much needed as approximately 40% of patients currently fail to benefit with conventional epicardial systems. A conventional pacing lead has been placed in the LV for endocardial stimulation via an atrial trans-septal approach and a ventricular septal approach. Patients have to be anticoagulated for life which is not the case with WiSE technology, an ultrasonic, leadless endocardial left ventricular, LV, pacing for CRT. This remains a first-generation product with a small, 12.7mm long, receiver placed on the LV free wall, but limited battery life, a requirement for a co-implant stimulating the RV and preferred 2 stage implant procedure. There are no technical restrictions to implementing a leadless CRT system combining the RV and LV leadless devices. A system has been developed to pace the heart without any leads or hardware on or in the heart. The lead is placed in tissue above the heart and connected to a small pulse generator on the sternum. Whilst not approved in any geography, this could be helpful in emergency and time compromised situations for temporary pacing. Self-powered pacemakers are in development using a piezo electric energy harvester.

Contribution ID: 419
13. Micro- and Nanosystems, Active Implants, Biosensors
13.04. Active implants

First steps towards an implantable electromyography (EMG) sensor powered and controlled by galvanic coupling

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In the past it has been proposed to use implanted electromyography (EMG) sensors for myoelectric control. In contrast to surface EMG systems, these implanted sensors will provide signals with low cross-talk. To achieve this, miniature implantable devices that acquire EMG signals and transmit them in real time are necessary. We have recently implemented and demonstrated in vivo (IEEE Trans. Neural Syst. Rehabil. Eng., 25(8):1343 – 52, 2017) prototypes of electronic implants for electrical stimulation which can be safely powered and independently addressed by means of galvanic coupling. Since these implants lack bulky components such as coils and batteries, we anticipate it will be possible to accomplish very thin implants to be massively deployed in tissues. We have also shown that these devices can have bidirectional communication capabilities. The aim of the present work is to demonstrate a circuit architecture for embedding EMG sensing capabilities in our galvanically powered implants. The architecture includes filters, a differential amplifier and an analog-to-digital converter (ADC) with 10 bits

resolution. The circuit was simulated using real EMG signals obtained from Physionet. These simulations showed that the EMG sensor is compatible with the galvanic powering scheme and does not affect the implant's ability to perform electrical stimulation. The system has a bandwidth of 960 Hz, an amplification gain of 60 dB, and noise measured at the input of the ADC of 830 μVRMS. The devices are conceived as flat implants to be located on the epimysium, with two electrodes at opposite ends for picking up EMG signals, for data uploading and for picking up the innocuous high frequency currents required for galvanic coupling. The proposed embedded EMG sensing capabilities will boost the use of these galvanically powered implants for diagnosis, closed-loop control in neuroprostheses, and man-machine interfaces as those used for prostheses control.

Contribution ID: 1391
13. Micro- and Nanosystems, Active Implants, Biosensors
13.04. Active implants

Monolithic implantable pressure switch for sensor recalibration

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Invasive long term monitoring of pressure can provide valuable insight to numerous physiological conditions. In the case of neurological disorders, outcomes of patients with hydrocephalus could be improved. However extended measurement periods is currently hindered by stability; in which the accuracy of the sensor drifts over time. Degradation is multifaceted, with contributions due to leakage, corrosion and changes in material properties. When a confident pressure reading is required, an invasive implantation surgery is necessary. Here we present a pressure switch, a fully implantable analog pressure sensing device for the in-situ recalibration of implanted MEMS pressure sensors. The device is a 1.5 x 1.5 x 1.0 centimeters, monolithic structure fabricated purely from Titanium grade II, and joined with minimal heating via hermetic laser welding. Recalibration relies on the pressure switch producing a characteristic pressure artefact, and reinstating the accuracy of the sensor being calibrated. The characteristic signal is produced from a change in switch compliance, due to deflection of a diaphragm against a physical barrier. A pressurization chamber constructed is capable of perturbing and monitoring fluid pressure, as influence by the pressure switch. Using the test rig, the long term stability of the pressure switches are investigated. Recalibration accuracy must be within +/-2 mmHg to meet standard NS28 for intracranial pressure monitoring devices. Looking forward, with miniaturization of the pressure switch, recalibration could be performed on pressure transducers implanted in other body compartments.

Contribution ID: 1395
13. Micro- and Nanosystems, Active Implants, Biosensors
13.04. Active implants

Effect of Parylene coating and human tissue on implantable titanium wire antenna

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Batteries are commonly used for powering implanted medical devices. However, batteries have limited energy storage capacity and lifespan, make up a large part of the implant's bulk and contain substances that are hazardous to humans.
Wireless power can be used as an alternative to batteries which overcomes these limitations, but current methods are of limited range (20-100 mm). We propose that wireless power transfer

around the 900MHz range can power an implant up to 2 meters away. This could enable implants for monitoring chronic conditions without requiring patient action.
A key component of the wireless power system is the antenna, which acts as a transducer converting transmitted electromagnetic waves into electric current. Current implanted antenna design focuses on making them smaller and more compact to minimise PCB footprints. Our design utilises space available from a co-located implant (hydrocephalus shunt) for a wire dipole antenna.
Antennas are affected by changes in the surrounding environment, especially when implanted due to variance in dielectric properties of human tissue. For biocompatibility, the material and coating of the antenna are also important factors. Our design uses titanium wires coated with Parylene, both biocompatible materials.
This work details the performance of a titanium wire dipole antenna operating at 915 MHz and the effects from the Parylene coating on antenna performance. The titanium antenna produced had a measured return loss of -15.1 dB, decreasing to -13.8 dB after coating. A detuning of 37 MHz was also measured.
A gel phantom is used to simulate the effect of implanting the antenna. The return loss decreased to -12.4 dB implanted in skin, with a detuning of 68 MHz. A difference in the radiation pattern was also measured.

Contribution ID: 60
13. Micro- and Nanosystems, Active Implants, Biosensors
13.05. Lab-on-chip/biochips

Rapid disease screening with a self-driving bead-based biosensor

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Diffusometry can be treated as a bead-based biosensor driven by Brownian motion. By functionalizing the particle surface with a specific antibody, the target antigens can be detected from the geometric change of the particle. The diffusometric immunosening features no washing steps, rapid detection, high flexibility, and high sensitivity. Up to now, the technique has been applied in many biomedical fields, such as monitoring of microorganism motility and diagnosis of diseases with biomarkers. Despite the mentioned advantages, the diffusivity change of the conventional diffusometry can be compromised at low abundance antigens because the proteins are much smaller than the capture particles in size. To lift the restriction, an improved diffusometric immunosensing technique by grafting additional gold nanoparticles to the capture particles to enhance the size changes was presented here. A diabetic retinopathy biomarker, TNF-α, was chosen to evaluate the proposed immunosensing technique. The limit of detection (LOD) was improved by at least 10 folds down to 10 pg/mL. In addition, a dichotomous method was also developed to enable rapid detection yet avoid the tedious calibration process. By comparing the diffusivity of an unknown concentration of target molecules with that of a reference solution, the relationship of concentrations between the two solutions could be explicitly determined in 1 min. The minimum distinguishable concentration reached as low as 2-fold higher or lower than the basal concentration. For a proof of concept in the diagnosis of diabetic retinopathy, tear samples were collected from four volunteers including three healthy subjects and one proliferative diabetic retinopathy patient. All of the data showed good agreements with the preset conditions. The technique eventually provides an insight to rapid diagnoses of diseases in the early stage.

Contribution ID: 88
13. Micro- and Nanosystems, Active Implants, Biosensors
13.05. Lab-on-chip/biochips

Automated patterning and manipulation of microbeads using a dual-beam 3D optical tweezers system

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Dynamic and precise arrangement of microbeads or individual cells offers great flexibility and potential as platforms for various biomedical applications such as bio-MEMS and Lab-on-chip. To realize such dynamic arrays, the precise and automatic micromanipulation techniques that allow us to transport the specified micro-objects and to dynamically immobilize them at the desired positions or pattern is essential. Optical tweezers is one of the most suitable techniques for the automated manipulation of biomedical materials in a range of micron sizes. In this research, for the automated assembling of dynamic microbead arrays in 3D workspace under an optical microscope, we developed a dual-beam 3D optical tweezers system with simple and inexpensive optical configuration using two electrically focus tunable lenses and two 2-axis scanning mirrors. Using the time shared scanning method combined with image processing techniques, this system could automatically trap a dozen microbeads at once for each laser beam; the resulting manipulation could perform the automated assembling of the arbitrary pattern in the true 3D workspace, without their collisions.
In the demonstration, twenty-two microbeads (2 microns in diameter) were automatically trapped at once, and subsequent collisionless micromanipulation arranged them into the specified patterns (e.g., alphabetic letters ‘TANAKA’). Each pattern was also able to morphing other patterns. In another demonstration, a dozen microbeads were automatically trapped to assemble two hexagons, and subsequent 3D motion-control of the hexagons was performed for the grasp and twist of a cell/micro-structure using the indirect micromanipulation method. These results demonstrate the possibility of the automated assembling and precise control of 3D complex structures as well as dynamic arrays by the optical method. It is expected that the developed system becomes an extremely useful micromanipulation tool for various biomedical applications, as compared to the conventional 2-beam optical tweezers. This work is partly supported by JSPS KAKENHI Grant No. JP15K05921.

Contribution ID: 144
13. Micro- and Nanosystems, Active Implants, Biosensors
13.05. Lab-on-chip/biochips

Microfabricated tools for quantitativebiology and precise medicine

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Understanding cellular individuality and interactions of cells in their microenvironments in a quantitative manner will provide valuable information to reveal the mechanism of diseases, immune defence and development of new treatment reagents and strategies for the diseases. Today one of the biggest limitation relies on the traditional methods and tools that we use to investigate the rare cells and specific events in biology particularly in immunology. Since these techniques are not adequate enough to be selective, specific and quantitative, the rare cells such as the metastatic or drug resistant ones or the events such as onset signs and symptoms of tumors and infections are being masked by majority of the cells or events in the population. Therefore, we cannot diagnose on time or provide successful treatment strategies for patients. As a consequence, our approaches might not target the right cells at the right time in the right place. To overcome these limitations, we might profit from engineering approaches and tools. We can

develop quantitative, accurate, reproducible and precise methods and use microfabricated tools to understand the nature and behaviour of cells in their microenvironment. The improvements from microfabricated tools in conjunction with microscopy might provide statistics from large numbers of single cells, short assay time, less sample consumption, less waste production, quantitative and reproducible data, single-cell resolution images, high-throughput, spatio-temporal tracking and real-time assays, etc. Herein, we will present recently developed microfabraicted tools to understand cellular individuality and interactions within their microenvironment.

Contribution ID: 336
13. Micro- and Nanosystems, Active Implants, Biosensors
13.05. Lab-on-chip/biochips

A single-cell microarray chip for separation, analysis and retrieval of different types of cancer cells

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Single-cell analysis is an important for understanding of higher levels of organization of tissues and organisms, and could reveal therapeutic approaches to correct flaws in the organization. Flow cytometry is one of the most conventional technologies in the single-cell analysis research field. However, this system is inadequate for evaluating spatial localization of protein expression in single cells. And it is not sufficiently sensitive to detect extremely low ratios of residual target cells among a major cell population. For example, it is quite difficult to detect rare cancer cells, circulating tumor cells (CTCs) in the peripheral blood of metastatic cancer patients using flow cytometry. Therefore, a single cell separation and analysis system requires a technology that provides high throughput and accurate evaluation under low stress conditions.
In this study, we have developed a new single-cell microarray chip for the separation, analysis, and retrieval of adherent and non-adherent cultured cancer cells. The single-cell microarray chip is made of polystyrene with over 60,000 microchambers of 10 different size patterns (31–40 μm diameter). A sample of suspension of adherent carcinoma (H1650) and non-adherent leukocyte (CEM) cells was placed onto the chip, and single-cell occupancy of these different cancer cells was determined to be approximately 80%. This was achieved by controlling the chip design and surface treatment. Analysis for the expression of proteins specific to different cancer cell types was performed on the single-cell microarray chip by multi-antibody staining. Furthermore, we succeeded to retrieve positive single cells from the microchambers by a micromanipulator system. Therefore, this system shows the potential for easy and accurate separation and analysis of various types of single cells.

Contribution ID: 853
13. Micro- and Nanosystems, Active Implants, Biosensors
13.05. Lab-on-chip/biochips

Rapid Determination of Bacterial Antibiotic Resistance Using a Hybrid Optofluidic-Electrokinetic Chip

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Conventional methods for bacterial quantification in the blood typically require 24-48 h for culturing owing to the poor detection limit of turbidity meter or plate counting. We propose an integrated chip that combines AC electrokinetics for concentration of bacteria and photoelectrical sensing technologies for rapid on-chip quantification of the concentrated bacterial cells. The proposed chip concentrates rare bacteria to form an aggregate in a small sensing area for on-chip quantification via measuring changes in electric current density in a thin photosensitive film. The current-voltage (I-V) response shows a good relationship between bacterial cell density and the change rate in I-V response, and reaches a low LOD in the order of 104 CFU/ml. The sensitive quantification of small numbers of bacteria provided an assay for rapid determination of bacterial antibiotic resistance in a short incubation period. The different growth rates of oxacillin-sensitive (OSSA) and oxacillin-resistant (ORSA) Staphylococcus aureus were successfully detected on the hybrid chip. The antimicrobial susceptibility testing of OSSA and ORSA was rapidly performed via quantification of differences in bacterial cell density after only 3 h of incubation with antibiotics, thus significantly reducing the required incubation period from 24 to 3 h. In addition, the low detection limit of the ACEK-OE platform makes it a promising method to detect bacterial antibiotic resistance using a lower initial bacterial cell density of 105 CFU/mL that is 2-3 orders of magnitude lower than that of conventional AST methods. Therefore, approximately 6-12 h of waiting time for blood culturing could be saved to shorten the total analysis time. This study could rapidly improve antibiotic selection protocols in intensive care units.

Contribution ID: 1537

13. Micro- and Nanosystems, Active Implants, Biosensors
13.05. Lab-on-chip/biochips

DNA microfluidic biosensor using NV centre charge state detection in diamond

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We present a novel biosensor for detection of charged biomolecules based on the nitrogen vacancy (NV) colour centre charge state detection in diamond integrated to a microfluidic biosensor. The innovative detection concept is based on combination of the electrochemical device combined with the NV centre optical readout. This design of the biosensor allows to set the potential promoting a specific electrochemical reactions and the NV centre can detect the product of such reactions by using the charge detection principle. Additionally the electrochemical readout can be used for verification of processes of specific molecules such as DNA by working as impedimetric sensor.
The diamond device consists of highly boron doped diamond electrode capped with a thin (20 nm) NV centres containing layer. The device is then covered by polydimethylsiloxane (PDMS) flow cell and transparent indium tin oxide (ITO) coated glass slide. Switching of the NV-/NV0 centre population is detected by photoluminescence (PL). We set first the charge state occupation of NV centre by applying a bias voltage between source and gate electrode. The charge state of NV centres then react to electrochemical potential of the environment. To demonstrate the label free optical detection the diamond surface is covered with a monolayer of strongly cationic charged polymer polyethylenimine (PEI) that modify charge state of near surface NV centres to NV0 or NV+ non-PL state. Immobilization of negatively charged DNA molecules on the sensor surface changes NV centres charge states to preferably NV- and the PL is detected by confocal microscopy. The biochemical reactions in the microfluidic channel are controlled by electrochemical impedance spectroscopy.

Contribution ID: 1551

13. Micro- and Nanosystems, Active Implants, Biosensors
13.05. Lab-on-chip/biochips

Modelling of NV diamond quantum chip with electrical readout of spin states

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Hybrid photoelectric readout of NV spin states opens important promises for developing scalable NV diamond quantum chips for room temperature operation. Here we present a detail modeling of photoelecric quantum chip
using all device components and incorporating MW antenna design, electrode layout configuration as well as laser light profile. Further on, based on solving the rate equations combined with the expression for 2 –photon and 1-photon ionization and the laser power density we discuss the chip operation performance as well as S/N ratio for quantum readout operation.

Contribution ID: 1706
13. Micro- and Nanosystems, Active Implants, Biosensors
13.05. Lab-on-chip/biochips

A microfluidic-based lung cancer organoid culture platform

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There are several approaches available that can be used to predict the efficacy or toxicity of anticancer drugs on cancer cells. In general, 2D culture systems have the advantages of being relatively low-cost, high-throughput capability, and convenient. However, 2D culture system is often associated with the loss of specific tissue architecture intact, mechanical and biochemical features, thus making them relatively poor systems to predict therapy responses for certain diseases, like cancer. Here we present a one-stop microfluidic device enabling both 3D lung cancer organoid cultures and drug sensitivity test directly on a chip. Our platform is based on siphon effect-driven micropump controlling fluid inlet of the microfluidic chip. The microfluidic system provides an environment for cancer organoids that mimics physiological relevant conditions including oxygen and nutrient supply. Lung cancer organoids can be rapidly proliferate and exhibit disease-specific characteristics in our microfluidic platform. Cisplatin and Etoposide, the standard regimen for lung cancer showed increased apoptosis induction when increased concentration of the drugs in the reservoir. Intriguingly, cells in LCOs core regions could survive, while cell death occurred in outer regions. We envision that this system may provide important information to guide therapeutic approaches at preclinical level.

Contribution ID: 1786
13. Micro- and Nanosystems, Active Implants, Biosensors
13.05. Lab-on-chip/biochips

DNA melting with Surface Acoustic Waves reveals new mechanical effects towards room temperature DNA amplification for Lab-on-a-Chip diagnostics

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Background:

There is increasing demand for miniaturised, portable medical diagnostic devices. Increasing costs coupled with a lack of infrastructure, trained technicians and funding are requiring new, innovative solutions to perform efficient disease diagnostics.
Lab-on-a-Chip technologies such as surface acoustic waves (SAW) produced by interdigital transducers (IDTs) on piezoelectric devices can contribute to both, reducing the cost and training required to diagnose disease, by integrating new microfluidic functions. SAW is particularly versatile and can be used to heat, move and mix droplets, and amplify DNA (by PCR) in a finger-prick volume of blood.
We show that the mechanical actuation of SAW enables a decreased melting temperature of DNA, relaxing constraints on DNA-based diagnostics, opening the way to better, faster systems.
Methods:
IDTs and Resistance Temperature Devices (RTDs) were fabricated onto lithium niobate and glass coverslips, further patterned with hydrophilic silane for DNA attachment surrounded by hydrophobic silane self-assembled layer.
LabView was used to actuate surface acoustic waves at MHz frequencies, measure temperature and collect data from the biochemical reactions using a fluorescence reporter sensitive to DNA double helix structure. We also used total internal reflection (TIRF) microscopy to observe fluorescence in a molecular layer on the surface of our devices.
Results:
DNA melting temperatures of varying GC content and length, in a range of buffer salt concentrations, were examined using SAW, and TIRF.
SAW resulted in lower than expected melting temperatures of DNA (10%+/-1%), TIRF experiments gave further insight as to streaming interactions with the fluorescence reporter molecule.
Conclusion:
This research improves the understanding of surface acoustic wave – DNA interactions for lab-on-a-chip diagnostics and opens up the possibility of carrying out complex enzymatic reactions usually requiring stringent temperature cycling, at room temperature, with relaxed constraints. This will provide the opportunity to develop point-of-care devices for medical diagnostics.

Contribution ID: 1796
13. Micro- and Nanosystems, Active Implants, Biosensors
13.05. Lab-on-chip/biochips

Self-assembled polysulfone nanoparticles using microfluidic chip

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Nanotechnologies are about to induce profound changes in our society and may have a tremendous impact in various fields spanning from information technology to biomedical sciences. However, scientists have yet to devise strategies to harness the matter at the nanoscale, more specifically, to fabricate nanomaterials with high-throughput and precise control. Self-assembly processes are viewed as the best way for the fabrication of three-dimensionally- structured nanomaterials such as those involved in biomedical sciences. Nanomaterials designed to deliver active drugs or genes into target cells, or to label specific tissues for bioimaging, are undoubtedly of great importance for the diagnosis and the treatment of diverse pathologies, and will translate into substantial economic benefits. Here, we have devised a microfluidics-based strategy for the control of the self-assembly of polysulfone nanoparticles. The strategy relied on nanoprecipitation performed by hydrodynamic flow focusing. It allowed us to lower the time required for mixing polysulfone in N-methylpyrrolidone with pure water in such a way that the coil-globule transition occurred faster than the typical aggregation time. We obtained nanoparticle hydrodynamic diameters smaller than 100 nm, which is a significant improvement compared to recent nanoprecipitation methods developed without microfluidics. We have also demonstrated the continuous encapsulation of fluorescent dyes within polysulfone nanoparticles. The resulting nanoparticles may find applications in biological imaging since polysulfone is a fully biocompatible material and sizes below 100 nm allow the nanoparticles to diffuse through cell membrane without disturbing the cell normal functions.

Contribution ID: 98
14. Neuroengineering, Neural Systems
14.10. Keynote lecture

KEYNOTE LECTURE: Neural implants for therapy and enhancement

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Starting with a quick discussion of Biohacking, implants connected into the brain can be employed both for therapeutic purposes and also for enhancement. Here a look is taken at present and future uses of cochlea implants, visual neuroprosthetics and deep brain stimulation. Also considered is the possibility of growing brains by culturing neurons and through a process of embodiment thereby learning about structures and possible treatments. Finally the BrainGate implant is investigated not only for therapeutic uses but also for the enhancement of human brain and nervous system functioning, in order to create new, improved, forms of communication and to extend the human nervous system via a network, thereby allowing for an individual's brain and body to be in totally different places.

Contribution ID: 303
14. Neuroengineering, Neural Systems
14.01. Brain physiology and modelling

A hypothesis: episodic memory is engraved in the associative cortex by the parahippocampal/ hippocampal neurons as a pointer-type mnemonic system

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It is confirmed that episodic memory is formed in the brain by some neurological function of hippocampal and parahippocampal regions, but detailed physiological mechanism of such function still remains a great mystery. To understand how memories of several items composing some event or episode are individually engraved in some cerebral regions, how these engrams are bound or serially ordered in the regions and how these are transformed to long-term stable memories are the key for us to cope with the amnesia in various senile degenerative processes. It is generally agreed that memory engrams are microscopically located on synapses with strengthened bindings in some cerebral cortices or hippocampal regions. Through a wide scope of recent electrophysiological findings using animal brain slices, a possible mechanism for effective enhancement of synaptic bindings in the associative cortices by the aid of parahippocampal/hippocampal neurons is emerged. Under the hypothesis, neurons in the regions may function as "pointer-type" mnemonics which control not only formation of engram in associative cortices but also binding of associative multiple engrams and transfer of engrams for the purpose of transformation into long-term memories.

Contribution ID: 517
14. Neuroengineering, Neural Systems
14.01. Brain physiology and modelling

EEG spectral asymmetry is dependent on education level of men

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Abstract— An objective indicator based on the asymmetry of electroencephalographic (EEG) signal spectrum has been shown promising for screening of population to discover occupational stress. However, the factors other than stress affect the EEG spectrum. The aim of the current study is to investigate the role of education level on EEG signals' band relative powers. For this purpose, 18- channel resting eyes-closed EEG was recorded from 30 men having Bachelor or higher education (tertiary education) and 16 men declaring to have lower, upper or post-secondary education (secondary education). For those signals, relative theta, alpha, beta and gamma powers were calculated. The results indicated increase in relative gamma power for the subgroup of men having tertiary education compared to the subgroup of men having secondary education in all channels. The increase was statistically significant in left frontal, left central and right frontal regions ($p<0.01$). No significant alterations were revealed in other relative band powers. Higher relative gamma power of men having higher level of education could be related to the higher cognitive load in their everyday life, as widespread gamma activation has been previously demonstrated during cognitive tasks. The results of the current study suggest that the level of education is one of the factors to be taken into account in EEG based evaluation of occupational stress or mental disorders. Keywords— EEG spectrum, relative gamma power, education level.

Contribution ID: 651
14. Neuroengineering, Neural Systems
14.01. Brain physiology and modelling

Vessels as possible source of intra- and extracellular iron in globus pallidus

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Iron imbalance seems to be important aspect associated with occurrence of neurodegenerative disorders. It is believed that cerebrovascular insufficiency plays a major role in pathogenesis of such diseases. Ten samples of globus pallidus collected post mortem from recently deceased patients with no clinically pathological symptoms of neurodegenerative disorders were processed by standard histological methods. Iron was detected in ferric form (Fe^{3+}) by Pearls staining and in form of ferritin by immunohistological staining in both forms – heavy chain (FHC), light chain (FLC) and serum albumin. Ferric iron was detected in both intra- and extracellular space with higher occurrence in 100 μm – 1 mm proximity of blood vessels in mostly globular shapes. Intensity, shape and size varied from light globular deposits to dark 5-25 μm globes concentrated into 1-2 mm clusters. In vessels the Fe^{3+} was often detected as globular 7-20 μm deposits by its walls or as thick dark layer within intima adventitia. Occurrence of FHC and FLC was not as tightly bound to proximity of vessels as Fe^{3+}. The size of iron deposits varied from 1-2 μm singular deposits to 2-3 mm wide clusters visible by bare eye. There were found correlations between FHC and Fe^{3+}. All procedures were conducted in accordance with the Declaration of Helsinki.

Contribution ID: 1102

14. Neuroengineering, Neural Systems
14.01. Brain physiology and modelling

The role of theta phase synchronization in memory encoding

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Theta synchronization is a general phenomenon when task demand increases or more efficient information processing is required. Significant theta synchronization has been found during memory encoding, especially for successful memory encoding. However, there is a paucity of research literature related to theta synchronization with different memory load conditions. In this study, theta phase synchronization elicited during performing a verbal span n-back task, which has five different memory load conditions (3, 4, 5, 6, and 7-span), were examined in 16 adult volunteers. Agree with previous studies, theta synchronization was significant in all load conditions. The high-performance group achieved more regular theta phase synchronization than the low-performance group. Meanwhile, items on the two ends of a series induced much stronger theta power than middle-items. This is because the first few and last few items are more likely to be remembered easier. Furthermore, we found that a theta power peak was shown at the end of memory encoding for low load conditions (3, and 4-span). However, this phenomenon is not obvious under high load conditions. Because different load tasks were executed randomly, the subjects had no idea how many items were enrolled in a trial. This results reveal that theta phase synchronization may not be induced passively. It may generate actively in memory encoding.

Contribution ID: 1692
14. Neuroengineering, Neural Systems
14.01. Brain physiology and modelling

Self-propagating waves in the hippocampus by ephaptic coupling

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Recent studies have shown that waves propagating in the hippocampus generated in the presence of 100um of 4-Aminopyridine can be observed to propagate at about 0.1m/s with synaptic transmission and gap junction blocked. Diffusion is too slow (0.001m/s) to explain this phenomenon and action potential propagation is too fast (0.3- 2m/s). The only other possible mechanism is ephaptic coupling and computer modelling of hippocampal networks with cells connected only by electric field coupling confirm that the mechanism is feasible with endogenous field amplitudes. The model also predicts that varying the distance between cells should slow or accelerate the speed of the propagating event. This prediction was confirmed by hippocampal slice experiments whereby osmolarity is varied. Model simulations also predict that applied electrical fields perpendicular to the longitudinal axis of the dendrites should also affect the speed or even block the propagation. This prediction was also confirmed with DC fields varying between 1 and 5V/m. Additional in-vitro experiments carried out with solutions known to mimic slow wave sleep also generated non-synaptic self-propagating waves at similar speeds. These results therefore support two conclusions: 1) endogenous electric fields have sufficient amplitude to excite neurons and underlie the self-propagation of waves and 2) neural transmission in the brain can take place in the absence of synaptic transmission and can be sustained by a novel mechanism: ephaptic coupling.

Contribution ID: 689
14. Neuroengineering, Neural Systems
14.02. Blood brain barrier & pharmacokinetics

Bacterial cellulose scaffold as a basal lamina for two dimensional blood brain barrier model

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Blood Brain Barrier (BBB) is the most important structure that protects central nervous system (CNS) from harmful substances, pathogens, neurotransmitters and plasma proteins. Apart from this important task, it is responsible for providing nutrients to the cerebral cells and maintaining chemical and ionic homeostasis of CNS. However, this structure hinders the treatment of CNS diseases by preventing the entrance of drugs that can stop/slow the progression. Since drug pathways of the BBB has great importance for the design and manufacturing of several types of drugs targeted for CNS disorders, pharmaceutical researchers use in vitro experimental BBB models frequently; but tissue engineered BBB models, where a carrier scaffold mimics the basal lamina are very limited. Correct selection of the tissue scaffold is necessary for a realistic BBB model since it is unequivocally accepted that extracellular matrix play a part in cell-cell interactions as a regulator. In this study, it is aimed to produce a tissue engineered realistic in vitro BBB model that allows monitoring cells and high throughput testing. Moreover, it is aimed to achieve a structure that supports cells like basal lamina of the BBB by using bacterial cellulose (BC), which has not been used for BBB models before. Within the study, human primary brain microvascular endothelial cells are seeded on the luminal surface and human primary astrocytes are seeded on the abluminal surface of BC. Junction proteins will be monitored by immunofluorescence staining method to observe the formation of tight junctions, and transendothelial electrical resistance measurements will be performed to evaluate BBB functionality.

Contribution ID: 1435
14. Neuroengineering, Neural Systems
14.02. Blood brain barrier & pharmacokinetics

Cardiovascular effects of blood brain barrier disruption induced by mannitol infusion vs. photodynamic treatment

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Blood-brain barrier (BBB) is of great interest particularly in terms of brain drug delivery in the treatment of brain tumours. Currently, clinical use is limited to mannitol infusion and other methods for BBB opening are in preclinical development including focused ultrasound (FUS) and photodynamic treatment (PDT). A method involving BBB disruption (BBBD) by intra-arterial

mannitol infusion is used in Oulu University Hospital, Finland, in treatment of primary CSN lymphoma (PCSNL) patients, providing first efficient treatment for otherwise lethal disease.
In the BBBD PCSNL treatment, however, very strong fluctuations in blood pressure, heart rate and vascular pulsations can be observed. In addition, recently we showed that mannitol infusion generates a strongly lateralized direct current change in electroencephalogram (EEG) response and a prolonged increase in the oxy/deoxyhemoglobin ratio in the human brain cortex. However, it is not yet clear what is the isolated role of BBBD in the observed signals. To study this, particularly the effect of BBBD on cardiovascular loading, we conducted experiments on rodent using two different methods to induce BBBD: mannitol infusion and PDT.
For monitoring cardiovascular signals we used a small photoplethysmography (PPG) sensor placed on head and an acceleration sensor on chest. Gathered signals, when processed, can provide estimates for such as heart rate, breathing rate, vascular pulsation and blood pressure propagation time (pulse transit time) between chest and head. In results, we compare responses of these signals and discuss the cardiovascular effects when using mannitol vs. PDT. (635 nm 15-20 J/cm2 with 5-aminolevulinic acid administration (20 mg/kg iv)).
Experiments were carried out in mice weight 20 g (n=40) using stereotaxic technique and anesthesia (ketamine (100 mg/kg, ip) and xylazine (10 mg/kg, ip). To evaluate the opening BBB we used the histological, MRI, confocal, two-photon, spectrofluorometric analysis of BBB permeability.

Contribution ID: 68
14. Neuroengineering, Neural Systems
14.03. Motor learning and neural control

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This paper presents the results of a designed automated system for prediction of metabolic syndrome (MetS) based on machine learning techniques. This study includes two approaches in creating this automated system, artificial neural networks and regression algorithms. For system design, 780 samples collected from Healthcare Institutions in Sarajevo over a two year period were used. Our results show that single-layer-feedforward neural network architecture provided the best classification results. The sensitivity of this system was 96.3% and specificity 95.1%. The average accuracy of feedback neural network architecture was 94.2% while regression algorithms performed better than feedback neural network architecture, but proved not to be as efficient as feedforward neural network architecture for this purpose. This study emphasizes the importance of automated systems for diagnosis of diseases and offer review of similar systems used for metabolic syndrome diagnosis.

Contribution ID: 1075
14. Neuroengineering, Neural Systems
14.03. Motor learning and neural control

Single-channel movement prediction in stroke and cerebral palsy patients from single-trial EEG

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Single-channel movement prediction in stroke and cerebral palsy patients from single-trial EEG
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Background: Recently, brain-computer interfaces (BCIs) have been suggested for inducing neural plasticity (underlying mechanism of motor recovery) in neurological movement disorders. The plasticity induction is maximized when relevant somatosensory feedback is timely correlated with a movement intention (MI). Thus it is crucial that MIs can be detected from the EEG and in response trigger an external device that can provide the timely correlated somatosensory feedback (e.g. FES). The aim of this study was to show that MIs can be detected from different types of patients using only a single EEG channel to reduce the setup time.
Methods: Twelve healthy, six stroke and eight cerebral palsy subjects performed 50-100 dorsiflexions of the ankle while EEG was recorded from Cz. The EEG was bandpass filtered from 0.05-45 Hz and divided into two epoch-types: “MI” (0-2 s prior the movement onset), and “idle” (4-6 s prior the movement onset). Epochs exceeding ±100 µV were removed from further analysis. Following features were calculated: average power in 5 Hz bins were calculated from 0-45 Hz (without overlap), correlation between an MI template (extracted from training data) and all epochs, slope fitted to the entire epoch, difference between mean amplitude of the first and second half of each epoch, and mean amplitude of the last 500 ms of each epoch. The features were classified using a linear discriminant analysis classifier through leave-one-out cross-validation.
Results and conclusion: Classification accuracies are presented as mean±standard deviation across subjects: 0.69±0.03 (cerebral palsy), 0.84±0.06 (stroke), and 0.93±0.06 (healthy). Conclusion: MIs can be discriminated from the idle state using only a single channel, but it should be noted that it is offline analysis with a priori knowledge of the movement onset.

Contribution ID: 253
14. Neuroengineering, Neural Systems
14.04. Brain computer/machine interfaces

Comparison of brain computer interface for selecting menus that utilize EEG and NIRS

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Introduction: The authors attempted to develop an environment control system for severely handicapped bed-ridden patients. In this study, for selecting menus of a system called the brain computer interface (BCI), utilization of electro-encephalograms (EEGs) and near infrared stereoscopy (NIRS) is tested and compared.
Methods: The input EEG signal is filtered by a 13-Hz low-pass filter and averaged 15 times. Finally, wavelet analysis is conducted to automatically detect the existence of P300. The features of this NIRS signal detection system are that the current strength of Oxy-Hb can be provided as a feedback to the subject in the form of a bar graph, Oxy-Hb signal is approximated by a spline, and support vector machine is used to determine the menu selection. Five characters “a,” “b,” “c,” “d,” and “e” are illuminated on the menu. The subjects are instructed to count the number mentally for the EEG system and concentrate for the NIRS system when the target character appears. For the EEG system, the illuminating time is varied as 0.25, 0.5, 0.75, and 1.0 [s], whereas for the NIRS system, it is fixed to 10 [s]. Ten sets of discriminating experiments are performed by eleven and seven subjects for the EEG and NIRS systems, respectively.
Results: The average success ratio of the EEG system with an illuminating time of 0.25, 0.50, 0.75, and 1.00 [s] is 0.65, 0.75, 0.80, and 0.68, respectively. The average success ratio of the NIRS system with and without feedback is 0.53 and 0.34, respectively, thus displaying a significant difference.

Conclusions: In general, in comparison with the NIRS system, the success ratio of the EEG system is higher and its required time for one set of experiments is shorter when the illuminating time is less than 0.50 [s].

Contribution ID: 616
14. Neuroengineering, Neural Systems
14.04. Brain computer/machine interfaces

Functional state assessment of an athlete by means of the brain-computer interface multimodal metrics

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Functional state assessment of an athlete by means of the brain-computer interface multimodal metrics
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Purpose. The estimation in real time of the functional and mental state level for the athlete during the loads is essential for management of the training process. New multimodal metric, obtained by means of the brain-computer interface (BCI), is proposed.
Materials and Methods. The paper discusses the results of the joint usage of data from EMOTIV EPOC + mobile wireless headset. It includes motion sensors (accelerometers) and EEG channels. Based on this data a new multimodal metric is proposed.
Approbation of the metric was performed for functional-stress studies on two groups of 10 volunteer subjects, including evaluations of the TOVA-test and the target-test.
To study characteristics describing the different functional state of a person, a series of experiments was performed using the EMOTIV EPOC + headset. Each experiment consisted of five stages:
• Functional rest (300 seconds)
• Test 1 (180 seconds)
• Functional load (180 seconds)
• Test 2 (180 seconds)
• Aftereffect (300 seconds)
Results. The joint application of different signals modalities allows to obtain estimates level of attention for these functional studies. That allows to generate a new metric. The results obtained in this work allow us to characterize the functional state of a person with an accuracy of about 92%.

Contribution ID: 701
14. Neuroengineering, Neural Systems
14.04. Brain computer/machine interfaces

A Hybrid BCI-based Environmental Control System Using SSVEP and EMG Signals

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To develop an home environmental control system based on Brain–computer interfaces (BCI) for paralytics’ active and assisted living, we designed a control method combining Electroencephalography (EEG) and Electromyography(EMG) signals. In this paper, EMG signals

from occlusal movement are integrated into a BCI based on steady-state visually evoked potentials (SSVEP) to build up a hybrid BCI, which can help to improve the performance of the system.
For the interface, we designed one main menu and five interfaces for household devices, the main menu conclude five targets, which represents electrical wheelchair, nursing bed, television, telephone, curtains and lights respectively. The timeline of a single trial can be divided into two stages: a target-selection stage and a target- confirmation stage. In the target-selection stage, each 3 second flickering at different frequencies were used to elicit SSVEPs corresponding to different command. In the target- confirmation stage, particular occlusal pattern was used to confirm the target. Canonical Correlation Analysis (CCA) was used to clarify SSVEP, and threshold method was used to detect the occlusal pattern. Besides, EMG signals of occlusal movement also were used as the “switch” of the system to avoid the idle state and returning from device interface to main menu.
As the online results obtained from ten subjects, we successfully employed a BCI smart home system which did not require extensive training with an overall classification accuracy of 96.8%. With the EMG for target- confirmation, the false operation ratio is reduced to 0.0% which improve the security of the system. Combining SSVEP and EMG will effectively enhance the performance of the whole environmental control system.

Contribution ID: 1170
14. Neuroengineering, Neural Systems
14.04. Brain computer/machine interfaces

Comparison between Support Vector Machine Polynomial and RBF kernel performance in recognizing EEG signal of dyslexic children

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Dyslexia is seen as learning disorder that causes learner having difficulties to recognize word, read fluently and write accurately. This is due to deficit in the region associates with learning pathways in the brain. Activities in this region can be investigated using electroencephalogram (EEG) which has high temporal resolution. This paper describes the classification of EEG signal during writing word and non-word from normal, poor dyslexic and capable dyslexic children. In this work, Discreate Wavelet Transform (DWT) with Daubechies order of 2 (db2) based features extraction was applied to the EEG signal and the power is calculated. Differences between beta and theta band measured from the EEG features produced by learning activities were explored. Multiclass Support Vector Machine (SVM) with polynomial and RBF kernels was used to classify the EEG signal and their performance was compared. It was found that SVM with RBF kernel accuracy in recognizing normal and capable dyslexic children is 91% which is higher than that produced by polynomial kernel.

Contribution ID: 1205
14. Neuroengineering, Neural Systems
14.04. Brain computer/machine interfaces

Applying weightless neural networks to a P300-based brain-computer interface to train social attention

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P300-based Brain Computer Interfaces (BCI) are one of the most used types of BCIs in the literature that make use of the electroencephalogram (EEG) signal to convey motor and nonmotor commands to the computer. The efficiency of such systems depends drastically on the ability of correctly identifying the P300 wave in the EEG signal, an event-related brain response to an infrequent stimulus. Due to high inter-subject and inter-session variability, single-subject classifiers must be trained every session. In order to achieve fast setup times of the system, only a few trials are available each session for training the classifier. In this scenario, the ability to learn from few examples is crucial for BCI performance and so the use of weightless neural networks (WNN) is promising. The WNN are fast to train since they are based on Random Access Memories and only require the forward step to compute. Despite its potential value, there are no studies, to our knowledge, applying WNNs to P300 classification. Here we compare the performance of a WNN (Wilkes, Stonham and Aleksander Recognition Device - WiSARD) against the state-of-the-art algorithms when applied to a P300-based BCI for joint-attention training in autism (Amaral et al.,2017). We adapted the WiSARD algorithm to consider prior class frequencies in its prediction, to deal with the unbalanced characteristics of this classification problem. Feature extraction was performed using the procedure of Pires et al. (2011). Our results show that the WiSARD performs at least as good as its competitors, and often outperforming them. We also perform an analysis of the WiSARD hyperparameters, and show that most cases better results are achieved with smaller memories. This study demonstrates that the adoption of this type of classifiers might help increase the prediction accuracy of P300-based BCI systems, and should be a valid option in future studies.

Contribution ID: 1390
14. Neuroengineering, Neural Systems
14.04. Brain computer/machine interfaces

Ensemble learning in EEG-based brain computer interfaces with applications to attention-based spellers

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Brain-Computer Interfaces (BCI) are systems in which the electrical activity of an animal brain becomes the main controller of an external electronic device capable of reading and processing electroencephalographic (EEG) signals. One early application of such systems is the attention-based spellers utilizing the P300 visually evoked potential in a framework known as the oddball paradigm. In this paper, we propose novel variants of machine learning model ensembles in addressing the task of P300 detection and attended target recognition in attention-based speller systems. Proposed ensembles adopted Bootstrap aggregation (Bagging) of calibrated support vector machines as well as data-driven learners. The latter is dominantly represented by Convolutional Neural Networks (CNN) with several variants including Inception, Xception, and Interleaved Group Convolutions (IGC). The proposed models are evaluated on two publicly available EEG dataset developed specifically for BCI applications and published in two successive public contests, namely BCI competitions II and III. The proposed models consistently outperform all previous works on the same datasets and show the highest 5- and 15-trial recognition rates of 76.5% and 98.5%, respectively, for both subjects in the second dataset jointly. Additionally, we introduce the first study on inter-subject training, reaching 30%-40% recognition rates, under similar training protocols. We further investigate the effect of reducing training data on the performance of the proposed models showing possibilities of reduced training time for a target recognition rate.

Contribution ID: 247
14. Neuroengineering, Neural Systems
14.05. NeuroProstheses

Cutaneous electric stimulation as an information input channel

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Cutaneous electric stimulation can elicit percepts by stimulating peripheral sensory nerve endings. This input channel could be used to provide real-time prosthetic feedback to a person, such as the gripping pressure of a prosthetic hand, or transmit signals to a person, such as an alert of imminent danger. Our objective is to investigate the percepts of cutaneous electric stimulation, their thresholds, and spatial differentiability around the upper arm.
With ethics approval, we applied bipolar monophasic square pulses of 200µs duration to eight pairs of gel electrodes (Ø16 mm) at regular positions around the right upper arms of four participants (2f, 2m, age 33±6y) at rest. By gradually increasing the amplitude we determined the amplitudes at which the pulse was (1) just noticeable, (2) drawing attention to itself, and (3) generating intolerable perceptions. In a separate experiment, we varied the distance between electrodes from 25 to 50 mm center-to-center in 5 mm steps.
Participants reported a short touch perception in the area of the electrodes for the first two thresholds. The lower perception thresholds were at 1.8±0.41mA (mean±std), the attention thresholds at 3.8±1.4mA, and the intolerance thresholds (pain or muscle contraction) at 8.5±4.4mA. While the first two thresholds were homogeneous around the arm, the intolerance thresholds were higher (10.3±4.7mA) at lateral to posterior sections and lower (6.3±3.5mA) at medial to anterior sections. For short distances (25 mm) the perception was consistently located between the electrodes, while for large distances (50 mm) the perception was dominant under one electrode. The transition interval varied considerably across subjects.
A robust amplitude window for tolerable percepts that draw the attention of the person could be found in all participants in the lateral to posterior sections of the upper arm. Short electrode edge distances of approximately 1 cm lead to consistent perceptions.

Contribution ID: 281
14. Neuroengineering, Neural Systems
14.05. NeuroProstheses

A computer simulation test of feedback error learning-based FES controller for controlling random and cyclic movements

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Feedback control can be useful for restoring movements by functional electrical stimulation (FES). However, it has not been used practically. Some of possible reasons are considered to be in designing a feedback FES controller and its parameter determination, and nonlinear characteristics with large time delay in muscle response to electrical stimulation, which are different between subjects. This study focused on realizing a hybrid controller consists of feedback and feedforward controllers for FES control based on feedback error learning (FEL) using fuzzy feedback controller. Artificial neural network (ANN) was trained by off-line learning to develop the inverse dynamics model (IDM) of electrically stimulated musculoskeletal system, which can be used as a feedforward controller. Although FEL can realize feedforward FES controller for each subject, target movement patterns are limited to those similar to patterns used in the training. In this study, FEL-FES controller was tested in learning both of random and cyclic movements under 4 different training

data sets: 1) sinusoidal patterns, 2) random patterns generated by low pass filtered random values, 3) using both the sinusoidal and the LPF random patterns alternatively and 4) random patterns that consisted of 3 random sinusoidal components. In computer simulation of knee joint angle control, ANN was trained by the FEL under the 4 types of target angle patterns and unlearned sinusoidal and random angle patterns were controlled by the trained ANNs. Training with sinusoidal patterns caused delay in controlling random angle patterns, and training with the LPF-random patterns could not control properly sinusoidal patterns. Using both patters alternatively could not improve delay in controlling random patterns. Random sinusoidal component patterns could control adequately both of random and sinusoidal angle patterns. The computer simulation tests suggested that random sinusoidal component patterns could be effective for learning various movement patterns for FES.

Contribution ID: 212

14. Neuroengineering, Neural Systems

14.06. Transcranial magnetic and electric stimulation

Intracortical facilitation to enhance effects of transcranial magnetic stimulation

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Objective: We applied transcranial magnetic stimulation (TMS) to produce maximal short-interval intracortical facilitation (SICF) via synchronization with TMS-induced cortical I-waves using paired biphasic pulse stimulation. This enables individually optimized SICF to enhance TMS effects for cortical mapping and neuromodulation therapies with repetitive TMS.

Methods: Nine healthy volunteers were recruited. Optimal stimulation site for dominant hand first dorsal interosseous (FDI) muscle was mapped using navigated TMS (Julkunen et al., NeuroImage 2009). Then, motor threshold (MT) was determined (Kallioniemi et al., Brain Stimulation 2017). Motor evoked potentials (MEPs) were measured for baseline using single-pulses. Paired-pulse TMS was delivered with interstimulus intervals ISIs between 1.2-4.3 ms at 0.1 ms intervals in random order. MEPs were measured from cortically adjacent FDI, APB and ADM muscles from the dominant hand at each ISI. 3-peak Gaussian model was fitted to MEP(ISI)-curves to characterize latency, amplitude and width of each peak. The study was approved by the local ethics board.

Results: The average peak latencies were 1.36-1.40 (1st peak), 2.75-2.81 (2nd peak) and 4.29-4.33 (3rd peak) depending on the muscle. There were differences between muscles in the peak amplitudes ($p = 0.001$), with greatest SICF effect in the targeted ADM (6.12-7.45mV). There was no significant difference between the three peaks in amplitudes. There was a significant difference between the peaks widths in all muscles ($p < 0.001$), 2nd peak being the widest.

Conclusion: The individual SICF I-wave interaction characteristics were successfully determined revealing differences in peak features with all subjects exhibiting SICF in the I1-wave. For enhancing motor TMS effects through SICF, optimal ISI for I-wave timing for individual subjects should be determined using a model such as the Gaussian model.

Contribution ID: 222

14. Neuroengineering, Neural Systems

14.06. Transcranial magnetic and electric stimulation

Organization of the functional primary motor cortex revealed using sulcus-aligned mapping

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Question: Navigated transcranial magnetic stimulation (TMS) is an accurate tool for mapping the representations of hand muscles in the primary motor cortex (M1). The aim of this study was to investigate the spatial and directional excitability dependent on the underlying cortical anatomy in the M1 hand area with sulcus-aligned mapping.
Methods: Structural MR images were taken from ten healthy subjects. Navigated TMS was applied to locate the site eliciting the largest responses (the hotspot) in the right first dorsal interosseous (FDI) muscle, in which the resting motor threshold (rMT) was measured. Six targets were placed at the anterior wall of the central sulcus, with three targets on each side of the hotspot at equal (approximately 5 mm) distances. After the determination of rMTs at all targets, the effect of coil orientation was investigated at four nearest targets by rotating the coil from the optimal direction in slight steps and measuring the motor evoked potentials (MEPs) at intensity of 120% of the rMT [1].
Results: The apparent rMT values increased as the distance from the hotspot along the central sulcus increased, on average more in lateral than medial direction. Distributions of MEP amplitudes with different coil rotation angles appeared wider in the targets nearest to the hotspot. In addition, two major coil directions were often present in these targets: coil perpendicular to the sulcus and coil pointing towards the hotspot.
Conclusions: As expected, more TMS power is required to excite the motor cortex when moving away from the hotspot of the muscle of interest along the central sulcus. The primary motor cortex is often activated with many coil orientations depending on the target location, demonstrated by the anisotropy of cortical excitability profile with different coil directions.
References:
[1] Kallioniemi et al., Journal of Neuroscience Methods, 2015.

Contribution ID: 245
14. Neuroengineering, Neural Systems
14.06. Transcranial magnetic and electric stimulation

Development and feasibility evaluation of transcranial direct current stimulation equipment (tDCs) for home based use

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Introduction: The transcranial direct current stimulation (tDCs) is a noninvasive brain stimulation method used to modulate the cortical excitability by means of low intensity direct current applied to the scalp via surface electrodes. Its effect tends to be cumulative and induced by repeated sessions. The evaluation of cortical excitability by means of motor evoked potential (MEP) is a standard measurement of motor response to transcranial magnetic stimulation (TMS).
Objective: To evaluate the effect of 10 sessions of home based tDCs on the cortical excitability in healthy subjects.
Methods: 17 healthy subjects (7 men/10 women), right-handed, aged between 18 and 40 years were selected. The MEP was evaluated before and after 10 sessions of home based tDCs measured by electromyograph (EMG) coupled to a TMS MaxPro100. Anodic stimulation of 2mA for 20 minutes on 35cm2 electrodes was applied on left M1 and right supraorbital cathode. For the

MEP evaluation, 10 magnetic stimuli with 130% intensity of MEP were applied and the mean of the EMG amplitude was calculated. Participants performed 10 daily home sessions and were re-evaluated at the end. Paired t test statistical analysis was used (p <0.05).
Results: The age was 25.70 ± 4.74 years. The volunteers performed 171 sessions of home based tDCs. There was a significant difference between MEP pre-sessions (1.28 ± 0.19 mV) and post-sessions (1.85 ± 0.53 mV) (p <0.001; effect size = 1.58). The mean contact resistance was 2.86 kΩ (± 1.04) and the adherence rate was 90.58%. The main adverse effects reported were tingling (50.3%), pruritus (44.4%) and hyperemia (38%).
Conclusion: The results suggest that the equipment developed induces changes in cortical excitability and presents viability for home use, with adequate monitoring of adhesion and contact impedance. There were reports of few adverse effects, with no difference of those found in outpatient use.

Contribution ID: 289
14. Neuroengineering, Neural Systems
14.06. Transcranial magnetic and electric stimulation

Effects of transcranial random noise stimulation on normal subjects

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There are little data about the effects or side effects of transcranial random noise stimulation (tRNS) on human brains in the past. In this study, we investigated the impact of single session tRNS on normal subjects. A session of tRNS consisted of a stimulation period of 15 minutes, a strength (root mean square) of 1 mA, a band-limited random noise waveform of 100-640 Hz and the locations at bilateral pre-auricular areas. Electroencephalography (EEG), functional magnetic resonance imaging (fMRI), transcranial magnetic stimulation (TMS) and Corsi block tapping test (CBT) were performed both before and after tRNS to evaluate the changes in power spectrum distribution of EEG, functional connectivity at resting state, cortical excitability (evaluated by silent period) and visuospatial memory, respectively. Twelve normal subjects (24.5±4.7 years) participated in this study. The results showed that the power spectrum distribution, functional connectivity, motor cortical excitability and visuospatial memory did not change significantly after tRNA. Subjectively, the subjects did not feel any changes in cognitive functions or consciousness, either. In conclusion, tRNS of 1 mA strength has no immediate adverse effects on brain functions of normal subjects.

Contribution ID: 526
14. Neuroengineering, Neural Systems
14.06. Transcranial magnetic and electric stimulation

System for motor evoked potentials acquisition and analysis

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Biological signal acquisition is a fundamental part of the following signal processing methods. This study is focused on hardware and software solution for an electrophysiological measurement in neurological patients and healthy controls. This paper deals with a design and an implementation

of the system for transcranial magnetic stimulation (TMS) applied over the human motor cortex, which has the diagnostic and potential therapeutic effect, respectively.
The created system measures the motor evoked potentials (MEPs) elicited by TMS applied over motor cortex. The signal is recorded using surface electrode from the targeted hand muscle, amplified (Quad System 1902, Cambridge Electronics Design), converted to the digital representation (ADC, Power 1401 mk II, CED) and then saved for later offline analysis. Whole process is driven by scripts written in Signal programming language (version 5.09, CED). These scripts ensure an adjustment of parameters of the ADC (sampling frequency: 5 kHz, resolution: 16 bit), signal conditioner (frequency band: 5 – 2000 Hz, filter type: B'Worth 3rd order) and TMS stimulator (number of pulses, stimulation intensity, interstimulus interval). Individual parts of the system communicate together using USB and RS-232 interface. Synchronized pulses are propagated through coaxial cable in TTL values.
Measuring chain is for better functionality and data reproducibility completed by an optical tracking system. This system is necessary for better monitoring of the magnetic field position and non-invasive stereotactic frame minimizes patients head movements.
The system was used for examination of 22 patients (mean age 51 ± (SD) 17 years) suffering from dystonia of various distribution and etiology treated by chronic deep brain stimulation of globus pallidus interna(GPi DBS). We found significant differences between the patients and healthy controls in MEP parameters (MEP onset latency, amplitude). Designed system for TMS examination is an effective tool for studying the pathophysiology of neurological and psychiatric diseases.

Contribution ID: 641
14. Neuroengineering, Neural Systems
14.06. Transcranial magnetic and electric stimulation

Experimental setup for the systematic investigation of infrared neural stimulation

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During the last decade infrared neural stimulation (INS) has seen a growing interest both in electrophysiological research and for potential clinical applications.
In comparison to established methods like direct electrical nerve stimulation, INS promises advantages like the contactless operation in combination with superior focality and lack of electrical artifacts. However, up till now, little quantitative investigation for an enhanced understanding has been performed.
Therefore, we established an experimental setup for systematic quantitative investigation of multiple parameters for peripheral nerve stimulation in vivo.
To evaluate relevant optical INS parameters, our setup allows the use of multiple fibre-based infrared laser systems of different wavelengths for nerve stimulation, including the accurate characterization of laser beam profile, effective spot size and time-dependent irradiance.
It consists of the particular laser connected to a customized infrared focusing optics mounted on an optical bench, with associated optical sensing equipment for power/pulse energy measurements in addition to a motorized beam characterization unit.
Targeting the sciatic nerve of anesthetized rats as a model for in vivo peripheral nerve stimulation, multi-site low-noise recording of electric muscle activity (EMG) and electric nerve activity (ENG) by

means of approved physiological nerve monitoring amplifiers facilitate the precise evaluation of evoked neural activity upon infrared laser stimulation.
All components are entirely controlled by a customized LabVIEW software, allowing automated experiments to systematically evaluate the effects of various technical and physiological parameters on the evoked compound motor action potential (CMAP) signals.
Hence, our setup enables the determination of safe margins for reliable infrared laser stimulation and therefore helps to understand the underlying physiological mechanisms of INS. This will assist to establish INS as alternative method for neural activation and future development of novel electrophysiological tools.
Here, we present the established experimental setup and current results of our ongoing work.

Contribution ID: 1032
14. Neuroengineering, Neural Systems
14.06. Transcranial magnetic and electric stimulation

Comparison of cathodic and anodic electrical stimulation of lumbosacral posterior roots

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In recent years, transcutaneous spinal cord stimulation (tSCS) become a possible method to activate posterior lumbosacral roots non-invasively. Biophysical advances of the spinal region provide a selective stimulation of large afferent, which projected directly to the motoneuron and the spinal cord internal networks. Here, we study the influence of the pulse polarity on elicitation of posterior root reflexes (PRR) during tSCS.
Five neurologically-intact subjects (1f, 5m) participated in the preliminary study. A transversally electrical field was generated where the active electrode (diameter 5 cm) was applied at the level of the intervertebral space T11-L1, and the indifferent electrode (16 x 13 cm) was paced umbilical.
The effect of both pulse polarities was tested in this study, whereas the active electrode acted as a cathode or an anode. The stimulation pulses were monophasic, rectangular having a pulse duration of 1 ms. The PRRs were recorded with surface electrodes in both lower leg muscles (TA, tibialis anterior and TS, triceps surae). The recruitment curve of PRRs in each muscle group was obtained by randomized application of stimulation pulses in a range form the activation threshold up to 100 mA.
On average, the areas under the recruitment curve by anodic pulses were 50% smaller than those evoked by cathodic pulses. Similarly, the average activation threshold 35 mA and 52 mA for cathodic and anodic polarity, respectively. However, in some examples, the saturation levels were similar in both stimulation configurations, which may suggest that both methods are activating the similar neural structures.
Despite the complex anatomical structure of the thoracic and lumbar vertebras, relatively small lumbosacral enlargement, and orientation of the posterior and anterior roots, we can conclude that cathodic stimulation is preferred over anodic stimulation to reduce the required stimulation intensity.

Contribution ID: 1369
14. Neuroengineering, Neural Systems
14.06. Transcranial magnetic and electric stimulation

Validity of electric field modeling in navigated transcranial magnetic stimulation – offline simulation study

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Objective: Navigated transcranial magnetic stimulation (nTMS) is a widely used method to locate, map and outline cortical speech and motor areas for presurgical and radiotherapy planning. The method relies on the online electric field (EF) modeling of the TMS-induced EF on the cortex. Our objective was to apply a more realistic modeling of the EF offline to validate the maximum EF location in the online model that is used for targeting during the nTMS procedure.
Methods: Two healthy volunteers were studied using nTMS by positioning seven stimulation targets along the precentral gyrus, one at the hotspot of the first dorsal interosseous (FDI) muscle, and three targets both medially and laterally from the hotspot, 1 cm apart. The locations of the TMS coil with the coil normal and direction were taken from each target for offline simulation. The model geometry was made based on structural MRIs, and the simulations were performed utilizing SimNIBS2 [1]. The maximum EF locations from the online nTMS were compared with those simulated with the more detailed offline model.
Results: The Euclidean distances between the online and the closest offline EF maxima were 9±1 mm. Unique EF maximum was found only in 3/14 simulated coil locations. Two or three maxima were found in 9/14 of the simulated coil locations. The distances between the online and the second and third closest offline EF maxima were 13±2 mm and 18±3 mm, respectively. The closest offline EF maxima were on average 5 mm lateral, 2 mm anterior and 5 mm superior to the online EF maxima.
Conclusion: The closest EF maxima of the offline model corresponded well with those of the online EF model. However, the online EF model is unable to handle multiple EF maxima likely due to simplified geometry.
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Contribution ID: 1494
14. Neuroengineering, Neural Systems
14.06. Transcranial magnetic and electric stimulation

EMG in pendulum test of brain injured people treated with transcutaneous spinal cord stimulation

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Introduction. Transcutaneous spinal cord stimulation (tSCS) has been shown to abbreviate spasticity in lower limbs in people with incomplete spinal cord injury (SCI). This is believed to be due to inhibiting effects on the neural network of the spine at the height of the motor neuron. We therefore hypothesized that the tSCS can influence the spasticity by brain injured people the same

way. In this work we investigate the changes in the electromyogram (EMG) taken in the Wartenberg pendulum test (WPT) and in Achilles tendon stretch test (ATS) before and after tSCS treatment.
Material and methods. Four hemiplegic subjects (man: 67 brain damage, women: 48 stroke, 72 brain tumour, 68 bleeding aneurism) with severe spasm are stimulated in the lumbar area, at the height of th 11 and th12. An assessment of the spasm consisting of EMG measurements and evaluation of passive and active movements was made before, immediately after and four to six hours post tSCS treatment.
Results. Changes in the reflex responses of the muscles are recorded. EMG activity during WPT and ATS is changed towards a clear division between the antagonistic muscles. Plantar and dorsiflexion of the foot is easier. EMG shows less co-contractions and therefore les effort for the movement. Three subjects report easier movements. But in the summary the parameters do not indicate a spasticity abbreviation.
Conclusions. That the measurement made in this work on brain damaged subjects do not indicate that tSCS abbreviates spasticity. This is different from results with spinal cord injured. Nevertheless the changes in the responses of the muscles are detected. The main difference between the two groups of subjects is that the SCI subjects do have a compromised connection from the brain to the spinal circuitry controlling the muscle whereas the subjects in this study have an intact pathway.

Contribution ID: 31
14. Neuroengineering, Neural Systems
14.07. Deep brain stimulation

Probabilistic random forest clinico-statistical regression analysis of MER signals with STN-DBS and improvement of UPDRS

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Background: In this study, we present a probabilistic random forest classification and statistically significant regression technique with machine learning approach to predict intra operatively microelectrode-recording (MER) with subthalamic-nuclei (STN) deep-brain-stimulation (DBS) in Parkinson`s disease(PD) and improve the unified Parkinson`s disease rating scale (UPDRS) during post DBS. We hypothesize that the data informed combination of features extracted from MER-signals of STN-DBS in PD can predict improvement of motor function and decrease tremor.
Objectives: The prime objective of our study was to disclose implication of intra-operative-neural-signals and expound their prognostic—extrapolative role in terms of reaction to STN—DBS.
Methods: We gathered STN MER signals from 20 PD-subjects with their mean age 60.9±6.30yrs and mean disease duration 14.8±4yrs. Study was conducted at Nizam`s Institute of Medical Sciences(NIMS) hospital Hyderabad (India). Study period was 2015-2017. Ethical clearance was approved. We used an ensemble of decision trees, known as random forests (RFs), which we have modified accordingly, and systematically identified MER features that can predict DBS response for each subject in connection to their corresponding clinical progress, as assessed by UPDRS. We modified the employed RFs to account for unbalanced datasets and multiple observations per subject, and shown that five neurophysiologically interpretable MER signal features/feature—extractions are suffice for predicting the enhancement of UPDRS. Our findings suggest that STN electrophysiological signal characteristics are strongly correlated to the extent of motor-behavior progress observed in STN-DBS.
Results: Five MER-signals features-of-STN were extracted with a maximum-correlation-coefficient of 0.9208 and corresponding to an NMSE of 3.37%was attained; PowerBUAT, maxPLB, maxPLHG, PAFCDT, and PAFCTG(Table) with FIs 0.2067, 0.0651, 0.1507, 0.0834, and 0.1739.

Conclusions:
This study showed five features are suffice for predicting UPDRS improvement and there is a significant enhancement in motor function and decrease tremor. Findings-suggested that STN electrophysiological-signal-characteristics are strongly correlated to the extent of motor-behavior improvement observed in STN—DBS.

Contribution ID: 50
14. Neuroengineering, Neural Systems
14.07. Deep brain stimulation

Latent variate factorial analysis of microelectrode recording of subthalamic-nuclei neuron signals with deep brain stimulation in Parkinson disease

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We present a latent-variate-factorial method to presume unified Parkinson's disease rating-scale(UPDRS) improvement after deep-brain-stimulation (DBS). Hypothesis of this study is that the developed method is capable of quantifying the effects of DBS "on state" in PD-patients. In that case, the measurement-characteristics-of-patients are more similar to the measurement-characteristics-of-healthy-controls with DBS "on" than "off." We hypothesize that a data informed combination-of-features extracted from intraoperative-microelectrode-recordings (MER) whichcan foresee motor-function-improvement of PD-patients undergoing-DBS-surgery and decrease tremor. In our study,high-frequency-stimulation in diseased-brain did not damage subthalamic-nuclei(STN)neurons but protected.
12patients with diagnosis of PD>6years as per United-Kingdom Parkinson's Disease-society brain-bank criteria with good-response to levodopa and Hoehn and Yahr score of <4 with normal-cognition were included in this study. Surgery was planned using CRW frame which has luminant-MR-localizer using Framelink-software with5channels. Targeting was performed according to Lozano's technique –2mm sections are taken parallel to the plane of anterior comissure-posterior commissure line and at the level with maximum volume of red-nucleus; STN was targeted at 3mm lateral to anterolateral-border of red-nucleus. MER was performed in all-patients extending from 10mm above target to 10mm below-STN. Final-target-selection was based on the effects and side-effects of macro-stimulation and confirmed by post-operative-MRI.
In all patients, total UPDRS-motor-score was lower with-DBS-on than with-DBS-off(Table). However, reduction-rate was highly-individual. The rest-tremor-scores decreased for most (10/12) of the patients and rigidity-scores for all patients in either-side(of-the-body).
MER-signals of these patients were computed by latent-variate-factor method (PC-approach). Exact stimulation-parameters were depending upon patient and they were not-registered-individually during measurements. In all patients, the stimulation-frequency130Hz-190Hz, pulse-width 90µsec, amplitude2-4V and electrode-polarity monopolar-or-dipolar depending upon patient. When discriminating between-subjects or between-different states-of-subjects (between DBS"on"and"off") on the basis of biosignal-measurements there are often many signal-parameters that can capture-essential-features in the signals. The sensitivity of the presented method to different types of PD should be estimated more carefully in further clinical-studies.

Contribution ID: 61
14. Neuroengineering, Neural Systems
14.07. Deep brain stimulation

Principal Component Latent Variate factorial Analysis of MER Signals of STN-DBS in Parkinson`s Disease (Electrode Implantation)

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Even though clinical benefits of deep brain stimulator(DBS) in subthalamic-nuclei(STN) neurons have been established, albeit, how its mechanisms improves the motor features(i.e.,symptoms) of PD have not been fully elucidated. DBS is effective in decreasing tremor—motor symptoms, and increasing motor-function of Parkinson's disease(PD) subjects(diseased conditions/patients). However, objective methods for quantifying its efficacy are lacking. In this connection, we present a latent-variate-factorial (or factor) method to extract features from miroelectrode-recording(MER) signals of STN-DBS and to predict improvement of unified Parkinson's disease rating scale(UPDRS) following DBS (applied on 12 human subjects, i.e., in PD patients). Hypothesis of this study is that the developed-method is capable of quantifying the effects-of-DBS "on state" in PD-patients. In that case, the measurement characteristics of patients are more similar to the measurement characteristics of healthy-controls with DBS "on" than "off." We hypothesize that a data informed combination of features extracted from MER can predict the motor improvement of PD-patients undergoing-DBS-surgery. This shows the high-frequency-stimulation in diseased-brain did not damage subthalamic-nuclei (STN) neurons but protect. Further, it is safe to stimulate STN much earlier than it was accepted so far. At the experimental level, high-frequency-stimulation of the STN could protect neurons in the subsstantia-nigra (SN, an important element of the brain). Therefore, to test this hypothesis in humans, we need to perform STN stimulation at the very beginning of the disease so that we can predict the disease at an early-stage. The latent-variate-factorial is a statistical-mathematical technique principal-component-analysis (PCA) based tracking method for computing the effects of DBS in PD. Ten parameters capturing PD characteristic signal-features were extracted from MER-signals of STN. Using PCA, the original parameters were transformed into a smaller number of PCs. Finally, the effects-of-DBS were quantified by examining the PCs in a lower-dimensional-feature-space. This study showed that motor-symptoms of PD were effectively reduced with DBS.

Contribution ID: 771
14. Neuroengineering, Neural Systems
14.07. Deep brain stimulation

Automated Atlas Fitting for Deep Brain Stimulation Surgery Based on Microelectrode Neuronal Recordings

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INTRODUCTION: The deep brain stimulation (DBS) is a treatment technique for late-stage Parkinson's disease (PD), based on chronic electrical stimulation of neural tissue through implanted electrodes. To achieve high level of symptom suppression with low side effects, precise electrode placement is necessary, although difficult due to small size of the target nucleus and various sources of inaccuracy, especially brain shift and electrode bending. To increase accuracy of electrode placement, electrophysiological recording using several parallel microelectrodes (MER) is used intraoperatively in most centers. Location of the target nucleus is identified from manual expert evaluation of characteristic neuronal activity.

Existing studies have presented several models to classify individual recordings or trajectories automatically. In this study, we extend this approach by fitting a 3D anatomical atlas to the recorded electrophysiological activity, thus adding topological information.
METHODS: We developed a probabilistic model of neuronal activity in the vicinity the subthalamic nucleus (STN), based on normalized signal energy. The model is used to find a maximum-likelihood transformation of an anatomical surface-based atlas to the recorded activity. The resulting atlas fit is compared to atlas position estimated from pre-operative MRI scans. Accuracy of STN classification is then evaluated in a leave-one-subject-out scenario using expert MER annotation.
RESULTS: In an evaluation on a set of 27 multi-electrode trajectories from 15 PD patients, the proposed method showed higher accuracy in STN-nonSTN classification (88.1%) compared to the reference methods (78.7%) with an even more pronounced advantage in sensitivity (69.0% vs 44.6%).
CONCLUSION: The proposed method allows electrophysiology-based refinement of atlas position of the STN and represents a promising direction in refining accuracy of MER localization in clinical DBS setting, as well as in research of DBS mechanisms. The optimal trade-off between STN identification accuracy and anatomical accuracy of model fit is yet to be done.

Contribution ID: 833
14. Neuroengineering, Neural Systems
14.07. Deep brain stimulation

Chronically monitoring of optogenetic stimulation induced neural and hemodynamic response in cerebral ischemia

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Understanding the link between neuronal activity and cerebral hemodynamics, known as neurovascular coupling (NVC), is critical for studying cerebral vascular dysfunctions. Impaired NVC has been observed in acute ischemic stroke. Optogenetics, which involves using light to control electrical activity of opsin-expressing neurons, is an approach to monitor and modulate functions of specific neurons in neuronal networks. Recent studies suggested that optogenetic stimulation induced hemodynamic response could be a good model for studying the mechanism of NVC in ischemic stroke. Furthermore, optogenetic stimulation in primary motor cortex (M1) of middle cerebral artery occlusion (MCAO) mice exhibits significant increase in cerebral blood flow that promotes functional recovery after ischemic stroke. However, the long-term progression of the NVC impairment in chronic ischemia has not been fully understood. The aim of the study is to develop an optogenetic platform for long-term monitoring of the cerebral hemodynamics for further optimizing the therapeutic parameters of optogenetic treatment on chronic ischemia. An implantable optrode for optical stimulation and neural recording in addition to near-infrared spectroscopy (NIRS) recording have been developed. Through fiber optics, the optogenetic stimulation was introduced into ChR2-positive glutamatergic neuron from M1 which were executed before and after MCAO surgery. Neural and hemodynamic responses were evaluated using local field potential and NIRS recordings. An in-line optical filter was applied to filter off the blue light collected from M1 and to avoid interfering the NIRS measurement. The results showed that the amplitude of the evoked hemodynamic response was correlated with the intensity and frequency of optogenetic stimulus. A positive correlation between evoked potential and hemodynamic response was also observed. Overall, our innovative optogenetic-NIRS interface could provide long-term observation on cerebral hemodynamics during optogenetic modulation. The therapeutic effect of long-term optogenetic treatment on impaired NVC can be further evaluated in chronic ischemia.

Contribution ID: 1144
14. Neuroengineering, Neural Systems
14.07. Deep brain stimulation

Deep Brain Stimulation: Patient-Specific Simulations for Creation of Probabilistic Electric Field Maps

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Deep brain stimulation (DBS) is an important therapy for Parkinson's disease and essential tremor (ET). During surgery and in the patient follow-up, many parameters and thus big data is generated. The projects overall aim is to bring together multi-parametric DBS data for clinical support i.e. to go from "mental imagination" to "intuitive visualization" in the surgical planning and follow up of DBS. This requires patient-specific simulations and mapping of anatomical areas linked to improvement.
Patient-specific simulations of the electric field (EF) around an implanted DBS electrodes active contact are generated in Comsol Multiphysics. An in-house developed software in Matlab, ELMA, is used to create a brain model and other in-data for the simulations. The brain model is built from corresponding electrical conductivity values from grey and white matter, cerebrospinal fluid and blood for the brain structures classified from the patients preoperative MRI. The DBS lead is positioned in the brain model based on the Leksell coordinates of the lead artefact as visible in the postoperative images. Cathodic simulation is performed around the active contact with care taken to pulse length and frequency. Typical values for ET with a 3389 lead (Medtronic Inc. USA) in Vim and Zi are: 2-4 V, 60 µs, 130 Hz. The simulated EF is visualized with 0.2 V/mm isolevel corresponding to the activation distance of an axon diameter of 3-4 µm in the thalamic region. The fixed isosurface is mapped to the individuals anatomy i.e. preoperative MRI. Intraoperative accelerometer data of movement, brain images, patient scoring and simulations are used to link the affected anatomical regions with the EF. Simulations have been done for 9 Vim and 5 Zi targets. As a next step probabilistic improvement maps will be generated for visualization of the most effective anatomical structures.

Contribution ID: 1427
14. Neuroengineering, Neural Systems
14.07. Deep brain stimulation

Towards normalization of intraoperative stimulation test results in deep brain stimulation

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Deep brain stimulation (DBS) is used for symptomatic treatment of movement disorders, but the mechanism of action is still not fully known. The optimal DBS position is usually identified by intra-operative stimulation tests, which are performed at several positions along parallel trajectories with various stimulation amplitudes. The aim of the present study was to propose a methodology summarizing all available intra-operative data of different patients in form of an atlas to provide targeting guidelines and better understand the mechanism of action.
We used acceleration sensors to quantify tremor improvement during these stimulation tests and collected data for 16 trajectories to the ventral intermediate nucleus (Vim) in six essential tremor

(ET) patients. Finite element modeling was used to simulate the spatial influence of electric field. Each patients' brain conductivity was modeled based on the greyscale values of T1-weighted MRI. Simulations were performed for all stimulation positions and for several stimulation amplitudes between 0 and 3 mA, each simulation corresponding to improvements measured during surgery. Electric fields were visualized as 0.2 V/mm isosurfaces. All data was summarized as a 3D "Improvement Map" by attributing the maximum improvement to each voxel. The individual maps were visualized together with 14 expert-labeled sub-thalamic structures per side and patient. This resulted in "hotpots" linked with the clinically selected implant position.
A normalization pipeline for the improvement maps was designed. Different normalization templates as well as group registration tools (FSL, ANTS and SPM) were evaluated based on probabilistic definition of sub-thalamic structures in order to obtain the best definition of these structures on the atlas.
Further progress will consist in the transfer of improvement values and spatial distribution to the anatomical atlas, and the selection of appropriate statistical methods to present the improvement atlas. The atlas will propose guidance for DBS implantation in Vim for ET.

Contribution ID: 186
14. Neuroengineering, Neural Systems
14.09. Neurological disorders

A hybrid module to produce clinical engineering professional for the hospital in under developing countries

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In recent years, it has found that under developing countries could not use the healthcare technology properly due to a huge shortage of clinical engineering professionals (CEP). As a result, quality of patient care in under developing countries likes Bangladesh, Bhutan, Nepal, Myanmar, and Pakistan, etc. are found in below standard as compared with the quality of developed countries. In this paper, we specify the basic education, skills, experiences, responsibility of CEP for the hospital in the under developing countries to ensure the safe health care delivery by applying an effective clinical engineering principle. We have evaluated the educational qualifications and skills level of present Electro- Medical Engineers (EME) in the healthcare system of these countries on healthcare technology management and their experiences will compare with clinical engineering professionals. A resulting statement was made based on the critical areas of dreariness and lacking the present EME. Accordingly, we propose to introduce a hybrid module for EMEs to enhance their capabilities as clinical engineering professionals. Moreover, in this module, they have designed additional courses and duration for B.Sc. in EEE / BME / ME / CSE / Medical physicists or other equivalent graduates to develop more clinical engineers by providing additional education to EME. In this regards, several sets of data have been collected from underdeveloping, developing, and developed countries. The proposed research will be helpful for the decision making bodies and will act as guidance to develop academic module of public and private universities for producing proficient CEPs. Finally, it will be impending to produce huge numbers of CEPs through the proposed module and the CE profession will bring an acceptable standard outcome for health care delivery in the hospitals of these countries in near future by 2025.

Contribution ID: 346
14. Neuroengineering, Neural Systems
14.09. Neurological disorders

Partial spinal cord injury induced alteration of brain resting-state functional connectivity in Rhesus monkeys' sensorimotor cortex and default mode network

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Spinal cord injury (SCI) disrupts the long-distance nerve fibers, which always lead to sensorimotor dysfunction. SCI-induced axonal disintegration regulates the flow of information between the brain and the spinal cord and may leads to reorganization of functional synchronization in brain.
To evaluate the alteration of brain resting-state functional connectivity (FC) after SCI, five female Rhesus monkeys (weight: 5±1kg; years: 4-6) were used. The experimental procedures had been approved by the Biomedical Ethics Committee of the Beihang University. A right hemi-section with remove 1cm tissue was performed at monkeys' thoracic cord (T7-9 level). Resting-state fMRI examination was performed on anesthetized animals in the healthy stage and 1, 2, 3, 6, and 12 months post-operation by using a 3T MR scanner (Siemens). The data were processed and were spatial normalization to INIA19 Primate Brain Atlas. 16 ROIs in the sensorimotor cortex (SMC) and default mode network (DMN) were defined. The average time series of each ROI were calculated by using Pearson's correlation analysis to form the FC maps. A paired t-test was used to detect the significant difference among different time-points ($p < 0.05$ with multiple corrections).
In the first 3 months, significantly decreased FC between sensory cortex and other regions ($p=0.045$), and increased FC between bilateral motor cortex and other components ($p<0.05$) were observed. DMN mainly exhibited the enhanced FC strengths among the internal nodes ($p=0.044$), and between the nodes and the right SMC ($p<0.05$). In the chronic stage, FC strength in the SMC trended to be normal. Meanwhile, FC in the DMN ($p=0.035$) and between SMC and DMN ($p=0.036$) showed pronounced attenuation.
In conclusion, this study demonstrated that SCI-induced long-term FC regulation in the SMC and DMN of monkeys' brain. These findings may give a potential insight into the research on spontaneous recovery and reorganization of brain functions after SCI.

Contribution ID: 434
14. Neuroengineering, Neural Systems
14.09. Neurological disorders

Photothermal inhibition of cortex neural activity by infrared laser

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Some brain diseases are caused by neurons being abnormally excited, such as Parkinson's disease (PD) and epilepsy. Recently there has been some research reported on optogenetic technique and near infrared laser technique with nanomaterials that could be used to reversibly block hyperexcited neural activity. However, both genetic modification and exogenous absorber

introduced to the targets is a hinder to the development of clinical applications. A number of previous studies using infrared neural stimulation (INS) have excited neurons without genetic or chemical pre-treatment. The aim of this study is to investigate the feasibility of inhibiting neuronal network activity by using the infrared laser.
In our research, the rat cortex neurons were cultured on the multi-electrodes arrays (MEAs). Neurons were irradiated using 1550 nm infrared laser with different intensity. Neuron activities were recorded using MEAs two to four weeks after seeding. A temperature model was created by using COMSOL multiphysics software to predict the temperature change at different laser intensity irradiation. The essential parameters (beam distribution, initial temperature, laser intensity, stimulation time, pulse duration and frequency) employed in the model were derived from the experiments. The model was validated using the open pipette temperature measurement method.
Our initial result shows that the wavelength of 1550 nm infrared laser can be used to inhibit the network activity of cultivated rat cortex neurons directly and reversibly. The degrees of network inhibition can be manipulated by changing the laser intensity . The optical thermal effect is considered the primary mechanism during infrared neural inhibition (INI). These results demonstrate that INI could potentially be useful in the treatment of neurological disorders and that temperature plays an important role for INI.

Contribution ID: 516
14. Neuroengineering, Neural Systems
14.09. Neurological disorders

Performance of hindlimbs locomotion after monkey unilateral thoracic spinal cord lesion

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Spinal cord injury (SCI) physically breaks neural circuits at the lesion site, which usually causes the loss of motor and sensory function beneath the injured site, and ultimately leads to paralysis. After incomplete SCI, neural circuits have plasticity in some degree, which would play a role in facilitating the recovery of motor function. The objective of this study was to observe the changes of gait parameters after spinal cord injury, and reveal the plasticity recovery of motor circuits.
We chose four monkeys for the thoracic hemisection surgery, and recorded their kinematics performance before surgery, 6 and 12 weeks after surgery. Monkeys were trained to perform bipedal stepping on a treadmill before surgery. All procedures performed involving animals were in accordance with the ethical standards of the Animal Ethics Committee of Capital Medical University. A total of 79 parameters of gait were computed for each gait cycle. Principal component analysis (PCA) was applied on these parameters to assess the degree of locomotor recovery.
PC1 explained the highest variance (34.79%) and represented the motor recovery. Approximately 50% of all parameters were highly correlated with PC1, which means motor function was seriously affect by SCI. Compared to pre-lesion values, step length, step height decreased at 6 week post-lesion. The limb, shank, foot showed limited movement. During most of the swing phase, the hindpaw kept dragging. In contrast to the knee joint, the hip joint had an increased range of motion. Twelve weeks after surgery, partial kinematics recovery was observed in most parameters, which showed motor recovery after SCI.
After SCI, Monkeys exhibited sustained locomotor deficits. In other side, we found recovery of motor function following injury. This would help to further understand the spontaneous plasticity of motor circuits after spinal cord injury.

Contribution ID: 769
14. Neuroengineering, Neural Systems
14.09. Neurological disorders

Analysis of Motor-Related Cortical Activity with Functional Near-Infrared Spectroscopy for Parkinson's Disease Patients

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Movement impairments like difficulty to maintain the balance of trunk, tremors, and walking dysfunction occurred on the Parkinson’s disease (PD) patients. For researches recently appeal that voluntary over-powered exercise for PD patients could enhance the stability and movement speed of upper trunk. Also there were many brain stimulation methods such as invasive deep brain stimulation and non-invasive repetitive transcranial magnetic stimulation targeted to motor cortex have been proposed to improve the motor learning and performance. Although the motor benefits of those methods have been widely published. However it remains unknown mechanism how they modulate the neural network and cortical activities. Previous studies demonstrate the abnormal electrical oscillation activities in motor cortex of parkinsonians, the results might also implied the asymmetrical hemodynamic changes in the brain. And functional Near-Infrared Spectroscopy (fNIRS) is a good assessment to monitor the cortical activities by detecting the concentration changes in oxy-hemoglobin and deoxy-hemoglobin which is similar to the Blood-oxygen-level dependent(BOLD) signal of fMRI. This study apply the fNIRS on the motor cortex to obtain the concentration changes and to analyze the symmetrical oscillation between different channel of optodes during the exercise. We also apply the patterned electrical brain stimulation on the corresponding area on the motor cortex, trying to see the modulating effect of neural system and motor system. The aim of this study is to investigate the feasibility of symmetrical analysis of concentration changes in blood flow with fNIRS in PD patients which might open another new window of brain activities assessment in PD.

Contribution ID: 800
14. Neuroengineering, Neural Systems
14.09. Neurological disorders

Head and hand tremor measurement and analysis using accelerometers and optical motion capture systems

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Head tremor is a common clinical manifestation in both essential tremor (ET) and cervical dystonia. Various clinical tests have been suggested to facilitate their differentiation, such as dissipation of head tremor due to ET in supine position while dystonic tremor (DT) is persisting. Therefore, we developed an instrumental method using accelerometers or optical motion capture system for measuring head and hand tremor in both the rest state and during motion.
The tremor was measured by Wireless XSens accelerometer (MTw awinda) and Optitrack V120 Trio systems (MOCAP). The parameters tremor frequency, amplitude and power were defined, computed and compared for both systems. The systems and parameters were tested on a

mechanic oscillator simulating human tremor in a still position and in movement. The mean square error of the measurement was specified for each parameter (accelerometer: frequency 0.05 Hz, amplitude 2 mm, power 0.2 dB, MOCAP: frequency 0.1 Hz, amplitude 1 mm, power 0.3 dB).
The systems were used for tremor analysis of 30 patients (15 patients with upper limb and head tremor, fulfilling the criteria of ET and 15 patients with cervical dystonia and dystonic head tremor). We found strong correlation between tremor power in a sitting and supine position (rho = 0.98, $p < 0.001$) for ET patients in contrast no correlation for DT patients. The most statistically significant difference ($p < 0.001$) between ET and DT was found in power tremor computed during finger-to-nose test.
Both systems can be used for the tremor measurement but have limitations. The accelerometers are heavier than reflective markers using by MOCAP but the accelerometers are more accurate in measuring tremor frequency and power. The most clinical relevant parameter for distinguishing the ET and DT patient was tremor power.

Contribution ID: 913
14. Neuroengineering, Neural Systems
14.09. Neurological disorders

Optimal time window for SCI examination and therapy

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How to adequately evaluating the injury process to determine the examinational and therapeutic window for neural injury plays a crucial role in spinal cord injury (SCI) researches. This study aimed to evaluate the longitudinal variation of diffusion tensor imaging (DTI) metric, locomotor outcomes and pathological process in rats after SCI to determine the best time window of examination and therapy.
Adult Wistar rats underwent cord contusion at T9 segment by an NYU impactor. The fractional anisotropy (FA) at the epicenter of injured spinal cord were collected and compared with the Basso-Beattie-Bresnahan (BBB) scores and positive areas of luxol fast blue (LFB) at 1, 3, 7 and 14 day post-SCI (each time-point, $n = 3$). The variations of these measurements after SCI were observed by One-Way Analysis of Variance and the correlations between these were explored by Pearson’s correlation. All experiments were approved by the Animal Ethics Committee of Beihang University.
After surgery, the FA and the LFB positive-area both showed a sharp decrease on 1 day, and reached the bottom on 3 day post-SCI. Then they tend to be stable until 14 day post-SCI. However, the lowest BBB score appeared on 1 day rather than 3 day post-SCI, and the significant recovery of locomotion was also observed between 3 and 7 day post-SCI. Moreover, FA was significantly correlated with positive areas of LFB and BBB scores.
The variation of each measurement revealed that the most severe WM loss may occur on 3 day post-SCI and could be detected by DTI, and the period of day 3-7 post-SCI might be the critical for rehabilitation. It suggested that the first 3 days after SCI may be the optimal time window for SCI examination and therapy. This finding holds the key to layouting the time-point for the future SCI repair trial.

Contribution ID: 1175
14. Neuroengineering, Neural Systems
14.09. Neurological disorders

Excitability-tests using multi-channel contraction force recordings: Development of a novel setup to study distal motor excitability properties.

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Introduction: In animal models of motor neuron disease downstream pathophysiological events were shown to occur at distal nerve terminal branches. Recently, distal excitability-tests were developed to assess changes in ion-channel activity in these branches. In these tests, electrical stimuli are delivered to distal motor axon branches near the muscle. The test stimulus amplitude is varied ('tracked') to asses threshold-changes for eliciting a given muscle force. Force is measured instead of the conventional EMG which is disturbed too much by stimulus artifacts. Current distal test methods use a single force transducer. We present a novel method to study distal excitability while monitoring force in multiple directions.
Methods: Excitability properties comparable to those in Kiernan et al, Muscle Nerve. 2000;23:399-409 were obtained. The median nerve was stimulated at wrist level and at the motor point over the thenar muscles. Thumb contraction force was recorded at the interphalangeal joint using four transducers, configured to measure perpendicular directions. The transducers were rotated per session to maximize the response in the direction used for threshold tracking, and to minimize perpendicular forces.
Results: Five excitability recordings were successfully performed at wrist level (n = 3) and motor point (n = 2) in a single test subject. The maximum baseline to peak force during supramaximal nerve and motor point stimulation was 2 – 3 N. The mean current for 50% maximum force was 2.4 mA at wrist level and 10.2 mA at the motor point. The mean strength-duration time constant was 0.48 ms at the wrist level and 0.21 ms at the motor point. In the recovery cycle, the thresholds from 2.5ms to 100ms were lower for motor point stimulation. Although minimal, small force responses were observed perpendicular to main recording direction.
Conclusions: Measuring excitability with multiple force transducers is potentially useful to optimize distal excitability recording.

Contribution ID: 1252
14. Neuroengineering, Neural Systems
14.09. Neurological disorders

Evaluation of Potency of BMSC to Create In Vitro Parkinson's Disease Model

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Parkinson's disease (PD) is a neurodegenerative disorder caused by the destruction of neurons that produce dopamine in the basal ganglia and the substantia nigra. Although etiology is not completely known, in vitro PD models are constructed with molecules such as 6-hydroxydopamine (6-OHDA), MPTP (1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine) and rotenone by assessing known effects such as oxidative stress, mitochondrial dysfunction, programmed cell death and endoplasmic reticulum stress. Parkinson's disease is caused by both genetic and epigenetic factors. Toxin-induced PD models that correspond to those with gene defects with regard to cellular and behavioral changes are often used for studies.
The development of PD symptoms usually varies patient to patient because of the diversity of the disease. Therefore, creating patient-specific models will give more accurate results for pre-clinical investigations in terms of therapeutic approaches. Bone marrow mesenchymal stem cells (BMSCs)

known to have the ability to differentiate into neurons may be promising for these patient specific models.
In this study, it is assessed whether in vitro PD model can be constructed with BMSCs. First, BMSCs are differentiated into neurons; later 6-OHDA as the neurotoxin is administered to BMSCs differentiated into neuron. The effective dose of the 6-OHDA will be determined by the MTT assay and the model will be evaluated by the immunocytochemistry staining to indicate the expression of tyrosine hydroxylase (TH), vasoactive intestinal peptide (VIP), substance P (SP) and synaptophysin (SYN).
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Contribution ID: 1326
14. Neuroengineering, Neural Systems
14.09. Neurological disorders

Body tracking method of symptoms of Parkinson’s disease using projection of patterns with the Kinect technology

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The analysis of the body movement is relevant in different areas, such as therapy, rehabilitation, bioinformatics and medicine. Nervous system controls the muscle movement. The Parkinson's disease (PD) is a degenerative and progressive process of the central nervous system that primarily affects movement. Facing the symptoms of parkinsonism, the necessity to use some sort of device to capture signals or indicators of the body movement of the patient turns evident, in order to assist diagnosis, knowledge, and evolution of the disease with impartiality of trial, which brings convenience and low cost, both to the patient as to the doctors. To measure motor disorders, body sensor networks and portable technologies set the trend for tracking and monitoring symptoms in PD.
Through the use of technological tools, such as sensors, either sensors for movement acquisition (accelerometers, gyroscopes, inclinometers) or environment sensors (sensors that record physiological properties), It is possible to track the symptoms of Parkinsonism of a person.
A system has been designed with the Kinect sensor, that uses the projection of patterns technology for monitoring change in body posture, obtaining information for a set of points or joints, and variation that could have during the observed period. The system designed using Kinect sensors consists of four modules: first one is an acquisition of the body movement of the patient with the Kinect sensor V1.0, the second one features the extraction module to process the scene captured by Kinect V1.0, third one works on the recognition of the skeleton module, and finally, the acquired data processing module, which is based on a routine in MatLab.

Contribution ID: 1377
14. Neuroengineering, Neural Systems
14.09. Neurological disorders

Evaluation of serum multivalent cationic dysfunction on the brain among patients with Alzheimer's disease

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Introduction: Regarding the social and financial burden of AD, detection of AD in its early stages is a topic of major research interest. Hence, emergence of well-validated screening methods for fast detection of AD in the early stages would be of great importance. It is now recognized that the serum bioavailability of multivalent cations is disturbed in AD.
Methods: This study was performed on the AD patients who were admitted to Roozbeh Hospital, Tehran, Iran. Human serum was extracted from a total of 50 healthy individuals (they are age matched with AD patients) without neurological disease (25 males and 25 females) serving as controls and 50 participants with clinical diagnosis of AD (22 males and 28 females) from the expert neurologist in dementia, according to NINCDS-ADRDA Alzheimer's criteria. Early onset familial AD was diagnosed by mutation of PSEN1, PSEN2 and APP genes by using clinical test according to NINCDS/ADRDA criteria. Neurological tests problem solving test, a Persian version of Mini-Mental Status Examination (MMSE) as a cognitive performance test and the Isaacs Set Test as assessing verbal fluency. Furthermore, confirmation of AD diagnosis was done by MRI. Then. the concentrations of multivalent cations (e.g. zinc, copper, iron, magnesium, and calcium) in serum samples were assayed. In order to systematically compare data between AD and control subjects, principal component analysis (PCA) was used. Also, dendrograms of hierarchical clustering analysis (HCA) were based on all dimensions of data, hence representing 100% of the total variance.
Results: Using a standard chemometric approach (HCA), we find that the serum concentrations of an array of such multivalent cations can be a fingerprint for identification of AD patients.
Conclusion: Our results may pave the way for a reliable, efficient, and inexpensive method for early detection and treatment of AD.
Keywords: Alzhimer; Cations; Hierarchical clustering analysis

Contribution ID: 1419
14. Neuroengineering, Neural Systems
14.09. Neurological disorders

A corpus callosotomy affects the functional network around hippocampus of epilepsy patients

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Epilepsy is a common chronic neurological disease which is caused by abnormal electrical discharges in the brain. Intractable epilepsy is a disorder in which a patient’s seizures are hard to control with drug treatment. A corpus callosotomy is a popular treatment for intractable epilepsy patients among other surgical therapies. Corpus callosum is a commissure which connects the left and right cerebral hemispheres. Removing of the corpus callosum makes it possible to relieve the symptoms of epileptic seizure and many treated patients also develop acute transection syndrome such as akinetic mutism. It is suggested that brain function has changed by corpus callosotomy but there is little knowledge about brain functional modification between before and after corpus callosotomy. We, therefore, performed network analysis on fMRI data to investigate the change in functional brain network before and after corpus callosotomy for intractable epilepsy patients. We also performed network analysis on fMRI data of normal healthy subjects in a resting state to compare with intractable epilepsy patients. In network analysis, we performed ROI-based functional connectivity analyses and set each side of hippocampus to ROI. As a result, there was a strong correlation between bilateral hippocampi before surgery in some epileptic patients, which is rarely observed in healthy subjects. In addition, the correlation between bilateral hippocampi disappeared after the surgery. The results indicate that there is little functional connectivity in the front commissure which is the anatomical connection of bilateral hippocampi, but instead there is functional connectivity between bilateral hippocampi through the cortex. Further, we introduced a new analysis method connecting the Brodmann areas which had strongest correlation between them and it showed a pathway between bilateral hippocampi via a cortex.

Contribution ID: 1748
14. Neuroengineering, Neural Systems
14.09. Neurological disorders

The method of estimation of AHP duration applied to assessment of bilateral changes in motoneurons of stroke survivors

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We aimed at verifying recently published findings that motoneurons supplying muscles on the non-paretic side of stroke survivors were different not only from those on paretic side, but also from the control motoneurons. The study population included 11 post-stroke patients and 8 healthy volunteers. The experiments were performed in agreement with the declaration of Helsinki and approved by the relevant Ethical Committee. The motor unit potentials were recorded from the brachial biceps at paretic and non-paretic side in patients and at the left, non-dominant side in control subjects. The signals were picked up by a bipolar concentric electrode, amplified, sampled by an A/D converter and stored on a computer for data analysis. The AHP duration was estimated by the method developed in our Institute, based on the analysis of interspike interval variability. The estimated AHP duration for patients' motoneurons supplying more-affected muscles was significantly longer than control values and the prolongation decreased with patient age and disorder duration. For motoneurons supplying less-affected muscles dependency on age was closer to the control data, but the scatter was substantially bigger. The AHP duration estimate of less-affected motoneurons tended to be higher than that of control for the short times after stroke and lower than control for the longer times. Our results confirm the recent observation that the motor units of the muscles at the non-paretic side are also affected. Thus, the non-paretic side does not provide a valid control for motor unit activity on the paretic side and control data should always be recorded in healthy subjects. Our results allow us to assume that the spinal motoneurons on both sides respond to the cerebral stroke very soon with prolongation of AHP duration, which tends to recover after the accident. We suppose also that the subsequent changes may be accelerated by the rehabilitation.

Contribution ID: 67
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Evaluation of liquid nitrogen-free electric programming freezer as cellular cryopreservation technology

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As establishing cell & gene therapy, technical development for manufacturing high quality cellular clinical products are extremely important, in particular, establishment of cryopreservation technology is crucial. Computer-controlled programming freezer equipped with automatic liquid nitrogen supply system (LN-PF) has been conventionally applied as standard. But usage of liquid nitrogen in an aseptic room involve troublesome issues as environmental disorder and complexity of its operation in the controlled room. In this study we investigated newly developed liquid nitrogen-free, only electric programming freezer equipped with high powered compressor and large

cavity to hold bag-type cell culture container (E-PF). After treatment by LP-PF and E-PF freezing step, the cells were thawed and re-cultured, and then we performed the following comparative evaluation of benefits between LN-PF and E-PF, in cell viability, proliferation, morphology, and apoptosis. Cellular metabolism and transfection efficiency were also evaluated. As results, in the 7-days culture assay using Jurkat cell line, the cell viability showed more than 92% in both methods (92.3±0.6 vs.92.6±1.2 %; LN-PF vs. E-PF), resulted in no significant difference. Similarly, no significant difference was observed between LN-PF and E-PF in cellular proliferation (55.8±0.8 vs. 57.8±2.1, x10 exp.6), in apoptosis analysis (1.25±0.15 vs. 1.15±0.05 %), and in cellular morphology at day 7 as well. No significant difference was found in each metabolites as glucose, lactase, NH3, LDH. Gene transfection efficiency with Lipofectamine of pAcGFP1-C1 vector (Clontech) exhibited no significant difference of GFP expression levels as well (30.7±6.9 vs.31.6±6.3 pg/mL of GFP). In conclusion, E-PF showed equivalent function and extremely useful as a freezing technique even compared with conventional LN-PF. Further investigation of optimising freezing condition for each cells by E-PF should be elucidated for application to regenerative medicine.

Contribution ID: 204

15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Supplementation of arachidonic or docosahexaenoic acid in culture medium improves contractile performance of cardiomyocytes

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Cardiac tissue equivalents constructed in culture have considerably low contractile performance. To improve the performance, we have focused on the difference in lipid environment between in vivo and in vitro, and found that polyunsaturated fatty acid (PUFA) contents were considerably lower in cultured cells than in in vivo myocardium; in particular, arachidonic (AA, C20:4n-6) and docosahexaenoic (DHA, C22:6n-3) acid contents were less than 20 % only. In the present study, either of these fatty acids was supplemented in conventional culture medium, and contractile performance of cultured cardiomyocytes was compared with that obtained in the conventional medium. Ventricles were harvested from fetal rats, and cardiomyocytes were isolated and seeded for culture in conventional medium with no PUFA, AA (20-60 micromolar), or DHA (10-40 micromolar) supplementation in a 37 deg C and 5% CO2 incubator. The medium was changed a day later, and every other day thereafter. On the 7th day of culture, video image of spontaneously beating cardiomyocytes was recorded, and contractile performance (contractile fraction and beat rate) was measured. On the 14th day, cultured cardiomyocytes were collected and fatty-acid contents in them were determined by gas chromatography. The results showed that AA or DHA supplementation increased its content in cardiomyocytes in culture, concomitantly with enhancement of their contractile performance up to 1.6 and 1.9 folds in cases of 50 micromolar AA and 20 micoromolar DHA supplementation, respectively, and that the maximum performance was seen when supplemented PUFA content in the cultured cells was close to that observed in vivo (5.2 and 2.2 micromole/(g wet tissue) in AA and DHA, respectively). These findings suggest that

supplemented fatty acids have very important roles in exerting the contractile ability of cardiomyocytes in culture.

Contribution ID: 205
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Functionalized peptide-based hydrogel with endogenous enzymatic crosslinking and proteoglycan-assisted delivery of growth factors for hemostasis and wound healing

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How to effectively achieve hemostasis is a critical challenge for surgical operations and emergency treatment. The up-to-date methods to stop bleeding often come with side effects and secondary complications. Although there are many synthetic materials to be used, they often lack of host cellular infiltration; thus, reducing therapeutic efficacy. Moreover, the presence of autoimmune response and thrombosis are major serious concerns for biological-derived hemostatic agents. In view of these problems and clinical unmet need, we propose an applicable approach by designing functionalized self-assembling nanopeptide (fSAN) hydrogel with two sequences of (RADA)16-GGQQLK and (RADA)16-GGLRKKLGKA. The involvement of endogenous transglutaminase enzyme (factor XIII) by crosslinking glutamine (Q) and lysine (K) improves the mechanical stability of peptide hydrogel and enhances its storage modulus for several folds. The heparan-sulfate binding consensus sequence, LRKKLGKA, can act as a cofactor by binding angiogenic growth factors including VEGF and HGF. This strategy can prolong the release time of growth factors and protect these factors from proteolysis, achieving the goal to recruit the circulating angiogenic progenitor cells and the migration and adhesion of epidermal keratinocytes and dermal fibroblasts for wound regeneration. By co-delivery of above two peptide sequences, the functionalized self-assembling peptide-based scaffold can be directly injected to the wound site as an ECM-mimic hydrogel for the treatment of chronic wounds and hard-to-treat ischemic infarction disease area. To conclude, the objective of this study is to develop a new class of hemostatic agent based on natural polypeptides with good shear thinning property, improved mechanical strength, and controllable release of growth factors, to achieve efficient hemostasis and facilitated wound healing.
Keywords: Self-assembling, Nanopeptide, Intrinsic factor, Hemostasis, Wound healing

Contribution ID: 327
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Effect of Low Intensity Pulsed ultrasound (LIPUS) Frequency on Fibroblast Proliferation

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INTRODUCTION: Low intensity pulsed ultrasound (LIPUS) treatment, a non-invasive treatment without significant thermal effect, has shown various potential effects, such as enhancement of bone formation, stimulation of cell proliferation, and in vitro stem cells differentiation. However, the optimal parameter settings of LIPUS for these treatments are not known. The purpose of this study is to find the effect of LIPUS frequency on fibroblast proliferation. RESULTS: The 1.0 MHz LIPUS

group showed the highest Relative Fluorescence Units (RFU), which indicated a highest cell metabolic activity of the group. For cells attaching to the dish surface during 0 to 24 hours, RFU showed no significant difference among control group, 0.5 MHz group, 1.0 MHz group, 1.5 MHz group, and 3.0 MHz group. The RFU of LIPUS groups except for 3.0 MHz was all higher than control group after 96 hours. After 96 hours, RFU was 2521 (49) for the control group, 3480 (53) for the 0.5 MHz group, 3828 (90) for the 1.0 MHz group was, 3470 (93) for the 1.5 MHz group, and 2088 (35) for the 3.0 MHz group. A two-tailed Student's t-test was applied for statistical analysis. The result showed a significant difference between the control group and the 1.0 MHz group (p-value<0.05). The 1.0 MHz group gave the highest RFU than the three other frequencies after whichever 48, 72, and 96 hours, meaning RFU of 1.0 MHz group represented a highest cell metabolic activity of all time. This study found the optimal LIPUS frequency on cell proliferation of L929 fibroblast. This proves a potential regeneration method for the intervertebral disc annulus fibrosus. Acknowledgement: MOST 104-2221-E-002 -121 -MY3

Contribution ID: 328

15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Effect of fibronectin-immobilized microgrooved titanium on human gingival fibroblast behavior

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Objectives: We aimed to determine the effect of fibronectin (FN)-immobilized microgrooved titanium (Ti) on human gingival fibroblast proliferation, gene expression and protein expression.
Methods: Human gingival fibroblasts were obtaimed form patients under the protocol by the Institutional Review Board of Kyung Hee University Hospital at Gangdong. 60-μm wide and 10-μm deep microgrooves were fabricated using photolithography with subsequent acid etching to generate a microgrooved Ti surface with acid-etched roughness (E60/10). Both smooth and acid-etched Ti were used as controls (NE0 and E0). Human serum FN was immobilized on the fabricated Ti surfaces by silanization using 3-aminopropyltriethoxysilane (NE0FN, E0FN and E60/10FN). Human gingival fibroblast proliferation was determined and the expression of 77 genes was analyzed by RT-PCR followed by confirmation of selected 44-gene expression using quantitative real-time PCR. From the results, selected 12 proteins showing more than 1.3 fold change were confirmed using western blotting.
Results: FN-immobilized microgrooved Ti significantly enhanced the fibroblast proliferation in various timeline of culture, among which a burst of 5-fold increase was induced by FN-E60/10 compared to either NE0 or E0 at 96 h. The two-way ANOVA result suggested a presence of synergistic promotion effect of microgrooves and FN immobilization on fibroblast proliferation. CDK6, c-Myc, c-Src, Cyclin D1, EGFR, ERK1, FN, Integrin α5, NFκB, osteonectin, paxillin, talin-2, and TIMP1 were determined as influential factors for enhancing fibroblast proliferation on FN-immobilized microgrooved Ti.
Conclusion: FN-immobilized microgrooved Ti can act as an effective surface for enhancing fibroblast proliferation, and can be used for promoting soft tissue response around the connective tissue attachment zone of oral implant abutment surface.
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Contribution ID: 630

15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

DNA intracellular delivery into 3T3 cell line using fluorescence magnetic iron oxide nanoparticles

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Gene delivery is a modern strategy in experimental medicine. Genetically modified cells can express functional ion channels and produce growth factors in cardiac therapy or express bioactive molecules in tumor therapy. In this work, we report a method for low-toxic DNA vector delivery and post transfection localization of these vectors (surface-modified iron oxid nanoparticles conjugated with Rhodamine B isothiocyanate (Rh-MNPs)) in mouse embryonic fibroblast cell line (3T3).
The surface of Rh-MNPs was modified with the most common transfection reagent – linear polyethyleneimine (PEI MAX 40k) and medium molecular weight chitosan to increase Accelerated Sensor of Action Potentials (ASAP1) DNA vector adhesion (plasmid contains GFP fluorescent dye). The size and zeta potential of Rh-MNPs/DNA transfection complex and the amount of conjugated treatment agent and DNA was studied using DLS, SEM and TEM techniques. The transfection complex internalization, plasmid expression, and nanoparticles localization and stability of rhodamine fluorescence in intracellular space were approved in time periods 6, 12, 24 and 48 hours post transfection.
Results showed high transfection complex intracellular biocompatibility – cell viability after Rh-MNPs labeling was higher than 97% 24 hours after transfection and higher than 95% after next 24 hours.
Selective Rh-MNPs localization in lysosome was quantified using LysoTracker™ Green fluorescent dye. High nanoparticle affinity to lysosomes was confirmed. More than 82% of nanoparticles were localized in the lysosomes after 12 hours post transfection and 94% of lysosomes have significant and long-time (48 hours) deposit of nanoparticles. DNA vector expression was visible in > 65% of the cell and precise protein localization on cell membrane was confirmed using fluorescent confocal microscope.

Contribution ID: 772
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Recent research progress on scaffolds for bone repair and regeneration

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Recent advances in the research community on nanotechnology, nanomaterials and nanomechanics have stimulated research activities in medicine and bone tissue engineering devoted to their development and their applications. Applications of nanomaterials in medicine involve diagnostic and therapeutic processes for several diseases affecting different organs.

Research on nanomaterials for medical applications has been carried out in the last 30 years; most studies focused on their safety and toxicity on human cell and tissue function. Several critical issues involve the ability to translate inorganic nanoparticle from academic studies to industrial scaling processes that comply with commercial quality systems, governmental standards, and regulatory contexts for human use. In particular, inorganic nanoparticle size and shape, their physicochemical properties and, most importantly, surface and interfacial properties in biological systems that result in formation of protein corona on particle surfaces are critical parameters to consider. In vitro tests may therefore provide only a partial indication of possible toxicity potential, compared to in vivo exposures.
Tissue engineering is another field in which nanotechnologies appear to have a promising role. In particular, skeletal reconstruction following bone fracture is of interest due to the increasing number of elderly people and bone fractures requibone tissue for various bone defects , ring reconstruction with tissue transplants. Other potential applications are trauma, congenital bone malformations, skeletal diseases and tumor resections. Musculoskeletal reconstruction requires three components: a biocompatible scaffold, cells replacing tissue and biochemical mediators (such as growth factors) to guide cell function. Nanotechnologies can be used to form scaffolds and to deliver drugs and growth factors in the lesion site in order to enhance bone formation thanks to their high surface-to-volume ratio.
In this paper, the recent research progress on scaffolds for bone repair and regeneration is reviewed, with particular reference to their mechanical properties and failure behavior.

Contribution ID: 858
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Electric microenvironment enhance bone regeneration and osseointegration

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Electrical current or electric potential of native bone tissue exists and plays an indispensable role in maintaining bone volume and quality. Although implanted biomaterials simulating structural, morphological, mechanical, and chemical properties of natural tissue or organ has been introduced in the field of bone regeneration, the concept of restoring or establishing physiological electric microenvironment remains ignored in biomaterials and implants design.
We hypothesized that (1) bone repair can be achieved by recovering destroyed potential microenvironment and (2) the rapid and high-quality osseointegration can be mediated by the built-in electric fields established between nano-film implant surfaces and bone defect walls. In our work, the composite membranes with biomimetic electric potential are implanted like native periosteum covering the bone defect, endogenous bone marrow mesenchymal stem cells can be recruited by galvanotaxis and induced to differentiate into osteoblasts. Consequently, the membranes sustainably maintained electric microenvironment giving rise to rapid bone regeneration and complete defect repair with mature bone-structure formation integrated with original bone. We establish built-in electric fields between electropositive nano-films and electronegative bone defect wall with physiologically matched electrical signals. In the presence of built-in electric fields, the significant enhanced efficacy and quality of osseointegration on nano-film implants were confirmed. The improved protein adsorption, stem cell adhesion, spreading, migration and the sequentially initiated osteogenic related gene expression underly the built-in electric fields-mediated osseointegration.
Our findings evidence that electric microenvironment should be paid sufficient attention in biomaterials design, and this concept might provide an innovative and well-suited strategy for bone regenerative therapies.

Contribution ID: 902
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Biphase systems under high pressure as promising media for cleaning and modifications of biomedical materials

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We here present the promising approach of purification, sterilization and modification of synthetic and biological connective tissue matrices in biphase systems based on CO2 under high pressure, capable of providing (a) a one-stage (that is, more economically effective) deeper purification due to increased penetrating ability of such fluids; (b) the possibility of forming a controllable porous system by varying physical conditions (such as pressure applied to the system and temperature) and also the type of co-solvent in a biphase solvent/CO2 under high pressure systems; (c) a fuller and deeper incorporation of masking or improving biocompatibility and antimicrobial properties of polymer coatings, as well as biologically active substances and recombinant protein factors for modification of connective tissue matrices.
The essence of advantages of this approach is that it is the application of high pressure that transfers the system to a fundamentally new state from the point of view of the ability to extract, dissolve, inactivate pathogens, penetrate into porous structures, etc. And release of pressure at the end of modification process transfers these systems into their original state with a high degree of biocompatibility (innocuousness to the patient) while preserving bioactivity of functional agents used (for example, highly effective SC CO2 for delipidation, or impregnation of certain biologically active agents (including highly-sensitive protein growth factors, antibiotics, etc.) when the pressure is released, turns into a CO2 gas, which immediately leaves finished product without leaving any traces in it; or acidic at high pressure biphasic medium of carbonic acid, capable of dissolving some biopolymers and other substances soluble in acidic media, when the pressure is released, becomes absolutely biocompatible water). Thus, it is possible to obtain not only highly biocompatible but also highly bioactive materials of a new generation that meet the needs of modern regenerative medicine.

Contribution ID: 966
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

The biomaterial surface nanoscaled electrical potential promotes osteogenesis of the stromal cells

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The calcium phosphate (CP) surface morphology and electrical charge were supplied because of the microarc coatings technology. The substrate was prepared from titanium.
The (CP) surface both nanoscaled morphology and electrical potential influenced osteogenic differentiation and maturation in vitro of the mesenchymal stem cells. The negative charge was located within the micro and nano sockets, however the positive charge - at the peaks of the nanorelief. The cells were mainly attached at the negatively charged sockets and expressed both osteocalcin and alkaline phosphatase as osteoblastic molecular markers. The electrical potential is considered as the factor to trigger human stromal cells for osteoblastic differentiation and maturation.

Contribution ID: 985
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Study of Magnetic Properties and Cell Behaviors on Thermoresponsive Magnetic Electrospun Nanofibers

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In this study, we successfully fabricated Poly(N-isopropyl acrylamide) (PNIPAAm)-based magnetic nanofibers which is composed of a chemically-crosslinking temperature-responsive polymer with magnetic nanoparticles (MNPs), and formed the thermal response magnetic membranes (TRMM) by electrospinning process. The TRMM morphology was characterized by scanning electron microscopy (SEM), the nanoparticle distribution in the TRMM was measured with transmission electron microscope (TEM). The TRMM could co-culture with the cell as a cell culture substrate. With the high surface area, porosity and thermal responsive phase transition properties, the cell can easily attach and detach on the membrane. The results showed the nanofibers loaded with magnetic nanoparticles displayed excellent magnetic responsibility. In vitro cytotoxicity analysis demonstrated that the cell proliferation in the TRMM was increased especially applied with an external magnetic field. The TRMMs provide a potential platform to explore the cell behaviors under the stimulation of external magnetic field.

Contribution ID: 1182
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Composite scaffold for bone tissue engineering

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The work is focused on preparation of biological composite scaffold for bone regeneration. The scaffold consisted of a calcium phosphate grid, the grid was printed using the Prusa printer. The printed grid was subsequently coated with polycaprolactone nanofibres containing hydroxyapatite particles. The individual components, and the entire composite scaffolds, were in-vitro tested with human cell line MG-63. During the experiment, testing of the nanofibrous layer of polycaprolactone without hydroxyapatite particles was performed, and testing resulted in higher cell viability in samples containing hydroxyapatite particles. The final composite scaffold has demonstrated suitability for bone regenerative medicine and for use in further experiments, such as a combination with collagen hydrogel to promote cell viability.

Contribution ID: 1357
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Fabricating multifunctional tissue engineering scaffolds via 3D printing

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Tissue engineering has become a highly innovative scientific field which investigates new approaches for repairing diseased or damaged human body tissues and organs. Scaffold-, growth factor (GF)-, or cell-based tissue engineering strategies are employed for tissue regeneration and the field is dominated by scaffold-based tissue engineering, with tissue engineering scaffolds playing vital roles for cell proliferation and differentiation and new tissue formation. Simple scaffolds produced by common techniques such as solvent casting/porogen leaching can meet the basic requirements. But for enhancing tissue regeneration or for regenerating complex human body tissues, multifunctional scaffolds are needed. 3D printing technologies have attracted much attention in the biomedical field due to many advantages. Many researchers around the world are applying 3D printing for biomedical applications, and a few 3D printing techniques show promises for scaffold fabrication. However, some 3D printing technologies impose stringent requirements for stock materials and also for the scaffold manufacture itself. Furthermore, the general 3D printing technologies are unsuitable for constructing multifunctional tissue engineering scaffolds in which biological molecules or even live cells need to be incorporated. Therefore, developing new 3D printing technologies for scaffold fabrication becomes important. Our group has investigated selective laser sintering (SLS) for making multifunctional scaffolds for bone tissue engineering. We developed osteoconductive nanocomposite materials as new scaffold materials. For the novel scaffolds, we also incorporated growth factor which provided osteoinductivity. Studies showed that bone regeneration was greatly enhanced by using our SLS-formed multifunctional scaffolds. We also investigated an extrusion-based cryogenic 3D printing technique for constructing scaffolds with the incorporation of biomolecules or cells. This talk will present our research on 3D printing of multifunctional tissue engineering scaffolds and discusses a few issues in scaffold design and manufacture.

Contribution ID: 1425
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Porous polycaprolactone fibers made by centrifugal spinning

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Centrifugal spinning is technology that allows production of fibers by using only centrifugal forces. These forces are caused by high-speed rotation of the spinneret unit. Big variability in spinning devices, used materials and process conditions lead to production of modified fibers, i.e. porous fibers, bicomponent fibers etc. for many applications.
The work deals with the centrifugal forming of polymer fibers with porous surface. As a basic material applicable to tissue engineering, polycaprolactone (PCL), which is a biodegradable and biocompatible polymer, was chosen. Further, pairs of its solvents and non-solvents were chosen, which facilitated production of smooth and porous fibers. Fibers were made by needle and needleless way of centrifugal spinning. The effects of all these variable parameters on the resulting fibers were studied and compared. BET analysis and basic tests of cells viability with human cell line MG-63 were done as well.

Contribution ID: 1484
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Producing tissue engineering scaffolds containing magnetic nanoparticles via magneto-spinning

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The term tissue engineering, has the goal of regeneration of damaged and/or non-functional tissues by enhancing biological reserves to restore and maintain tissue functions using scaffolds and also biochemical agents and cells. When cells are seeded on a biocompatible scaffold, they can populate within the scaffold, form their own extracellular matrix (ECM) and become functionally active. Biomimetic scaffolds have widespread applications with their hierarchically structured nanofibers and nanopores to behave like the natural (ECM). It is adventageous to produce cell-laden scaffolds instead of seeding the cells onto previously produced scaffolds for higher spatial control and homogeneity. One of the mostly preferred methods for production of biomimetic nanofibrous scaffolds has been electro-spinning; yet due to the obligation of high voltage, it is troublesome to sustain mammalian cells during the process. This leads us to an alternative biomimetic scaffold production approach, magneto-spinning, that directly aims to carry live cells on our semi-synthetic fibrous scaffolds. In order to mimic basic (ECM) of fibrous features by magneto-spinning, magnetic field was employed. Main procedure is based on extrusion of a viscous polymer containing magnetic nanoparticles (MNPs) towards a rotating magnetic field. Due to the magnetic field gradient acting on the extruder, MNP loaded polymer is pulled by the magnetic force and a very thin fiber is wrapped around the rotating mandrel like a spider's web. Rotating magnetic field is generated by the rotation of a rectangular NdFeB permanent magnet on the axis of the mandrel. In this study, micro/nano biocompatible polymers polyethyleneoxide (PEO) and polycaprolactone (PCL) fibers with and without cells are produced by magnetospinning. Cell viability on fibers will be determined by live-dead staining and MTT assay. This web-like scaffold might provide new opportunities to spin biocompatible polymers incorporated with live cells during production of micro-fibrous scaffolds for tissue engineering and regenerative medicine applications.

Contribution ID: 1631
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Intelligent Wound Dressing Prototype For Sensing And Killing Pathogenic Bacteria

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the evolved resistance of antibiotics exhibited by some dreaded clinical pathogens and formation of biofilms has caused life-threatening problems for patients with burns and other wounds. Here, in order to avoid antibiotic overuse, and thus decreasing the occurrence of antimicrobial-resistant bacteria, a theranostic wound dressing, composed of biocompatible UV-photocrosslinkable methacrylated gelatin (GelMA) encapsulating both antimicrobial and fluorescent vesicles, has been developed. The system can respond to the microbiological environment of the wound via a simple color change and antimicrobials release only when require and this is in essence passive as they

do not respond to their local environments and benign bacteria, and only operates when pathogenic bacteria exist. Both in Vitro and in Vivo study demonstrated that the proposed wound dressing was able to kill/inhibit the growth of methicillin-resistant S. aureus and P. aeruginosa, whilst providing a visual warning of infection, due to vesicle bilayer membrane lysed by toxins secreted by the two strains of pathogens but not by a non-pathogenic Escherichia coli species. The strategy of microbiologically responsive wound dressing proposed here could also be used as a general methodology for the design and fabrication of bacterial responsive functional biomaterials that offer opportunities to combat drug-resistant bacterial infections.

Contribution ID: 1655
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Preparation and characterization of the thermally modified polyacrylonitrile scaffold for bone tissue engineering

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Bone tissue engineering is devoted to the development of biocompatible materials suitable for the replacement of defect bone tissue [1]. Bones represent a very dynamic structure and its understanding is the basis for designing materials mimicking the extracellular matrix [2].
A porous 3D material called Black Orlon was produced by thermal modification of polyacrylonitrile at 360°C with air access. Morphological structure of Black Orlon is created by interconnected pores that were characterized by scanning electron microscope. Communicating pores of sizes suitable for the growth and proliferation of human osteoblasts were formed in the structure by incorporation and subsequent washing of the porogen particles. Fractionate crystals of sodium chloride of suitable size were used as the porogen. The mechanical properties of the material were improved by introduction of a secondary interpenetrating chitosan network. Two types of chitosan crosslinking agents were also compared: commonly used glutaraldehyde and genipin. The main factor for the comparison was their effect on cell viability. Proposed material and its hydroxyapatite composite have been studied in biological experiments for their osteoconductivity. The materials proved to be non-cytotoxic and their chemical composition and morphological structure promote the adhesion, proliferation and growth of human osteosarcoma cell line MG 63 strain that formed a confluent layer on the surface of the scaffolds.
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Contribution ID: 1764
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Synthesis of germanium doped biomaterials

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Diamond-like carbon layers doped with germanium are able to improve biocompatibility of perspective biomedical applications, including implants covering. Advantages and present state of art and experiences with Ge- DLC layers are summarized and discussed. The system of combination of two laser beams for coating of implants was developed. System is able of fine tuning of dopands concentration Deposition arrangement and deposition conditions using dual-pulsed laser ablation with two KrF excimer lasers and two targets (germanium and carbon) is presented.

Contribution ID: 1782
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.01. Nanotechnology in regenerative medicine and tissue engineering

Simultaneous nano- and microstructure control of injectable hydrogels for biomedical applications

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Injectable hydrogels are advantageous as tissue regeneration scaffolds, as they can be delivered through a minimally invasive injection and seamlessly integrate with the target tissues. However, an important shortcoming of current injectable hydrogels is the lack of simultaneous control over their micro- and nanoscale structures, both of which are crucial for regulating cell function and promoting tissue regeneration. Herein, the authors report a strategy for developing injectable, photo-curable hydrogels that integrate a fibrous nanostructure and porous microstructure. In vitro and in vivo experiments demonstrate that the hydrogels support cell infiltration, elicit mild inflammation response, and promote the formation of blood vessels. These findings suggest that the hierarchically structured hydrogels may provide new directions in designing injectable hydrogels for regenerative medicine.

Contribution ID: 11
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Creation of bio-roots with usage of bioengineered periodontal tissue – a general overview

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The teeth are crucial for human health and they are not just there to look attractive in pictures. Loss of teeth lead to functional, psychological and esthetic problems. For many years, osseointegrated dental implants have been successfully used as a popular prosthetic restoration for the missing teeth. But, those implants have direct connection with bone and can cause damage to the alveolar bone, the implant itself, and even the temporomandibular joint. Thus, those implants should be inspired by natural teeth, which possess periodontal ligament - a connective tissue structure that has supportive, remodeling, sensitive and nutritive function. With advancement in the fields of tissue engineering and dental implantology, a great number of experiments is performed to reconstruct the periodontium around the titanium implants. The aim of this study was to examine studies published between 2000 and 2017 and clinical benefits of such bioengineered implants. Research is based on full-length papers retrieved from PubMed/Medline electronic database using the key words ‘dental implants’, ‘regenerative dentistry, ‘tissue engineering’, ‘bioengineered periodontal tissue’, ‘tooth replantation’. After application of inclusion and exclusion criteria, 14 papers were selected and critically reviewed. In those articles it was found that bioengineered dental tissue could be used as a successful therapy with focus on a significant improvement in

quality of patient's life. Further studies are needed for the development of these novel approaches because they cannot be easily applied clinically for various reasons such the complexity of procedure for wrapping of periodontal ligament around dental titanium implants. In addition to this, aggravating factors for usage of such tissue engineering implants on the daily basis are the costs and time required for practical applications.

Contribution ID: 74
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Fabrication and characterization of 3D printed PLA/Ti composite scaffolds by FDM process for hard tissue engineering

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One of the most important tissue engineering methodologies is the combination of 3D scaffolds with autologous cells to produce bioimplants capable of promoting tissue regeneration. Poly lactic acid (PLA), approved by the FDA, has attracted much attention as a polymer scaffold for tissue engineering because of its good biodegradability, compostable characteristics. However, PLA is relatively bioinert, and has poor mechanical properties. This study was aimed to produce 3D printed PLA/titanium (Ti) composite scaffolds for by fused deposition modeling (FDM) process, and to examine the effect of the complexation of Ti and PLA on the mechanical and biological properties of the porous scaffolds for hard tissue engineering, in comparison with the pure PLA scaffolds. Mixing of PLA and 10, 15 and 20 vol% Ti powder was carried out in a shear mixer for 6h at 5 rev/min at a temperature of 180 ℃. Mixed PLA/Ti compounds were formed to filaments with 1.75 mm in diameter by single extruder. 3D-printing of porous scaffolds was fabricated using commercial FDM based 3D printer at a nozzle diameter and temperature of 400 μm and 210 ℃, respectively. The mechanical properties, thermodynamic properties, thermal stability, and biocompatibility of the produced porous PLA/Ti scaffolds were evaluated. Titanium powder was used as ductile reinforcement for enhancing the mechanical properties and the in vitro biocompatibility of PLA polymer. The porous PLA/Ti scaffolds with various Ti contents were successfully produced via FDM based 3D printing technique. For all PLA/Ti composites, the Ti particles, appearing bright on the micrographs, were well dispersed in the PLA matrix and did not show any pronounced agglomeration. Fabricated porous PLA/Ti scaffolds by 3D printing process had uniform structure showed good cellular response. Our results show that PLA/Ti composite scaffold is a potential alternative to existing polymer-based implant materials.

Contribution ID: 246
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

An Alternative Production Method for Collagen to Obtain Scaffolds

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Background:Collagen is a basicstructural element in nativeextracellularmatrices, anditsabundant presence in naturaltissues, composing 30% byweight of body protein tissues1 ,predestines it as a

polymerforbiomedicalmaterialsandtissueengineeringmatrices.It is generally extracted from the natural tissues by treatments with acid or alkali, enzyme, and microorganisms2.However these methods are generally depend on batch type and reactants, time and energy consuming, and highly costly methods. In this paper, we discuss an alternative method that could be applied on different tissues to extract collagen. It decreases the time and energy consumption and the usage of environment hazardous chemicals.
Methods:In this study, we developed an improved method that reduces the time needed to extract this protein and increase the efficiency (Figure 1). The results were compared with the one obtained from the traditional methods. The alternative method uses traditional extraction buffers combined with forceful agitation and centrifugal filtration to obtain highly-pure, soluble collagen extraction.
Results:This method is simple to perform using standard methods and equipment found in many laboratories. By employing high-speed agitation, this protocol reduces the time necessary to isolate solution, collagen extraction from approximately 7 days to less than 3 hr.3
Conclusions:This paper indicates that these waste materials of animals have potential in supplementing the skin of land vertebrates as a source of collagen. The end product (collagen) could be used in many different applications, ranging from drug carrier systems to tissue scaffolds and reconstructive surgery.

Contribution ID: 405
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Osteochondral Regeneration Induced by TGF-beta Loaded Hyaluronic Acid Hydrogel Infiltrated in 3D Scaffolds

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The aim of this study was to report the fabrication of porous scaffolds with pre-designed internal pores using fused deposition modeling (FDM) method. In our study, the filaments of methoxy poly (ethylene glycol)-block-poly (ε-caprolactone) having terminal groups of carboxylic acid were deposited layer by layer. Raw materials having a weight ratio of hydroxyapatite (HAp) to polymer of 1:2 was used for FDM. To promote cell adhesion, the Arg-Gly-Asp peptide were condensed with the carboxylic groups on the surface of the fabricated scaffold. Then the scaffold was infiltrated with hydrogel of glycidyl methacrylate hyaluronic acid loading with 10 ng/ml of TGF-beta1 and photo cross-linked on the top of the scaffolds. The mechanical properties and cellular responses were evaluated. HAp was found to increase the compressive strength of the porous scaffolds. Among three orientations of the filaments, the scaffolds having the lay down patterns 0o/90o exhibited highest compressive strength. Fluorescent staining of cytoskeleton showed well spread osteoblast-like cells and stem cells on RGD-modified PEG-PCL film indicating a favorable surface for cell adhesion. In vivo test was performed on rabbit, and the histological sections indicated that the bone and cartilage defect produced on knee were fully healed 12 weeks post the implantation of the TGF-beta1 loaded hydrogel and scaffolds, and regenerated cartilage was hyaline cartilage as indicated by alcian blue and periodic acid-schiff double staining. The present study demonstrated a potential approach to heal the osteochondral defects using 3D printing scaffolds containing TGF-beta.

Contribution ID: 482
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Determinations of Modification Degree and Cross-linker Ratio Degradation in Degradation of Hyaluronic acid by SEC-MS and NMR

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Hyaluronic acid (HA) has gained momentum in clinal applications and cosmetic surgeries. Due to its strong water-retainability and good biocompatibility, HA has been widely used in ocular surgery, viscosupplementation therapy dermal filling, and tissue augmentation. The digestion of natural HA happened easily, while cross-linking HA can resist enzyme degradation several months. A generally used method for hyaluronic acid crosslinker on market is 1, 4-butanediol diglycidyl ether (BDDE). In this study, we commit to set up an analysis platform, which could quantify the degree of modification and simulate the HA digestion in vivo. An Analytical method of determined effective cross-linker ratio (CrR) and other derivative values via size exclusion chromatography (SEC) with electrospray ionization mass spectrometry has been established while degree of modification (MoD) and degradation lifetime could be calculated by NMR. In this study, we collected four hyaluronic acid relative products (V1, VC1, VC2, DC1), including viscosupplementation and dermal fillers used, in order to find the correlation between MoD(0%, 3.0%,5.0%, 8.2%), CrR(0, 0.108, 0.177, 0.191) and degradation lifetime(24, 19.9, 50.8, 29.4hr). Rheology properties were also compared in the results for approaching actual physical supporting ability. Our data showed that despite the MoD value of DC1 is higher than VC2 and two CrR values were close, longer degradation lifetime were found in VC2. This method is applicable in quality control for crosslinking HA products in medical instrument market.

Contribution ID: 683
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Biomaterials from freshwater snail shells waste: production and characterization

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Shell wastes of two species of freshwater snails Bulinus globosus and Melanoides tuberculata were investigated as sources of chitosan. The chitosan yield was 39.25 and 32.27% for B. globosus and M. tuberculata respectively, had a moisture content of 5.63 – 5.78%, ash 75.28 – 77.46%, crude fibre 9.83 – 10.65%. Fat was negligible. Mineral values were sodium 1.95 – 2.20%, potassium 1.64 – 1.80%, calcium 1.86 – 2.18%, magnesium 1.47 – 1.58%, heavy metals arsenic, mercury and lead were present in traces. The snail shells chitosan had a degree of deacetylation of 69.77 – 71.75%, a viscosity of 4.93 – 4.95 centipoises (cP) a wettability of 4.0 – 9.0s and emulsion capacity 100%.
Keywords: Biomaterials, snail shells, production, characterization.

Contribution ID: 718
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Crude oil in drinking water: chitosan intervention

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Abstract
Evidence of crude oil in drinking water from Owaza Imo River in Ukwa West Local Government Area, Abia State, Nigeria and the potential impact of chitosan treatment on the water quality were investigated. Triplicate water samples from the river were treated with different chitosan concentrations (0.1, 0.2 and 0.3mg/L). Results showed that the raw (untreated) water samples had a brown colour, hydrocarbon odour and taste, pH 5.67, but with low turbidity of 0.009 units Hazen. In addition, the water contained high concentrations of heavy metals such as lead (0.84mg/L), Zn (2.38mg/L), Fe (3.27mg/L), Cu (0.92mg/L) Cr (0.47mg/L) and Ni (0.41mg/L), had a total plate count of 252.67x10 cfu/mL and a coliform value of a most probable number (MPN) of 8.67/100mL water. With chitosan treatment, the water sample was clear, odourless, tasteless, slightly brown in colour with pH of 6.75. At the highest chitosan concentration of 0.3mg/L reductions in the heavy metals were lead (56.25%), zinc (52.10%), Ion (29.97%), Cu (36.96%), Cr (34.04%) and Ni (51.22%). Although significant reductions were observed in the concentrations of the heavy metals, the water samples did not meet the WHO standards for drinking water quality. Similarly,chitosan treatment reduced the total plate count to 135.0 cfu/mL and the coliform count to a most probable number (MPN) of 2.00/100mL water representing 76.93% reduction in the coliform load indicating the antibacterial activity of chitosan. Generally, the results showed that Owaza Imo River was grossly contaminated with crude oil and heavy metals and therefore unfit for human consumption.
Keywords: Crude oil, drinking water, chitosan.

Contribution ID: 727
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Bioactive calcium phosphate coatings on biodegradable magnesium using detonation

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Application of bioactive and bioinert calcium phosphate coatings is prospective approach to control the degradation rate of self-degradable magnesium bone implants. The current study describes the method of gas detonation deposition (GDD) to obtain high-quality bioactive and bioinert coatings based on hydroxyapatite (HA) and tricalcium phosphate (TCP) onto pure magnesium samples (tablets with thickness of 2 mm and diameter 5 mm). The surface morphology of deposited single- and double-layer coatings with and without zirconia dioxide ($ZrO2$) as well as the effect of deposition process on preservation of Ca/P ratio of initial powder was investigated. The previously optimized parameters (cyclicity 6 s-1, deposition distance 150 mm) were used for deposition. The composition of initial powders and obtained coatings as well as the surface morphology of the coatings was characterized using a scanning electron microscope (SEM) with a module for energy dispersive X-ray spectroscopy (EDX) (S-3400N, Hitachi, Japan). The surface morphology of HA-

based coatings was homogeneous throughout the surface; whereas the surface morphology of TCP coated magnesium samples contained some irregularities that may be due to a wide size distribution of initial powder. The measured Ca/P ratio values were 1.96±0.09 and 1.98±0.12 for initial HA and TCP powders, respectively. The measured Ca/P ratio values for powders were found to be greater as compared with those specified in literature for stoichiometric HA (1.67) and TCP (1.50); they correspond to the Ca/P ratio value of tetra-calcium phosphate (TTCP – 2.00). On the other hand, the Ca/P ratio values for the coatings ZrO2/HA “mixture”, ZrO2/HA “sandwich”, HA and TCP were calculated as 1.83±0.21, 1.76±0.10, 1.84±0.22 and 1.67±0.07, respectively. In conclusion, the developed and utilized GDD method is highly promising to obtain bioactive coatings on magnesium to control its degradation.
Acknowledgements: This work was supported by IP@Leibniz Program as well as Ulderup Foundation.

Contribution ID: 795
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Fabrication of electrospun fiber mats with defined geometry and load profile

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The general feasibility to manufacture a model-based implant for the muscle-tendon transition at the rotator cuff is focused in this research. The idea to replace the native tendon with an electrospun fiber mat based is based on biodegradable polycaprolactone (PCL). The fiber mats will exhibit graded mechanical and geometric properties as well as a defined load profile. The detailed aim is to mimic the mechanical properties of the collagen structure of the native tendon.
Therefore two different fiber morphologies are needed. On the one hand aligned fibers who assimilate the full mechanical load. On the other hand non-aligned fibers are needed to act as scaffold for cell migration. The main task is to combine aligned and not aligned fiber mats within one fiber mat.
Commonly used dynamic rotation drum collectors generate increased alignment in dependence of increased circumferential speed. However, with this technique, it is merely possible to either get aligned or non-aligned fibers. In contrast, the gap spinning effect combines both in a static setup. To quantify these results, the orientation degree was measured. The lower the range, the higher the orientation. The gap spinning shows highly aligned fibers (<15°) between two collectors and non-aligned fibers (~100°) at the surface of the collector.
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Contribution ID: 803
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Cross-linked alginate structures for engineering of scaffolds for neural tissue engineering

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In neural tissue engineering polymers are being investigated as potential scaffolds for supporting nerve regeneration processes. Electrospun piezoelectric scaffolds from polyvinylidene-fluoride (PVDF) with introduction of alginate encapsulated cells and growth factors are very promising to stimulate and accelerate nerve cells ingrowth. In previous studies, the biocompatibility of the scaffolds has been proved and their morphological, mechanical and electric properties have been investigated. This study reports developing a 3D-printing strategy for generation adjustable cross-linked alginate structures for engineering of PVDF-scaffolds.
A hand-made 3D-printer and a coaxial nozzle have been designed and constructed to produce cross-linked alginate structures. Alginate (1.5%, w/v) was pumped at different flow rates through the needle (outer diameter 0.4 mm). The printing speed (0.5-4.5 mm/s) was controlled using developed software. The size of generated structures was analyzed using a Zeiss SteREO Discovery.V12 microscope. The amnion multipotent stromal cells (3×106 cells/ml) were used to print alginate structures with encapsulated cells. The viability of cells was analysed using Calcein AM/EthD-1 live-dead viability and visualized using a fluorescent microscope Zeis Axiovert 200M.
Preliminary experiments using the hand-made 3D-printer have shown that size of cross-linked alginate structures can be precisely controlled (100-1000 µm) by a range of process parameters, such as printing speed, alginate flow rate as well as nozzle diameter. As expected, the viability of cells entrapped into printed alginate structures analysed using a Calcein AM / Ethidium Homodimer live-dead viability assay was not significantly lower (87.3 ± 3.2%) as compared to initially viable cells (90.1 ± 2.4%).
Taken together, the experiments prove a great potential of a 3D-printing strategy to develop multistructural tissue-engineered PVDF scaffolds with an application of alginate encapsulated cells and growth factors to develop an effective method for replacement and regeneration of damaged nerves of a peripheral nervous system (PNS).

Contribution ID: 807
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

µCT based characterization of biomaterial scaffold microstructure under compression

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In this study, two scaffolds (PLCL and collagen) were subjected to deformation under uniaxial compression. The corresponding changes in the scaffold bulk characteristics were observed through micro computed tomographic imaging. Calculated parameters for both samples were porosities, material thickness and pore thickness of analysed volumes. The results show an expected decrease in porosity with increasing deformation. Especially in sandwich constructs of collagen-PLA it was evident that different materials can be affected differently which may be of significance in certain applications. The results of this study are a step towards understanding the changes in the structure of these scaffolds under expected operation.

Contribution ID: 845
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Fabrication of a multi-layered human breast cancer tissue model for clinical evaluation of photothermal therapy

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Photothermal therapy (PTT) provide a strong potential in medical treatment of tumors or targeted cell death by radiation of gold nanoparticels (GNPs). Upon local delivery at the tumor site, the GNPs can be electromagnetically irradiated to generate destructive heat to kill the tumors in the tissue. However, current studies give insufficient information for the clinical reference regarding to the PPT with in vitro or animal models. To present accurate data for the clinical application of the PPT,a human tissue-like multi-layered platform of superficial breast cancer mimetic tissue was fabricated using 3D cell printing technology, a powerful fabrication tool enabling precise control and distribution of cell encapsulated biomaterials evenly. The platform was comprised of a porcine skin gel layer which mimic the epidermis, dry skin, adipose tissue layer and breast cancer tissue layer including a 2 mm wide hemisphere containing GNPs with a defined concentration. Human adipose-derived decellularized extracellular matrix hydrogel encapsulating adipocytes or Michigan Cancer Foundation-7 (MCF-7), a breast cancer cell line, was formed in each layer. This study quantizes the effect of PPT on GNP's heat generation in the tissue at several situations by changing the conditions such as depth of the adipose layer, radiation power and the amount of GNP. Our tissue model presents the potential strategy for the plasmonic photothermal heating conditions and precisely controlled heat generation of GNPs or the destruction of breast cancer cells surrounded in the tissue for the use of PPT in clinical cancer treatment.

Contribution ID: 882

15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Exposure to static magnetic field increases salivation in human submaxillary salivary gland cells

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Saliva, which participates in lubrication, digestion of food, immunity and oral homeostasis, is critical to oral health. Patients with salivary glands impairment suffer from xerostomia. Salivary glands are the main site of salivation. Salivary gland fluid secretion depends on Ca2+ influx. Static magnetic fields (SMF) with intensities between 1mT to 1T (tesla) were found to enhance Ca2+ influx from extracellular medium but varies among cell types. Therefore, exposing to SMF may regulate Ca2+ influx to enhance salivation. In this study, human submaxillary salivary gland cell line A-253 was exposed to 0.1 to 0.4T to demonstrate the effects of SMF on salivary gland cells. The present results showed that SMFs did not change cell morphology nor cause cytotoxicity but increased viability of cells when 0.3 and 0.4 T SMF was applied. Some cells formed aggregates under SMF exposure. In addition, SMF modulated the mRNA expressions that related to secretory functions of salivary gland cells. A relatively weak SMF (0.1 and 0.2 T) up-regulated the AQP5, MUC5B, MUC7, RYR1, ORAI1, and AMY1 expressions. In conclusion, SMF may be an alternative treatment to improve glands function to xerostomia patients.

Contribution ID: 1092

15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Computational Modeling and Analysis of Knee Cartilage Tissue for Development of its Biodegradable Scaffold

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Articulating cartilage plays an important role in smooth mobility and cushioning of bone joints. Loss/damage of cartilage by trauma or inflammation causes restriction in free mobility of joints. It is usually composed of multiphasic and anisotropic material. Computer Aided Tissue Engineering plays a vital role in in-vitro regeneration of cartilage tissue on porous scaffolds from biocompatible and biodegradable materials which can replace the degenerated cartilage. Biodegradable scaffolds are porous 3-Dimensional structures that are fabricated from biocompatible and biodegradable biomaterials like chitosan, polycarpolactum (PCL), hydroxyapatite (HAP) etc. This study is focused on the development and analysis of subject specific biocompatible scaffolds for knee cartilage. Recruitment of knee cartilage, computed tomographic (CT) image data in DICOM format of one human subject was performed on patient informed consent. Semi-automatic segmentation in conjunction with region growing algorithm was used to interpolate 2D-DICOM image data to reconstruct 3D knee cartilage model. Finite element analysis (FEA) was performed on developed cartilage to estimate the exact material strength and solid free form fabrication in the development of porous scaffolds. The results showed that chitosan could be a better source of biomaterial for development of cartilage tissue scaffolds. Authors likewise discussed the importance of computational modeling and analysis in development of porous tissue scaffolds for cartilage development.
Keywords: - Computer Aided Tissue Engineering, Cartilage, Scaffolds, Knee joints

Contribution ID: 1131
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Natural cellulose ionogels for soft artificial muscles

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Rapid development of soft micromanipulation techniques for human friendly electronics has raised the demand for the devices to be able to carry out mechanical work on a micro- and macroscale. The natural cellulose-based ionogels (CEL-iGEL) hold a great potential for soft artificial muscle application, due to its flexibility, low driving voltage and biocompatibility. Herein, we describe an electro-chemo-mechanical study of actuators based on CEL-iGEL. The CEL-iGEL composites undergo reversible bending already at ±500 mV step-voltage values. Actuators were made from the natural cellulose (degree of polymerization 780, α-cellulose content >93%), confined ionic liquid 1-ethyl-3-methylimidazolium acetate [EMIm][OAc], and activated carbon filler. A fast response to the voltage applied and high ionic conductivity of membranous actuator is achieved by a complete dissolution of cellulose in 1-ethyl-3-methylimidazolium acetate [EMIm][OAc]. The CEL-iGEL supported cellulose actuator films were cast out of cellulose-[EMIm][OAc] solution via phase inversion in H_2O. The facile preparation method ensured uniform morphology along the layers and stand for the high ionic-liquid loading in a porous cellulose scaffold. During the electromechanical characterization, the CEL-iGEL actuators showed exponential dependence to the voltage applied with the max strain values reaching up to 0.6 % at 2 V. Electrochemical analysis confirmed the good stability of CEL-iGEL actuators and determined the safe working voltage value to be below

2.5 V. CEL-iGEL actuators showed 0.05% strain values already at 500 mV excitation voltage pulses and achieved a max speed at a fraction of seconds while the steady state bending was observed within 30 seconds. A successful mathematical model was provided to analyze and estimate the deformation for various step input voltages.

Contribution ID: 1269
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Development of fibers by electrospinning for application in scaffolds from PLGA and IR blends with different amounts of hydroxyapatite

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Among human health problems, the loss or failure of tissues it's very normal. For this kinds of problems, tissue engineering appears as an important area for studying and working on the injured tissues regeneration and restoration. Bioactive scaffolds from polymers blends and hydroxyapatite (HAp) are a tissue engineering devices that can be used to bone tissues treatment. In this study, has been used a polymer blend from poly (lactic-co-glycolic acid) (PLGA) and polyisoprene (IR) (50:50 w/w) and HAp to obtain micro and nanofibers by the electrospinning technique. The fibers were obtained with three concentrations of HAp (1, 3 and 5% by weight) and two heights between the target and the tip of the syringe (5 and 7 cm). The voltage was maintained at 15 kV for all tests performed. The samples were characterized for their chemical and structural composition (FTIR and XRD) and morphology (SEM). Chemical evaluation showed the presence of the PLGA and IR groups in the formation of the blends and the RXD indicates the formation of HAp phases. Scanning electron microscopy images showed a preferential formation of the fibers on the target's central region and in the targets that were 7 cm from the needle. From these results, it can be concluded that it was possible to obtain fibers with the studied blends and different amounts of HAp. However, there was only fibers formation at distances of 7 cm between the target and the tip of the needle.

Contribution ID: 1284
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Design and modification of poly (L-lactic) acid microcarriers and their biocompatibility for MC3T3-E1 cells culture

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Nowadays microcarriers have been a promising form designed by biomaterials, widely being utilized in drug delivery, defect filling and cell three-dimensional (3D) culture and thus have

intrigued much interest in tissue engineering. They can realize the uptake of cells attached on their curved surface; also have significant influence on cell proliferation and differentiation. And due to the special 3D structures, they can suitably adapt to the dynamic milieu produced by bioreactors protecting cells from mechanical damage. Based on this, utilizing emulsion solvent evaporation method, three kind microcarriers have been prepared in this study, named respectively Poly (L-lactic) acid (PLLA), PLLA/nanohydroxyapatite (PLLA/nHA) and PLLA/nHA/Chitosan (PLLA/nHA/Ch) microcarriers. The fabricated microcarriers were preliminarily screened using standard test sieves. Afterwards morphology and composition characterizations were carried out including particle size analysis, scanning electron microscope (SEM) observation, energy spectrum analysis (EDS), Fourier transform infrared spectroscopy detection (IR) and elemental analysis. The statistical results of particle sizes showed that the average diameter of PLLA microcarriers was 291.88±30.74μm; and the average diameter of PLLA/nHA microcarriers turned to 275.69±30.62μm; while the average diameter of PLLA/nHA with cross-linked chitosan has decreased to 269.43±26.32μm. Three of them were solid microcarriers with completely different surface topography. Furthermore, the existence of nanohydroxyapatite and chitosan was investigated depending on composition tests. Next the three kind microcarriers were developed for culturing murine MC3T3-E1 cells. It was found that the PLLA/nHA microcarriers had the greatest promoting effect on cells proliferation, whereas the PLLA/nHA/Ch microcarriers were at a disadvantage but performed the strongest adhesion with MC3T3-E1 cells. And the cells growing on the three kind microcarriers exhibited approximately equivalent expression of osteogenic differentiation activity. In summary, the fabricated microcarriers might suggest a promising tool for the delivery of cells and be a good candidate for bone tissue engineering.

Contribution ID: 1286

15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Influence of copolymer grafting density on cell adhesion performance onto surface of a novel thermosensitive chitosan membrane

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Poly N-isopropyl acrylamide (PNIPAAm) as one temperature-sensitive material has a significant advantageous over the enzymatic lysis in protecting and retaining the extracellular matrix proteins when applied to the cultivation and non-enzymatic harvesting of adherent cells, which, to a large extent, can reduce the cell damage caused by the conventional enzymatic lysis. It is thus expected to provide seed cells of high quality for tissue engineering using the PNIPAAm polymer to harvest the adherent cells cultured in vitro. In this study, the chitosan (CS) double layer film was prepared through grafting the temperature-sensitive copolymer P (NIPAAm-co-HPM-co-TMSPM) onto the modified chitosan film. The Fourier transform infrared spectroscopy (FTIR) of the CS double layer film demonstrated some new functional groups, such as ester group, isopropyl bond and siloxane bond, which strongly proved that the P (NIPAAm-co-HPM-co-TMSPM) had been grafted onto the surface of the CS film. Then through the adhesion and detachment experiments of MCF-7 cells, Hela cells and hADSCs cultured on the surface of double layer film, it was shown that cells have a selectivity for the grafting density, including that the optimal coating concentrations for adhesion and detachment of MCF-7 cells was 1-2 mg.mL-1, while for Hela cells it was 1 mg.mL-1, and for hADSCs was 0.25-0.5 mg.mL-1. And the cell adhesion and detachment tests give a powerful fact that the prepared CS double layer film has good biocompatibility, and also presented the successful connection between the copolymer and chitosan again.

Contribution ID: 1394
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Injectable antibiotics-loaded oxidized hyaluronic acid/adipic acid dihydrazide/tricalcium phosphate hydrogel as a bone substitute

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Bone substitution procedure is one of the most prevalent surgery. In clinical practice, preformed bone substitute is brittle so that hard formed according to the required implant materials. In addition, osteomyelitis is commonly seen associated with traumatic open bone wounds, post-operatively after orthopedic procedures such as bone fracture repair. In previous research, injectable oxidized hyaluronic acid/ adipic acid dihydrazide (oxi-HA/ADH) hydrogel has been applied to eyes vitreous chamber substitutes. According the literature record, tricalcium phosphate (TCP) has osteoconductive property that can help bone regeneration. Thus, using of injectable oxi-HA/ADH hydrogel combined with TCP powder as an injectable antibiotic carrier may effectively repair the bone defect and prevent osteomyelitis. In this study, the oxi-HA/ADH/TCP hydrogel contained various concentration of vancomycin and daptomycin were prepared. The rheological results showed that the hydrogel could remain in liquid at room temperature about 20 mins for injection, and then allow rapid gel formation within 5 mins upon heating to 37°C. The swelling test and in-vitro degradation results demonstrated that the injectable bone substitute could maintain gel matrix over 35 days depending on the composition of oxi-HA/ADH/TCP. The vancomycin and daptomycin releasing curves were showed two-stage release behavior. In the first stage, a great amount of gentamicin was burst release from oxi-HA/ADH/TCP. In the second stage, the release curve showed a sustain release of antibiotics. After release for 21 days, the oxi-HA/ADH/TCP antibiotics delivery system still releases enough concentration of antibiotics to inhibit the growth of staphylococcus aureus and pseudomonas aeruginosa. This study suggests that the injectable oxi-HA/ADH/TCP hydrogel containing vancomycin or daptomycin should be a potential bone substitute to reduce and prevent the occurrence of osteomyelitis.

Contribution ID: 1642
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Hyaluronic Acid-based Thermosensitive Hydrogel Combined with Acellular Cartilage Matrix for Cartilage Defect Treatment

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Trauma, osteonecrosis or osteochondritis are the major reasons of cartilage defect, and microfracture, cartilage transfer and cartilage implantation are the most common clinical methods for defect treatments. However, there are some limitations, such as fibrocartilage formation, repairing area limitation and mul-tiple surgeries. In the previous study, we have evaluated the possibility using cartilage fragment for cartilage defect treatment. We found the cartilage fragment could assist mesenchymal stem cell (MSC) synthesis cartilage extracellular matrix (ECM) and

promote MSC chondrogenesis. In the present research, we moved on the second stage of the study, we prepared the acellular cartilage matrix (ACM) from porcine first, and then mixed into hyaluronic acid-based thermosensitive hydrogel to form an in situ forming ACM-Hydrogel for cartilage regeneration evaluation. WST-1, real-time PCR, biochemical anal-ysis and degradation time were evaluated. Results showed that the ACM-Hydrogel could promote cell proliferation, possess good biocompatibility with MSC, and enhance MSC to produce more ECM. Besides, the ACM-Hydrogel could up-regulate MSC express type II collagen and SOX9, and down-regulate MSC express type I and type X collagen. In conclusion, hyaluronic acid-based thermosensitive hydrogel combined with ACM possess biocompatible, nontoxic, easily to use and ECM production promoting properties, and it could be a promising biomaterial for cartilage defect treatment in the future

Contribution ID: 1656
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.02. Artificial skin, bones, joints, teeth and related biomaterials

Enhanced osteoblastic differentiation and osteogenic transcription factor expression on fibronectin- or bone sialoprotein Ⅱ-immobilized microgrooved titanium substrata

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Enhanced osteoblastic differentiation and osteogenic transcription factor expression on fibronectin- or bone sialoprotein Ⅱ-immobilized microgrooved titanium substrata
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Objective: We aimed to determine the effect of fibronectin (FN)- or bone sialoprotein Ⅱ (BSP2)-conjugated microgrooved titanium (Ti) substrata on osteoblastic differentiation and time-dependent osteogenic transcription factor expression in human bone marrow mesenchymal stem cells (MSCs).
Methods: 60-μm wide and 10-μm deep microgrooves were fabricated using photolithography and subsequent acid etching to generate a microgrooved Ti surface with acid-etched roughness (E60/10). Both smooth and acid-etched Ti were used as controls (NE0 and E0). Human serum FN and human BSP2 were immobilized on the fabricated Ti surfaces by silanization using 3-aminopropyltriethoxysilane (NE0FN, E0FN, E60/10FN, NE0BSP2, E0BSP2, and E60/10BSP2). The osteoblastic differentiation of MSCs was determined, and the time-dependent expression of major psteogenic transcription factors were analyzed.
Results: Both FN- and BSP2-immobilized microgrooved Ti synergistically enhanced the osteoblastic differentiation and the time-dependent expression of ARF4, FRA1, RUNX2, and OSX. Human plasma FN was shown to have superior osteoblastic differentiation promotion- inducing capabilities than human BSP2. From the multiple regression analysis using various timelines of osteogenic culture as independent variables, Day 13 was verified as the most prominent influential timeline for the promotion of osteoblastic differentiation induced by the matrix protein-microgrooves Ti composite surface
Conclusion: The composite surface of FN- or BSP2-microgrooves can strongly induce promotion of osteoblastic differentiation in human MSCs. The proposed surface is expected to be useful in the development of a variety of osteogenic biomaterial surfaces.

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Contribution ID: 36
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.03. Cardiovascular biomaterials, artificial heart

In vitro and in vivo hemolysis tests of a maglev implantable ventricular assist device

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Objective: Implantation of a ventricular assist device (VAD) is a seminal therapeutic option for patients with terminal cardiac failure. A growing number of VAD patients are successfully bridged to transplantation, or can even live permanently with the device. However, the success is restricted by frequent severe complications. Haemolysis is a relevant adverse effect of several VAD types, which is the result of destruction of red blood cells, reduced by wall shear stress, flow acceleration and interaction with artificial surfaces. The CH-VAD, a small implantable continuous-flow blood pump (CH Biomedical Inc, JiangSu, China), featuring a magnetically levitated impeller and enough hydrodynamic performance, was under development and completed for a 60-days animal implantation experiment in 6 sheep. The goal of this study is to validate the hemolysis of the pump through in vitro and in vivo studies. Methods: A series of in vitro tests was quantified experimentally by using in vitro circulation loop system according to ASTM F1841, the standard practice for the assessment of hemolysis in continuous-flow blood pumps. The hemolysis test in vivo was performed during a 60-days ovine model implantation, which was being conducted under the IACUC protocol 05-0600 1. Results In vitro tests showed that the average normalized index of hemolysis (NIH) value of the VAD was 0.0007 mg/dL. The hemolysis in vivo was evaluated based on the amount of free hemoglobin in the plasma, and which showed that the free hemoglobin level in plasma peaked at 9.5 mg/dL on the fifth postoperative day and then returned to an acceptable range of 6.0 mg/dL. Conclusion The magnetic levitation left ventricular assist device has good hemolytic performance. These acceptable performance results supported proceeding initial clinical trail conditions.

Contribution ID: 123
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.03. Cardiovascular biomaterials, artificial heart

Therapeutic embolization by a cyanoacrylate liquid glue mixed with oil contrast agent: time evolution of the liquid emboli

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Glue embolization is a therapeutic treatment technique used to block the blood flow to specific targeted sites. Major applications comprehend the embolization of arterio-venous malformations, of tumors, of trauma or hemorrhage. Cyanoacrylate liquid glues, mixed with radio-opaque iodized oil, are widely used as embolic agents owing to their low viscosity, rapid polymerization rate and low tissue toxicity. Upon injection in the blood flow, the glue mixture simultaneously polymerizes and flows with the blood, leading to vessel occlusion. However, the procedure is difficult to control,

because very little information exists on the polymerization kinetics of the glue-oil mixture. The objective of the present work is thus to analyze the polymerization process of n-butyl cyanoacrylate glues mixed with oil. A new in vitro experimental setup is designed to characterize the polymerization process of glue-oil mixtures on contact with an ionic or proteinaceous solution.
We show that glue-oil mixtures with glue concentrations larger or equal to 25% polymerize when put in contact with an ionic solution containing at least 4% of albumin.
The polymerization process includes two phases. A fast zwitterionic polymerization, induced by albumin molecules, takes place at the interface as soon as the two liquids are in contact. It is characterized by a time scale of the order of the minute. This process is followed a volumetric polymerization, during which a reaction front propagates within the mixture bulk with a characteristic time scale of the order of tens of minutes.
Correspondingly, the time for the glue mixture to polymerize over a 1 mm thickness varies from 5 s for pure glue to about 1 min for a 50% glue concentration, and 10 min for a 25% glue mixture.
Such information can help interventional radiologists understand the glue behavior upon injection, and thus control embolization.

Contribution ID: 432

15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.03. Cardiovascular biomaterials, artificial heart

Near-infrared fluorescent imaging as a method of classification for an aneurysm tissue

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The method of near-infrared fluorescent imaging was used for cerebral aneurysm tissue classification. The results obtained show a perceivable difference between ruptured and unruptured aneurysms. Experiments using rupture machines were performed on the harvested samples and stress-stretch relationships were found. This is the first study applying this coupled approach to cerebral aneurysm tissue.
This study was supported by a grant from Government of Russian Federation No. 14.W03.31.0002.

Contribution ID: 681

15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.03. Cardiovascular biomaterials, artificial heart

Hydrogel coatings to improve hemocompatibility and compliance of electrospun vascular grafts

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Electrospinning is a promising method to fabricate highly porous scaffolds for applications in Regenerative Medicine. Blood vessels require scaffolds with an appropriate hemocompatibility. The scaffold has to match the compliance of native blood vessel to avoid intimal hyperplasia. Due to their fibrous structure, electrospun scaffold show anistropic material properties and suffer from high blood leakage.
We fabricated tubular scaffolds with an inner diameter of 4mm. To tailor surface and mechanical properties solution composition was modified by changing polymer concentration or blending different polymers. The scaffolds were fabricated of polycarpolactone, polylactide acid, polyethylene glycol as well as of blends of these materials. One group was dip-coated with poly(sodium acrylate-co-acrylamide). Blood compatibility was tested in a custom-made Chandler Loop system. Number of platelets was measured before and after dynamic blood contact for 1h. Compliance was analysed with a custom-made test bench by increasing the pressure from 80-120mmHg and measuring the change in diameter. Water leakage was measured at 120mmHg for 1min.
Modifying the solution composition resulted in fiber diameters between 1 and 2.5µm. The change in fiber diameter had a minor effect on the hemocompatibilty while the number of platelets decreased by 12% if the polymer composition was modified. The compliance was significantly ($p<0.001$) influenced by either changing fiber size or polymer composition. The compliance decreased with increasing fiber diameter from 13% to 2.9 % or addition of polylactide acid from 13% to 2.1%. Coating of the electrospun scaffolds resulted in a strong decrease in water leakage compared to the control while the compliance was not influenced. Number of platelets decreased by 13% compared to control.
We showed, that hydrogel coating of electrospun scaffolds is a promising method to reduce leakage without changing the mechanical properties. Further studies will be performed with drug loaded hydrogels to improve hemocompatibilty.

Contribution ID: 708
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.03. Cardiovascular biomaterials, artificial heart

Improving cell infiltration depth in electrospun scaffolds intended for cardiovascular tissue engineering

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While electrospinning is a remarkably protean method to create nanofibers, it poses certain challenges when used to fabricate scaffolds for tissue engineering. Given the direct correlation between fiber diameter and pore size in porous scaffolds, cell infiltration into nanofibrous structures becomes a difficult task. However, it is known that cells show better 3D attachment and proliferation in a nanofiber environment. This research (supported by DFG EXC 62/1) aims to create a heterogenous electrospun scaffold structure with micro and nanofibers to increase cell infiltration, especially in vascular graft applications.
Single polymer electrospinning in either the horizontal or vertical orientation has a negligible effect on the micro/nanomorphology of the resulting scaffolds. But when a second polymer is introduced, with vastly different solution properties, the effect is exacerbated and it produces different microstructures when spun in the horizontal and vertical orientations. The comparison of electrospun structures of Poly(ϵ-caprolactone) (PCL), horizontally spun blend of PCL and gelatin, and vertically spun blend of the same, yielded homogenous structures in the former two and largely heterogenous structures in the vertical blend. Scanning electron microscopy measurements showed that the vertically spun samples had nearly 4.5 times the pore size of the other samples (~114µm vs ~26µm).

Subsequently, a 15-day infiltration study with 3T3 fibroblast cells was performed on these electrospun fiber mats (150µm thick and having same overall concentration of constituent polymers of 175mg/ml). Depths were calculated using confocal LSM. As expected, PCL175 and PCL125g50 (horizontal) showed the lowest infiltrations and even stagnation by day 10. PCL175 stopped at 22±12µm depth after 15 days. Vertical samples on the other hand showed a higher and faster infiltration of 37±14µm in PCL100g75 and a substantial 67±18µm in PCL125g50. Therefore, we see significant advantages of such electrospun scaffolds with specialised morphology.
Acknowledgment: Dr. Zelena for her support in the lab.

Contribution ID: 753
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.03. Cardiovascular biomaterials, artificial heart

Characterization of fibroblast and osteoblast growth on gold electrodes in the 20 Hz -1 MHz frequency range

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Characterization of fibroblast and osteoblast growth on gold electrodes in the 20 Hz -1 MHz frequency range
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Impedance measurement of osteoblast and fibroblast growth on coplanar gold electrodes is performed in the 20 Hz-1MHz frequency range with 5, 10 and 100 mV applied potentials.
Cell growth is monitored through seven days after the seeding process. In the high frequency range, measured impedance is increased in both cell types as the number of cells increased in the growth area. In the low frequency range, however the impedance of the Day 1 showed higher impedance values and whereas the Day 7 showed the lowest value being almost the same as the no cell-only medium-results. These data are consistent with the expected values. Changing medium amount on Day 1 and Day 3 also exhibited different changes in impedance magnitude, in high frequency region. The impedance Cole-Cole plots are used for characterization of the electrical characteristics of the two different types of cells; osteoblasts and fibroblasts.

Contribution ID: 1026
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.03. Cardiovascular biomaterials, artificial heart

Inhibition of heart valves bioprostheses calcification with chitosan and bisphosphosnates in advanced biocompatible solvent carbonic acid under high pressure

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At the moment, in surgical practice, biological prostheses of heart valves are the most promising alternatives to replaceable human heart valves. However, it is known that the presence of free residual aldehyde groups on the surface of glutaraldehyde cross-linked bioprosthesis brought into contact with blood elements is the main factor of calcification, which leads to valve incapacitation. Our research team has shown the possibility of effective inhibiting calcification of such bioprostheses in a promising ecologically benign solvent - carbonic acid solution, by covering them with chitosan film. A particularly important property of such media for biomedical applications is the synergy of antimicrobial activity at high pressures (due to the harmful effect of CO2 molecules under high pressure on bacteria, spores and microbes) and biocompatibility after decompression (since the above media self-neutralize during decompression). To increase the effect of suppressing calcification, bisphosphonates were introduced into the coating as additional inhibitors of calcification. Due to high pressures in carbonic acid solutions, bisphosphonates penetrate deeper into the matrix of the pericardium. In case of immobilization of bisphosphonates directly on the xenopericardium tissue, an even more pronounced effect of suppressing calcification should be expected. In addition, carbonic acid itself improves mechanical properties of pericardial tissue, so modification of bioprostheses of heart valves in carbonic acid has obvious advantages over conventional solvents. The patterns of applying bisphosphonates on pericardium tissues in a biocompatible solvent - carbonic acid was studied for the first time, with varying parameters such as temperature, pressure, the effect of mixing, and time. The internal structure of the modified by bisphosphonates pericardium was examined by SEM, and the amount of bisphosphonates in the collagen matrix after such treatment was determined by the tritium label method.

Contribution ID: 1176

15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.03. Cardiovascular biomaterials, artificial heart

Improving alarm algorithms for adverse event detection in left ventricular assist devices

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Left Ventricular Assist Devices (LVADs) provide circulatory assistance to end-stage heartfailure patients. Adverse events like pump thrombosis remain a challenge in LVAD treatment. An early detection of these adverse events could supply caregivers with sufficient time to act before clinical symptoms become apparent. The purpose of this work is to develop a method to detect pump thrombosis from pump data only.
Development was based upon retrospective patient logfile data of the HVAD LVAD system. 8 patients, which were rehospitalized for pump thrombosis and 8 propensity score matched patients without pump thrombosis were analysed for a total of 6292 patient days. The existing “2 Watt elevation from baseline” alarm algorithm was compared to the newly developed Normality-Deviation Score (NoDeS) algorithm. The NoDeS compares live data to statistical properties of the previous day, and can thereby quantify abnormal changes.
The clinical standard “2 Watt elevation from baseline” alarm was activated in 4/8 thrombus patients on the day of readmission. The NoDeS was able to detect pump thrombosis in 7/8 patients. It was able to anticipate readmission in 2 cases by 2 days and in another 2 cases by 3 days. Elevated NoDeS was measured on 8 additional days in the control dataset, whereas 3 alarms were not explainable by clinical records. The other algorithm did not produce any false positives. Additionally, the NoDeS was able to detect 3 bleeding events in the dataset.
The presented NoDeS algorithm is easily implementable and offers the benefit of anticipation of pump thrombosis before evident clinical symptoms. This may lead to improved clinical outcome and reduced burden on the caregiver. If the NoDeS could also reliably detect other forms of adverse events remains to be investigated more thoroughly.

Contribution ID: 1185
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.03. Cardiovascular biomaterials, artificial heart

Physiologically adaptive control of rotary blood pumps: Conclusions of clinical studies

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For hemodynamic support of the failing heart, rotary pumps have nearly completely replaced pulsatile membrane pumps. However, whereas membrane pumps provided intrinsic preload sensitivity, rotary pumps are intrinsically sensitive only to the pressure difference between inlet and outlet. As arterial pressure can change in wide range, the unloading of the failing heart changes also considerably. This lack of adaption is currently only compensated by the recovering regulation mechanisms of the unloaded heart itself.
A datarecorder for continuous longterm recording was developed, which allows continuous recording of pump flow, heart rate and its variability, contractility, aortic valve opening and occasional overpumping/suction for up to 6 weeks. Further, a setup for physiologic pump control in a clinical setting at various activity situations was implemented. Two observational studies were performed (a) on suction/heartrate in outpatients, and (b) on hemodynamic reactions during exercise and hemodynamically challenging tests. Moreover, an acute study (c)with active control was performed in 19 patients.
Study (a) showed that outpatients even under optimal conditions (trained, compliant, pump adjusted) may experience massive overpumping and suction, which can also cause extended periods of arrhythmia and elevated heart-rate. Study (b) demonstrated the existing yet very limited response of the circulation to exercise (depending on the recovery status of the assisted heart), underlining the necessities of speed control and pumps with sufficient output. Study (c) proved, that feedback control can minimize overpumping, avoid suction also in critical situations and increase the pump response to exercise, however with considerable limits for overall oxygen consumption.
In conclusion, at constant speed mechanical cardiac support has only very limited response to patient demand and increased suction can have negative effects. Active control based on preload sensitivity provides adaequate reactions to patient demand. However during heavy exercise it is limited by the available output of current devices.

Contribution ID: 1188
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.03. Cardiovascular biomaterials, artificial heart

Mechanical stimulation of adipose derived stem cells in decellularized pericardium for cardiovascular applications

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Decellularized xenogenic pericardium tissue hold a great promise in advanced tissue engineering and repair of irreversibly damaged tissues in cardiovascular surgery – patches, valves. Decellularization itself minimizes the immunity response of xenogeneic tissue however it also reduces its mechanical properties. Unlike crosslinked tissue that is commonly used, the

decellularized tissue can be remodeled by cells or even by autologous cells harvested from patient prior surgery. Mechanical stimulating of adipose derived stem cells (ASC) with controlled pressure and strain support their phenotypic maturation and differentiation into smooth muscle cells and production of collagen that can improve its mechanical properties. Designed bioreactor consists of special cultivation chamber where the decellularized tissue is fixed and cells are seeded in fibrin gel suspension on its surface. The cultivation chamber construction creates two compartments system where the tissue acts as diaphragm. The pressure and strain stimulation is generated by two electronically controlled syringe pumps that can generate different pressure in each compartment. This leads to generating pressure force on surface with living cells and tends tissue to bend and generate mechanical strain mimicking physiological arterial wall. This system has been used for multiple week cultivations. Experimental results show significantly improved production of alfa-actin, calponin, desmin and also collagen I at culture under dynamic cultivation in contrast with static cultivation already after 3 days. The fibrin gel was completely remodeled in 7 days with massive production of collagen type I. Histological analysis after 14 days also shown the migration of cells into decellularized tissue that is important to its remodeling.

Contribution ID: 1746
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.03. Cardiovascular biomaterials, artificial heart

A porous sodium polyacrylate-grafted chitosan xerogel for severe hemorrhage control synthesized from one-pot reaction

Zhiyong Qian
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Controlling severe hemorrhages remains a challenge. Successful hemorrhage control depends on the speed and quality of blood clot formation. Fast deprivation of water from blood leads to the concentration of blood cells and coagulation factors and thus triggers blood clot formation. This inspired us to develop a new hemostatic material. In this study, we grafted sodium polyacrylate (SPA) onto the backbone of chitosan (CTS) and crosslinked with methacrylic anhydride-modified polyethylene glycol (MAAPEG) to provide a flexible and elastic inter-chain connection between SPA and CTS chains in the presence of a blowing agent to achieve a porous structure. By a simple one-pot reaction, we fabricated a soft, elastic porous xerogel sponge that could reach maximum water absorbency of 180 in less than 200 seconds. This SPA-co-chitosan xerogel sponge demonstrated superior hemostatic properties in thromboelastography (TEGs) test and in a rabbit lethal extremity arterial bleeding model as compared to zeolite granules, kaolin gauze, and chitosan granules. Furthermore, this hemostat worked as a whole to transfer external pressure to the bleeding area and was adhesive to wet wound tissue to seal the bleeding site. In general, the SPA-co-CTS sponge demonstrates a fast and powerful hemostatic effect both in vitro and in vivo, which is superior over the existing commercial products. It might be a promising first-aid device for severe hemorrhage control.

Contribution ID: 1747
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.03. Cardiovascular biomaterials, artificial heart

A porous sodium polyacrylate-grafted chitosan xerogel for severe hemorrhage control synthesized from one-pot reaction.

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Controlling severe hemorrhages remains a challenge. Successful hemorrhage control depends on the speed and quality of blood clot formation. Fast deprivation of water from blood leads to the concentration of blood cells and coagulation factors and thus triggers blood clot formation. This inspired us to develop a new hemostatic material. In this study, we grafted sodium polyacrylate (SPA) onto the backbone of chitosan (CTS) and crosslinked with methacrylic anhydride-modified polyethylene glycol (MAAPEG) to provide a flexible and elastic inter-chain connection between SPA and CTS chains in the presence of a blowing agent to achieve a porous structure. By a simple one-pot reaction, we fabricated a soft, elastic porous xerogel sponge that could reach maximum water absorbency of 180 in less than 200 seconds. This SPA-co-chitosan xerogel sponge demonstrated superior hemostatic properties in thromboelastography (TEGs) test and in a rabbit lethal extremity arterial bleeding model as compared to zeolite granules, kaolin gauze, and chitosan granules. Furthermore, this hemostat worked as a whole to transfer external pressure to the bleeding area and was adhesive to wet wound tissue to seal the bleeding site. In general, the SPA-co-CTS sponge demonstrates a fast and powerful hemostatic effect both in vitro and in vivo, which is superior over the existing commercial products. It might be a promising first-aid device for severe hemorrhage control.

Contribution ID: 96
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.06. Drug delivery systems

Translating a conformational change of biomolecule into macroscopic swelling/shrinking in dynamic hydrogels

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Hydrogels are water-swollen polymer networks that have found a range of applications from drug delivery to regenerative
medicine. Historically, their design has consisted mainly of static systems and those that undergo simple degradation.
However, advances in polymer synthesis and processing have led to a new generation of dynamic systems that are capable of responding to artificial triggers and biological signals with spatial precision. These systems will open up new possibilities for hydrogels as model biological structures and in tissue regeneration.
In this presentation, we will report the evolution of hydrogel design towards dynamic behavior and particularly emphasize recent developments in hydrogel design that offer the ability to precisely control trigger-responsive properties.

Contribution ID: 401
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.06. Drug delivery systems

Synthesis and characterization of manganese-doped mesoporous silica nanopowder produced by a pulsed electron beam evaporation for drug delivery

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The purposes of this research were production and analysis of properties of manganese-doped mesoporous silica nanopowders (NP SiO2-MnO2) for drug delivery. NP SiO2-MnO2 with different

dopant concentrations were produced by the physical method of electron beam evaporation in vacuum on NANOBIM-2 installation.
According to BET-analysis, produced NP SiO2-MnO2 with 0.1, 3, 5 % of dopant concentration are highly porous with high pore volume accounted for 0.36, 0.88, 0.52 cm3/g, respectively. The Sssa has risen with the increasing of dopant concentration. The average pore size is 22.6 nm. The porosity and Sssa basically determine the loading capacity of NP, so for toxicity and loading experiments SiO2-3%MnO2 NP was chosen as the sample with the highest values of defining parameters.
The XRD analysis demonstrated that NP SiO2-MnO2 are completely amorphous.
By means of magnetic measurements, it is established that NP SiO2 – MnO2 show ferromagnetic behavior. The increasing of ferromagnetic response, which could be caused by structural defectiveness, was observed with the increasing of manganese dopant concentration. Due to the magnetic properties, using an external high-gradient magnetic field is the possible way to target specific locations in the organism.
In vitro cytotoxicity was carried out on the human dermal fibroblasts using a cytometer. The calculated cytotoxicity index of NP SiO2-3%MnO2 (500 μg / ml) suspensions was 40% (36% control), so it can be concluded that NP exerted low toxicity.
Loading experiments showed qualitative interactions of antibiotic “Amoxicillin” with NP surface. The spectrophotometric analysis of sonicated NP suspensions with the addition of drug showed that optical density of suspensions with drug increased by 15% in comparison with increasing by 200% of pure solution of drug.
To sum up, amorphous mesoporous NP SiO2-MnO2, produced by a pulsed electron beam evaporation, are the potential material for creating targeted drug delivering system.

Contribution ID: 472
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.06. Drug delivery systems

Redox-responsive nanophotosensitizer composed of water-soluble chitosan and chlorin e6 for photodynamic therapy of gastrointestinal cells

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Photodynamic therapy (PDT) is regarded as an efficient palliative candidate for the treatment of various kinds of cancers. PDT is believed to be a safe treatment for human body because it is composed of light, oxygen and photosensitizer. Photosensitizer is known to be activated at specific wavelength and then generated reactive oxygen species (ROS) while it is non-toxic in the absence of light. However, conventional photosensitizer has low specificity against tumor tissues and penetration depth.
The aim of this study is to synthesize redox-responsive nanophotosensitizers using photosenstizer and methoxy poly(ethylene glycol)-g-chitosan (ChitoPEG) copolymer. Chlorin e6 (Ce6) was used as a model photosensitizer. Ce6 was conjugated with ChitoPEG copolymer using diseleno compounds. Nanophotosensitizers have spherical shapes and small diameter ranged about 70nm~200nm according to photosensitizer contents. Their PDT effect was assessed with colon cancer cells such as CT26 and HCT116 cells. Nanophotosensitizers showed redox-sensitivity, i.e. fluorescence intensity was gradually increased according to the dose of hydrogen peroxide. They showed significantly enhanced uptake ratio of Ce6 into tumor cells and then higher ROS generation rather than Ce6 itself. Furthermore, they also showed higher photo-toxicity against tumor cells than Ce6 itself in vitro. We suggest redox-responsive nanophotosensitizers as a promising candidate for PDT of human colon cancers.

Contribution ID: 523
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.06. Drug delivery systems

Design of Dual-drug Chitosan-based Nanotherapeutic system to Synergize Anti-lung cancer Treatment

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A nanotechnology-based dual-drug delivery system was reported to against non-small cell lung cancer (NSCLC), a highly malignant tumor taken ~85% of the lung cancer population worldwide and has been one of the most deadly tumors among others. This work synergizes two chemo-drug, namely cisplatin (CDDP) and a Chinese herbal extract demethoxycurcumin (DMC) entrapping into a single nanocarrier, which is known as amphiphilic carboxymethyl-hexanoyl chitosan (CHC). The use of DMC is originated from its highly-potent MDR-suppressed nature. A challenge in dual-drug encapsulation with high efficiency has been optimized, where the amphiphilic nature of the CHC allowed both hydrophilic CDDP and hydrophobic DMC to be co-encapsulated under optimized synthesis protocol, forming a sphere-like nanocarrier with an average size of 150-nm diameter. A tumor-specific EGFR antibody was modified onto the surface of CHC/CDDP-DMC nanoparticle for tumor targeting. The efficiency of tumor inhibition from multifunctional CHC/CDDP-DMC@antiEGFR nanoparticles was then evaluated in vitro and iin-vivo. IC50 and combination index of different CDDP-DMC ratios, a synergy presentation, was determined through Chou-Talalay's Plot. The mechanism of dual-drug synergy in NSCLC cancer was disclosed via Western blot analysis, where the variation of cell signaling was specifically highlighted in this report. According to experimental outcomes, CHC/CDDP-DMC@antiEGFR nanoparticles was proved to be an outstanding anti-cancer formulation with high synergistic efficiency on NSCLC inhibition. It is expecting that by utilizing this dual-biomarker design concept, the use of biocompatible and biodegradable CHC nanocarrier is able to provide a promising impact on clinical translation to against lung cancer.

Contribution ID: 1013
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.06. Drug delivery systems

An interesting approach for hospital-acquired infections. PVA/CHI/AMP as a valuable drug delivery system

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New combination of polymers, synthetic (polyvinyl alcohol-PVA) with naturals counterparts (chitosan-CHI) have been proposed as a new bio-artificial polymeric systems (BAMS) with remarkable behavior due to the mechanical, physical, and biological properties that the final material could possess. These properties may be brought by the harmonious effect of the individual components. In this context, the mentioned combination could be referred as a potential biomedical system used as a hydrogel, biofilm, artificial skin, wound-dressing, or drug delivery system. Regardless of their inherent properties, the lack of bacteriostatic or bactericidal properties

have triggered the studies of antibacterial systems which are related to decrease the high costs of medical treatments and death of patients after some surgical procedures. As a matter of fact, the present research has been focused in the study of the performance of a PVA-CHI system. Despite of several studies of the antibacterial activity of the CHI itself, this property should be reinforced with an antibacterial substance such as sodium ampicillin (AMP). For this particular case, aqueous solutions of PVA at 1 % wt were mixed with acid solution of CHI at 1 % wt followed by additions of sodium ampicillin running from 0.3 % to 1.5 % wt related to the total amount of the polymer. The obtained films will be tested with common infectious strains related to hospital-acquired infections; among them Staphylococcus aureus and Eshcerichia coli are included. It is expected that the resultant samples might show reinforced physical properties and enhanced bactericidal activity due to the interactions occur between the polymers. In addition, the AMP is known for its wide antibiotic spectrum that, uniformly distributed, may influence the mechanical behavior of the system, allowing it to be used as a controlled drug delivery system.

Contribution ID: 1538
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.06. Drug delivery systems

Greener click chemistry for the functionalization of biopolymers using supercritical CO2 as solvent

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Most of the drug related allergies is suspected that could be in relation with a deficient removal of synthesis and manufacture residues. This issue is even more critical in polymers destined to controlled drug delivery because the objective is that have a prolonged stay in the body until being biodegraded and bioabsorbed by the body. Supercritical CO2 is finding application in the production of pharmaceutical related products due to their ability to solve difficult process, particulation and formulation problems.
Click chemistry emerged two decades ago as one of the most promising reaction pathways for drug synthesis because it is classified as a very specific, efficient and versatile reaction which allow to obtain high products yields. Within the reactions included in the field of click chemistry, Huisgen 1,3-dipolar cycloaddition is the most employed in polymer chemistry where DMF or THF are the most common solvents used for functionalization.
For the first time the functionalization via click chemistry of polylactic acid (PLA) with coumarin in supercritical conditions CO2 has been achieved, with a yield higher than 95%. Once click functionalization of PLA in scCO2 was achieved the influence of operational conditions on the polymer characteristics and in the yield was studied to get an optimized functionalization process. The use of scCO2 allows the polymer functionalization without the necessity of using organic solvents to solubilize all the substances used in the reaction, solving so the potential problems caused by traditional solvents.

Contribution ID: 1539
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.06. Drug delivery systems

Impregnation and foaming of PLGA matrixes using supercritical CO2 for drug delivery systems

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Supercritical fluids (SCF) are used to produce different types of biomaterials and it is proposed as the best green technology in the production of micro-, nanoparticles and scaffolds for drug delivery systems. Among the most important reasons to use SCF in the production of polymeric scaffolds are: SCFs leads to the complete solvents elimination, the formation of smaller cells and the control its size, distribution and morphology.
Moreover, some studies have demonstrated the production of foams by using polymer in solution. This is a promising alternative to avoid the necessity of working at high temperatures besides the polymer and drug degradation. The proper solvent in the formation of polymeric foams should be established according to the FDA. Thus, Ethyl Lactate (EL) is a safe, non-toxic, volatile and non-hygroscopic solvent whose use in the process is highly advantageous.
In this work, Poly (lactic-co-glycolic acid) (PLGA) was selected thanks to its degradability and biocompatibility. The production of polymeric foams and its morphology was investigated trough a design of experiments by varying the initial concentration of the polymer and the drug in the solvent, the operation pressure and depressurization time.

Contribution ID: 1666
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.06. Drug delivery systems

Fabrication and characterization of chitosan microspheres/ CEL2 bioactive glass scaffolds with acetaminophen releasing function

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Ceramic materials with medical applications have become an interesting field of research and development in the manufacture of bone implants. Including drugs in these materials would be an important advance for the field of health; this would impact in a proportional way to the economic world. The interest in the controlled release of drugs through carriers has increased in recent years. Recent studies have shown that microspheres of biodegradable biopolymers are excellent vehicle for the controlled, localized drug delivery.
Biopolymers are usually used in the preparation of microspheres focused drug delivery because it is not necessary to remove them inside body.
In this context, chitosan is a good candidate because it is biocompatible, biodegradable and antimicrobial polymer. Solvent evaporation method is widely used in the preparation of microspheres made of biodegradable polymers.
The objective of this work was to apply an accurate preparation of scaffolds by the CEL2 bioactive glass (SiO_2-P_2O_5-CaO-MgO-K_2O-Na_2O) and chitosan microspheres, which were incorporated by immersion to the scaffold walls for controlled release of acetaminophen, which is an anti-inflammatory drug and it is used as a drug model. Chitosan microspheres with a mean particle size 1 to 2.3 μm loaded with acetaminophen were obtained by oil-in water single emulsion solvent evaporation method and applied to the surface of bioactive glass scaffolds by immersion technique. The microspheres and their interface were characterized by scanning electron microscopy, X-ray diffraction, differential scanning calorimetric, infrared spectroscopy and their mechanical properties were studied.
The microspheres were to be homogeneously dispersed on the scaffold surfaces. . The acetaminophen encapsulation efficiency (EE) was release from the microsphere loaded scaffolds lasted almost 21 days and was determined to be diffusion controlled. The microsphere loaded CEL2 scaffolds with acetaminophen releasing capability obtained in this study are a candidate for tissue engineering.

Contribution ID: 1779
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.06. Drug delivery systems

Fabrication of graphene oxide-carboxymethyl cellulose nanocomposite hydrogels for pH-sensitive, controlled release of doxorubicin

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Graphene oxide (GO)-based nanomaterials possess unique structures and behaviors leading to their wide biomedical application especially in biosensors, targeted drug delivery systems, and bioinspired materials. Combining GO with biopolymers may improve its solubility and biocompatibility, and other functionalities such as temperature- and pH-response. In this study, nanocomposite hydrogels were obtained by physically cross-linked carboxymethyl cellulose (CMC) with GO nanoparticles to produce a pH-sensitive drug carrier with selective drug-release properties. GO nanoparticles were prepared according to the modified Hummers' method. A 'greener' method was employed by eliminating the use of sodium nitrate in the process to avoid the generation of toxic NOx gases. Characteristics, chemical structure, and morphology of GO and the prepared hydrogels were identified using Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and field emission scanning electron microscopy (FESEM). Swelling behavior of GO-CMC nanocomposite hydrogels was investigated in phosphate-buffered saline (PBS) solution with various pH (pH 1.2, 6.8 and 7.4). Anticancer drug doxorubicin (DOX) was selected to study the drug loading/releasing profiles and cytotoxicity measurement. The effect of GO mass loading in nanocomposite hydrogels on DOX loading capacity and its release profiles was also studied. We observed that the presence of GO within hydrogels resulted in higher loading capacity of DOX onto GO-CMC nanocomposite hydrogels. The release profile of DOX from hydrogels beads indicated a strong pH-sensitive behavior within the range of pH studied. The reduction in drug release may be due to strong interactions among amine groups of DOX and carboxylic groups of GO. Biocompatibility test of GO-CMC nanocomposite hydrogels showed no cytotoxicity towards L929 cell lines. The GO-CMC/DOX complex showed an obvious loss of cell viability against breast cancer cell lines, thus the CMC-GO/DOX has the potential for selectively killing cancer cells in vitro.

Contribution ID: 1849
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.06. Drug delivery systems

Synergistic effect of photodynamic treatment and cold plasma against gastrointestinal cancer

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Cold atmospheric plasma (CAP) is has been considered as a safe treatment option for cancer therapy. Cancer cell viability is known to be inhibited by generation of reactive oxygen species (ROS) by CAP treatment and then induces apoptosis of cancer cells.
Photodynamic therapy (PDT) is also regarded as an safe and effective treatment option for cancer patient.
Photosensitizer such as chlorin e6 (Ce6) produces excessive ROS in cancer cells and this induces apoptotic death of cancer cells. The aim of this study is to study synergistic effect of PDT and CAP treatment against gastrointestinal cancer cells. HuCC-T1 human cholangiocarcinoma cells and CT26 colon cancer cells were maintained in RPMI1640 medium. cancer cells (1×10^4 cells/well) were exposed to various concentration of Ce6 and irradiated at 664nm light (2J/cm2) with or without CAP (60s). This was incubated for 1 day and viability was measured with MTT assay. ROS generation was investigated by DCFH-DA assay.
PDT treatment using Ce6 inhibited viability of CT26 cells and HuCC-T1 cells dose-dependently. Viability of cancer cells was properly decreased at higher than 1microgram/ml Ce6 concentration. Viability of cells was significantly inhibited when CAP was simultaneously treated to this cells. Futhermore, combination of Ce6 and CAP treatment also significantly increase ROS generation in cells.

Contribution ID: 730
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.07. Current advances in stem cell biology

Cryopreservation of stem cells within intact alginate microspheres

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The possibility of long-term storage of clinically relevant cells combined with daily availability of genetically stable materials gives cryopreservation a high potential in modern cell therapeutics. Although cryopreservation of alginate-encapsulated cells is very promising for further clinical application, there is still no optimal cryopreservation protocol for freezing and thawing of cells within intact and mechanically stable alginate microspheres. In this work, a range of parameters such as alginate crosslinking time, concentration of dimethyl sulfoxide, its loading time and cooling rate were analysed. The structural integrity was evaluated upon freeze-thaw cycles using an Axio Imager M1m microscope with Linkam cryostage to identify an optimal combination. Verification of optimal cryopreservation protocol yielding intact capsules has been performed using multipotent stromal cells (MSCs) derived from the common marmoset (Callithrix jacchus). Freezing of alginate-encapsulated cells has been conducted using a controlled-rate freezer Planer Kryo 560-16. Analysis of cell viability after thawing and subsequent culture for 24 h (recultivation) has been performed using live-dead Calcein AM / Ethidium homodimer assay following image analysis using ImageJ and MicroVision software. Among the optimal conditions, the following ones yielded the highest cell viability of 60% after thawing: crosslinking time 15 min, 10% (v/v) of dimethyl sulfoxide, incubation time at 4°C of 45 min and a cooling rate of 2.5 K/min. Moreover, considering 75% of viable cells before cryopreservation, the viability analysis yielded 83% of encapsulated cells, which survived the cryopreservation process. The results of this study are the first report of cryopreservation of alginate-encapsulated cells within intact structure after thawing thus having a high potential for clinical application of mechanically stable alginate capsules for efficient treatment of rare diseases.
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Contribution ID: 740
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.07. Current advances in stem cell biology

Modern semiautomatic setup for testing cell migration with impact to therapy of myocardial infarction

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Ischemic heart disease followed with myocardial infarction (MI) is one of the main cause of morbidity and mortality. Cardioprotection after MI is based on traditional surgery and pharmaceutical applications, and also on modern strategy to affect the leucocytes and progenitor/stem cell migration.
Modern therapeutical strategy based on activation of progenitor/stem cell migration or reduction of inflammatory cell migration in MI regions was proposed in last 15 years as a results of physiological observation on experimental animals. Published data from direct measurements of cells migration and evaluation of migration speed in different conditions are limited. We present a universal setup, which can be used for testing of the cell migration in cardiac or cardiac-like tissue. The setup brings a possibility of microenvironment setting and time-lapse experiments on cell migration.
The experimental setup was built on the platform of Leica TCS confocal microscope. The micro-chamber on microscope can adopt 2D or 3D substrate, which mimic various properties of the native cardiac tissue and distribution of chemoattractant. The micro-chamber was aseptic and connected to a temperature regulator, gas detectors and gas reservoirs (O_2 and CO_2). The cells tested for their migration potential were injected to some starting point on the substrate. The microscope allowed imaging of cells in micrometer-resolution every 2 minutes. Our software tools provided precise 2D and 3D tracking of moving cells and data export for statistical analysis. Mesenchymal stromal cells (MSC) were used for our experiments. Results show that geometry of tissue and gradient of chemoattractant had significant influence on direction of cell migration. Setting of hypoxic environment modified speed of cell migration.
In future, the setup will be rearranged to fully-automatic preclinical screening tool, which could be used for examination patient´s MSC and leucocytes.

Contribution ID: 1180
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.07. Current advances in stem cell biology

Investigation of in vitro neural differentiation of olfactory mucosal mesenchymal stem cells in 2D and 3D

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Effective treatment methods for nerodegenerative diseases are not available yet. The lack of effective treatment methods has emerged as a serious and immediate problem that could potentially be solved by bioengineering applications such as neural tissue engineering. Neural regeneration can be achieved to a larger extent by tissue engineering approaches, such as supporting isolated cells with neurotrophic factors and extracellular matrices. Stem cells, because

of their unique features such as self-renewal and differentiation, have become a focus in neural tissue engineering applications, and are thought to have capability for neural differentiation.
The aim of this study is to support the neural differentiation of olfactory mucosal mesenchymal stem cells by tissue engineering approach. Olfactory mucosal mesenchymal stem cells are tested for their 2D and 3D in vitro neural differentiation capacity. Neural differentiation is supported by a self-assembling peptide gel. Peptide gels are known as perfect candidates for neural regeneration due to their ability to support the neural cell differentiation, proliferation and migration.
Peptide gels are added onto the stem cells when working on a two-dimensional structure. When forming a three-dimensional construct, stem cells are mixed with the peptide gel before injecting in culture dishes. Both experimental steps are cultured in media supported by the combination of various neural growth factors. Immunofluorescence staining is applied to detect the differentiation of stem cells into neural cells. Antibodies such as GFAP, O4, β-III tubulin, synaptophysin and neurofilament 200 are used as markers of neural differentiation.
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Contribution ID: 1206
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.07. Current advances in stem cell biology

Influence of mechanical stimulation on differentiation of adipose stem cells into osteoblasts in bioreactor

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Mechanical stimulation combined with additives like β-glycerol phosphate, dexamethasone, ascorbic acid promotes differentiation of adipose derived stem cells into osteoblasts. The aim of this study was to develop and validate system for mechanical stimulation promoting in-vitro osteogenesis under conditions mimicking in-vivo bone microenvironment. This system consists of cultivation chamber and pulsatile/perfusion generator. The uniqueness of cultivation chamber lies in possibility to cultivate cells on different types of rigid planar substrates – glass (model substrate), titanium alloys used in osteosynthesis (pure Ti or Ti6Al4V alloys), nanofibers and their modifications with nanodiamond and polymer coating, used for advanced tissue engineered bone repairs. To achieve three-dimensional structure of cells a fibrin gel is used as temporary scaffold. The pulsatile pump is generating microperfusion with pressure stimulation. This stimulation can be controlled in manner of amplitude (up to 100 kPa) and frequency (up to 2 Hz). It was performed a series of culture experiments, where the cells were seeded and stimulated up to 14 days under different conditions. The analysis of the proteins expression was done, especially alkaline phosphatase, collagen type I, osteocalcin and osteopontin as markers of osteogenic differentiation. These results demonstrated the effectiveness of mechanical stimulation in contrast with static culture including the static culture with osteogenic culture media.

Contribution ID: 1285
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.07. Current advances in stem cell biology

Anti-tumor potential of astragalus polysaccharides on breast cancer cell line mediated by macrophage activation

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Adverse effects are pressing challenges produced by chemotherapy and radiotherapy for the treatment of breast cancer. Nontoxic herbal medicines are therefore considered as favorable alternative. Astragalus membranaceus has attracted growing interest in biomedical field responsible for its various activities, among which the anticancer activity is considered to be closely associated with its active component-astragalus polysaccharide (APS). Currently, direct anti-tumor activity and the activation of immune response of host have been widely acknowledged as the mechanism by which APS exerts anti-cancer effect. In this study, we aimed to investigate whether APS could inhibit MCF-7 growth and active macrophages to further kill cancer cells. The results indicated that the obtained APS was pyran configuration of polysaccharide and contained 89.75% total carbohydrate and a minor amount of uronic acid (9.3%). APS failed to significantly inhibit MCF-7 cells growth. Encouragingly, APS-activated RAW264.7 macrophages present anti-cancer activity as evidence by (a) cell proliferation inhibition (41% inhibitory rate), (b) G1-phase cell cycle arrest, as well as (c) apoptosis-related genes (Bax/Bcl-2) regulation (13.26 fold increase than untreated cells). In addition, APS could upregulate nitric oxide (NO) and tumor necrosis factor-α (TNF-α) production, which acted as the tumor cell apoptosis inducer. Collectively, our findings suggest that APS can active macrophages to release NO and TNF-α, which directly blocks cancer cell growth. The anti-breast cancer effect of APS and action mechanism in vivo will be further elucidated with a review to provide a therapeutic strategy for breast cancer.

Contribution ID: 742
15. Biomaterials, Cellular and Tissue Engineering, Artificial Organs
15.08. Neurocultures

A near real-time closed-loop system of an in vitro neuronal network and a digital signal processor via a microelectrode array

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Microelectrode arrays (MEAs) are used to measure the extracellular electrical activity of in vitro neuronal networks. A MEA experiment usually involves observing the network activity in time, often accompanied by an electrical or chemical stimulation paradigm applied on the neuronal cells. The possible stimulation paradigm has been defined beforehand to address a question at hand. The measured extracellular MEA data is then mostly analyzed off-line. This means that during the experiment, the in vitro network is functioning by itself without experiencing I/O with its external environment.
Here is presented a closed-loop system that analyzes MEA measurements near real-time in a digital signal processor (DSP), and applies electrical stimulation based on the analysis results and a communications logic, which may be adaptive. I.e., the in vitro neuronal network under study is in near real-time I/O communications with the DSP via the MEA. Here, the DSP is the Texas Instruments TMS320C6454 DSP embedded in a MEA2100-System by Multi Channel Systems MCS GmbH, Reutlingen, Germany.
Such close-loop systems present a paradigm shift in in vitro neuroscience: In nature, local neuronal networks function in continuous communications with other neuronal networks in the system. With a close-loop system, it is possible at least to some extent mimic this natural setting. It can be expected that more information on the functioning of neuronal networks can be obtained by

novel network analysis paradigms based on continuous interaction and interrogation, made possible by closed-loop systems.
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Contribution ID: 295
16. Assistive Technologies
16.01. Telemedicine, distant monitoring, tele-homecare, and domotics

Evaluation example of touch screen operability of children for improvement of usability in digital textbooks for learners

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Digital textbooks and teaching materials equipped with a touch screen have been increasingly introduced into the classroom and utilized for children’s learning or teacher guidance. However, the touch screens have usability problems in the context of teaching materials that children use for learning. Many previous studies regarding touch screen operability have been reported, but most of them were for adults or elderly people. Since a function of movement and cognition of children is different from that of adults or elderly people, operational characteristics for a user interface will be different. Therefore, it is necessary to newly evaluate the operational characteristics of children and to accumulate knowledge. In this study, we aimed to evaluate the touch screen operability of children in order to obtain a knowledge for improvement of usability of digital textbooks for learners. Concretely, the operational performance when changing the button size and spacing was compared between children and adults, focusing on button used as one of the typical GUI (Graphical User Interface) components in digital textbooks.
The participants were one female kindergarten child and five adults. The age of the child was five years old, the width of the forefinger was 9.4 mm, and the continuous use history of the touch screen was one year. The average age of adults was 20.2 years, the average width of the forefinger was 15.3 mm. The experimental factors were size and spacing of square button. To evaluate the accuracy and speed of the operation, “error rate”, “error of pointing position”, “pointing time” were adopted as evaluation indices.
As a result, it was shown that the operational characteristics of children and adults could differ from the viewpoint of accuracy and speed of operation and the distribution of pointing position.

Contribution ID: 300
16. Assistive Technologies
16.01. Telemedicine, distant monitoring, tele-homecare, and domotics

Effect of dot spacing on TRUCT Braille readability in Braille reading beginners

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Braille is an important communication tool for the visually impaired. In recent years, as a result of advances in Braille printing technology, the use of transparent resinous ultraviolet cured type (TRUCT) Braille has spread rapidly. However, learning Braille requires a great deal of time and the acquisition of various skills. Among the visually impaired due to accidents, disorders, and aging cannot adequately read Braille. One of the reasons is that Braille reading beginners are difficult to read the common Braille patterns for the visually impaired who already has mature Braille reading skill. Therefore, it is necessary to investigate the easy-to-read Braille patterns for Braille reading beginners. In this study, we evaluated the TRUCT Braille patterns that would make reading easier for Braille reading beginners. Especially, we conducted an experiment to reveal the relationship between dot spacing of TRUCT Braille and its readability.
Participants were ten sighted adults that were assumed to be people with acquired visual impairment. In this experiment, they were put a blindfold on and asked to read test pieces of TRUCT Braille. The experimental factors were vertical and horizontal dot spacing of TRUCT Braille. Both of them were six conditions (2.0, 2.3, 2.5, 2.7, 2.9, 3.1 [mm]). To evaluate the accuracy and speed of Braille reading, “accuracy rate”, “reading time”, and “sureness for Braille reading” were adopted as evaluation indices.
The results showed that Braille reading beginners could read Braille accurately and quickly, when vertical dot spacing is more than 3.1 mm and horizontal dot spacing is more than 2.9 mm. From this study, Braille reading beginners found it easy to read TRUCT Braille with adequate vertical and horizontal dot spacing.

Contribution ID: 377
16. Assistive Technologies
16.01. Telemedicine, distant monitoring, tele-homecare, and domotics

Measuring the response of patients with type I diabetes to stress load

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The aim is to present measurement methodology and systems for measuring and evaluating the response of patients with type I diabetes to stress load. Proposed methodology and systems are related to the research of the influence of type I diabetes on the response of the organism during the stress load and the possible impact of the reaction time on the working performance. Multi-sensory monitoring is designed to measure stress load. The main measurement method is direct monitoring of level of sugar in the blood. The second method is based on monitoring of physiological stress symptoms by measuring pulse rate, respiratory rate, blood pressure, temperature, galvanic skin resistance, and electrical activity of the muscles. In particular, it has been suggested to monitor the glycemic trend and the time from the stress stimulus, after which it starts to grow and then decrease. Under the guidance of psychologists, a methodology has been proposed and used to measure the stress load of diabetics, i.e. patients, and control group of healthy subjects. The benefits of the proposed measurement methodology and systems are important not only from a technical point of view in designing systems and algorithms for detecting psychological stress with monitoring systems, but also with regard to the treatment of subjects with diabetes I and the assessment of their physical / mental state during performing difficult working tasks. In particular, the point of view of the trend of sugar level development and the length of time in response to stress load is important. Measured physiological variables also allow the level of stress to be determined indirectly, and their use in practice during work is more appropriate.

Contribution ID: 397
16. Assistive Technologies
16.01. Telemedicine, distant monitoring, tele-homecare, and domotics

A wearable device for monitoring urine amount in bladder by using near-infrared spectrometer and ultrasound technology

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Neurogenic bladder dysfunction (NBD) is a major cause to the morbidity and mortality to subjects with spinal cord injury (SCI) who commonly have voiding dysfunction and loss of bladder fullness sensation. Bladder emptying with clean intermittent catheterization (CIC) is currently available measure to maintain urologic health with low urinary tract complication. However, patients have to rely on regularly scheduled urination to avoid overload in the bladder which greatly influence their quality of life (QOL). Although ultrasound techniques have been utilized to measure bladder volume in clinical with professional manipulation and in laying position, there is currently no effective way to monitor bladder in low-pressure storage and continuous monitoring for homecare and in different posture constraints. Our study aims are to develop an assistive device for non-invasive and ambulatory urodynamic monitoring in various posture positions (e.g. siting in wheelchair condition) based on wireless near infrared spectroscopy (NIRS) and miniature ultrasound sensing techniques.
A wearable NIRS module using optoelectronic method for measuring the changes in chromophore concentration related to oxygenation and hemodynamic changes in real time. This NIRS approach is particularly useful when the underlying pathology related to a disorder of oxidative metabolism or hemodynamics involving the bladder and or urinary sphincter. Ultrasound and inertial sensors will be utilized to measure the distance between abdominal with bladder urine which is useful for easy positioning.
The proposed measurement ultrasound positioning and non-invasive NIRS bladder hemodynamic measurement devices can be firstly validated in clinical setup for human healthy and SCI subject as a means of ambulatory monitoring of voiding. With recruitment of a SCI subject dedicating for this device, the developed device is designed for the needs of SCI subjects which not only will be validated in clinical setup but also tested for daily homecare toward optimal urination with CIC of SCI subjects.

Contribution ID: 604
16. Assistive Technologies
16.01. Telemedicine, distant monitoring, tele-homecare, and domotics

G.O.A.L. (Games for Older Active Life): a Web Application for cognitive impairment tele-rehabilitation

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Vascular Dementia (VaD) and Alzheimer's Disease (AD) are the major causes of advanced cognitive deficiency. Many studies have been initiated with the aim of identifying preventative approaches to be applied in the prodromal phase of neurodegenerative dementia, the so-called Mild Cognitive Impairment (MCI) and Vascular Cognitive Impairment (VCI). Serious Games (SGs) are computer games designed to be used in several contexts, recently proposed in the healthcare

sector, specifically in the evaluation and rehabilitation of psychiatric and neurological disorders. The main objective of the GOAL project is to test a suite of SGs on a group of subjects affected by MCI and VCI, presenting high risk of AD conversion, with the aim to characterize and quantify their functional, cognitive and motor skills. The games were implemented using “ad hoc” ICT tools, for longitudinal monitoring and rehabilitation management directly from home. In this context, the Web-Application GOAL-App was developed for giving patients a single familiar place for scheduled physical and cognitive trainings. GOAL-App integrates a motor module realized by the University of Florence in collaboration with Don Gnocchi Foundation, a BrainHQ cognitive module by Posit Science and a caregiver module by Gutenberg Srl. The motor module includes a physical training program delivered through guided video, and specific questionnaires about the performed activities. HTML5, Javascript and CSS have been used to create a clear, intuitive and extremely easy to use UI, in relation to the target. HTML5 allows the playback of videos directly on the browser without any plugins and the creation of a full-screen video player with intuitive controls. Alpaca JS was used for rendering HTML5 forms using JSON Schema. The back-end is JAVA-based. The preliminary results showed excellent feedback from the subjects, who regularly practice the proposed scheduled trainings.

Contribution ID: 866
16. Assistive Technologies
16.01. Telemedicine, distant monitoring, tele-homecare, and domotics

Wearable sensors and domotic environment for elderly people

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Technology is an important instrument for a new concept of home care and continuous monitoring. New and smaller devices and communication advances have constructed a more humanitarian model of assisted alternative to hospital. For this purpose an integral scheme must to consider physiological, emotional, social and environmental conditions that promote the multidisciplinary support for the patients.
In this work we present an Integral Assistive Home Care System, specially designed for elderly or chronic illness people. The approach proposed comprises a user wearable device, a domotic system’s core installed in a personal computer (PC) and an ichnographic software (SICAA) that allows the interaction of the patient with the environment and peripheral devices.
Wearable sensors system have a master module that deals with data acquisition, synchronization and wireless transmission, connected to sensors or slaves which acquire biological signals and process them to minimize the amount of data to be transmitted by Bluetooth. The biologic variables (each with its own specific acquisition and preprocessing module) acquired are temperature, heart rate and pulse oximetry, and kinetics measurements through an inertial sensor IMU.
The domotic SICAA soft and control hardware was designed to achieve some automatic tasks through an ichnographic software. The programmed functions comprises: house control (that comprises blinds, lights, orthopedic bed, air conditioner, television, and intercom); medication alarm; career communication (nurse call, voice synthesizer), and computer access (internet, chat, games, and text processors). The software must accomplish several requirements, regarding the limited experience with technology or reduced capabilities of the users. An intuitive interface, big buttons and vibrant colors were chosen for the software.
The entire system is low cost, modular and adaptable for different user’s capabilities and pathologies.

Contribution ID: 1088

16. Assistive Technologies
16.01. Telemedicine, distant monitoring, tele-homecare, and domotics

Development of Unobtrusive Heart Rate Monitoring System on the Chair for Daily Life

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Heart rate variability (HRV) is one of the important indices for a health condition. Heart rate (HR) is affected by the physiological phenomenon of variation in the time interval between heartbeats; its variation may contain warnings about impending cardiac diseases, or the status of the autonomic nervous system (ANS). HRV monitoring in daily life is important for screening study. There is a risk that sensor attachment would affect the status of ANS. Ideally, the subject should not be aware of being continuously monitored. Electrocardiogram (ECG) as typified by Holter ECG is usually used to monitor HRV. Photoplethysmograph (PPG) is increasingly used as pulse rate monitor in terms of comfort. However, these monitoring systems need to fit electrodes or devices to the skin surface. For unobtrusive monitoring in daily life, we developed the chair shaped monitoring system based on ballistocardiogram (BCG). This paper discusses the relationship between measurement sites and accuracy. The ECG heart rate (HR) was used as the gold standard, and the pulse rate (PR) obtained from the BCG were compared to the HR. Once the band-pass filter was obtained, the pulse rate was calculated by peak detection using predetermined thresholds. Two band-pass filters were used; 0.7-2.0 Hz and 4.0-10.0 Hz. The error rate for detecting pulse rate obtained from the BCG had location dependent. The sensor located on the back had the lowest error rate. The suitable frequency band for heartbeat detection differed depending on the sensor location. The aim of this study is to evaluate the effect of sensor location in HRV monitoring. Our data suggested that the backrest part on the chair was suitable for monitoring HRV.

Contribution ID: 1506
16. Assistive Technologies
16.01. Telemedicine, distant monitoring, tele-homecare, and domotics

Wearable wellness motivator for supporting permanent lifestyle change

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Lifestyle has the single most important role in maintaining or affecting general health condition of a person. Sedentary lifestyle and poor dietary habits are the main causes of increase in prevalence of cardiovascular diseases, obesity, type-2 diabetes, and metabolic syndrome in Western countries and recently also in Middle East and Asia.
We present a system designed for assisting people in obtaining healthier lifestyle. The system includes a monitoring device worn on the chest and a web portal that visualizes the measured parameters and provides the user motivating tips for helping with lifestyle change. The monitored parameters include heart rate, step count, calorie consumption, activity level, heart rate variability and sleep quality. A unique feature of the system is that the communication from the wearable unit to the backend server is arranged via direct mobile network connection, thus avoiding the need for a separate gateway device. The measured data can be viewed with a web browser user interface. We evaluated the beat-to-beat heart rate estimation performance with ten subjects in a controlled exercise protocol and with three subjects in 24-h free-living conditions. The average mean absolute

error of the R-R interval estimation was 8.0 ms and 6.4 ms in the two test scenarios, respectively and the corresponding coverages of the obtained individual R-R intervals 76 % and 94 %.
The chosen connectivity approach with direct mobile network access would also enable the use of the developed platform in scenarios where guaranteed connectivity for real-time data flow is important, such as outpatient monitoring of certain patient groups and surveillance of elderly suffering from mental decay. In the final paper, we will also discuss about requirements and critical design considerations related to direct connectivity with cellular network technology.

Contribution ID: 1798
16. Assistive Technologies
16.02. Internet of everything

Internet of Instruments - the future of instrument management in hospitals

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“Digitalisation”, “Internet of Things” and “Digital Transformation” are keywords well known from industry or consumer market. Though, also the healthcare sector is getting more and more interested in this trend, exploring the many possibilities the connected world can offer. Therefore, the wall between the analogue and the digital age is getting removed with each new product increasing the autonomous communication and decreasing inefficient tasks in a hospital.
One big issue occurring in hospitals is the difficult assessment management which mostly needs to be done by hand. Therefore, it is difficult to have an overview of the amount and state of the existing equipment. Furthermore, additional information about a single instrument like the age, sterilisation cycles and general state are not available.
One approach to solve these issues is the development of smart medical instruments, able to be identified within a blink of an eye, providing all needed data to the clinical staff. The identification and additional data can be implemented into an assessment management system with a possible connection to mobile devices. Thus, the whole equipment can be registered and updated in a single database. But the digitalisation doesn’t need to stop here. To increase the safety and give an immediate feedback to the surgeon, miniaturized sensors can be added to selected instruments, providing important data about the current task. These data can be displayed with an external device like a screen or smartphone. To provide a safe use, these sensors need to be either sterilisable or single use that no contamination of the patient is possible.
The digitalisation offers a multitude of possible new ways supporting clinical staff in their daily work. The approach presented in this work shall ease the organisation and use of medical instruments significantly.

Contribution ID: 1800
16. Assistive Technologies
16.02. Internet of everything

Self powered sterilisable IoT modules in healthcare

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Digitalization and Internet of Things (IoT) has numerous applications in healthcare, from remote patient monitoring to smart devices. It is easy to imagine the idea of "connected hospital" with traceable, smart surgical instruments, container and devices. Even so, the application of IoT

technology in medical facilities is still in the infancy. This is caused because of the few reasons. One of the biggest challenges with digitalization of surgical devices is the steam sterilisation process involving high temperature and pressure. Such an environment can destroy the electronics and power source of the sensor causing the device failure and in worst case may lead to the battery explosion.
Thus, our aim was to design an energy source module based on partially insulated thermoelectric generators (TEG) combined with high-temperature resistant power storage with possible connection to different communication modules enabling IoT integration with the cloud. In our approach we use partially insulated TEG in the way that the hot side of the generator is exposed to the temperature inside the autoclave and the cold side is connected to a heat-storage which is insulated with aerogel-based materials. The generated power can be then stored or used for feeding the different sensor nodes or communication devices. The energy management algorithms keep the track on how much power is consumed by the electronics and optimize the life time of the node.
The first prototypes proved that we are able to power up a Bluetooth module with the temperature difference gained by the sterilisation as well as log the sensor data. Our design allows flexibility in modification and further increase of efficiency by using organic easy-to-shape TEGs. Due to these reasons we plan to miniaturize the module and embed it in surgical instrument in the near future allowing it to become a real IoT device.

Contribution ID: 1295
17. Biological Effects of Electromagnetic Fields
17.01. Biological effects of non-ionizing radiation

The effects of electromagnetic fields on human health

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Since The beginning of the 20th century, we are overwhelmed by the increasing sources of the Electromagnetic Field (EMF) that is coming from telecommunication, electricity, appliances, medical equipment, and many other apparatus that we use in our daily life. Although these new technologies became inevitable and indispensable, the EMF they produce may cause health risks and hazards to human.
Some studies show a link between exposure to EMF and increased rate of Leukemia, cancer, brain tumors and other health problems. Also, there is some uncertainty remains as to the actual mechanisms responsible for these biological hazards and which type of fields magnetic or electric or both are of great concern.
It is needless to say that no matter the effects of these EMF be trivial or catastrophic, we should take all the necessary precautions to reduce our exposure to EMF as low as reasonably attainable. For this to occur, all those involved or affected by this exposure should follow the RF safety standards and guidelines set forth by the regulatory authorities like the IEEE, WHO, ICNIRP, and other likewise organizations.

Contribution ID: 1872
17. Biological Effects of Electromagnetic Fields
17.01. Biological effects of non-ionizing radiation

Pulsed electromagnetic field at frequency and intensity resembling calcium ion cyclotron resonance selectively impairs breast cancer cell through apoptosis

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Background and Objective: Breast cancer (BC) is the most common women cancer worldwide. Radiotherapy and chemotherapy as the two common BC treatment options suffer low selectivity and adverse effects on surrounding normal tissues. Non-ionizing pulsed electromagnetic fields (PEMFs) at specific frequencies and intensities have shown anticancer effects. Changing calcium (Ca2+) activities has been reportedly a main mechanism regulating several physiological functions and cell proliferation. PEMFs at ion cyclotron resonance (ICR) tuned to main biological ions particularly Ca2+ reportedly could modulate cell proliferation. The present study aims to comparatively investigate the effects of PEMF at frequency and intensity resembling Ca2+-ICR condition (50 Hz, 65.27 μT) on cancerous (MCF-7) and normal breast cells (MCF-10) using MTN assay and flow cytometry.
Method: The both cell lines were treated by PEMF (50 HZ, 65.27 μT) for 24 and 48 h in a special purpose built PEMF generator that generated uniform magnetic fields resembling the Ca2+-ICR condition. The cell viability and apoptosis percentage were assessed using MTT assay and flow cytometry, respectively. Annexin V apoptosis assay was used for flow cytometry.
Results: In the PEMF with 24 h exposure time, viability percentage of cancer cells significantly decreased compared to the normal cells (P=0.001) (71.18% versus 92.7%). Interestingly, proliferation in MCF-10 cells significantly increased as exposure time increased from 24 to 48 h (P=0.001), whereas the mortality rate in MCF-7 cell line significantly increased by 61.5%. In the 48 h exposure time, late and early apoptosis percentage significantly increased in MCF-7 cells, compared to the normal MCF-10 cells (9.96% and 9.41%)(P= 0.001).
Conclusion: PEMF with Ca2+-ICR condition selectively impaired breast cancer cell viability while did not affect normal cell line. Induction of apoptosis seems the main mechanism of actions of cell death in the cancerous breast cell line under PEMF exposure.

Contribution ID: 17
17. Biological Effects of Electromagnetic Fields
17.02. Modelling

Bone Fracture Treatment via Dielectrophoretic Forces – a simulation research

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In this research, we present a novel method for shortening fracture healing times based on the use of dielectrophoretic forces (DEPFs). The DEPFs can be used to manipulate blood flow at a fracture site, promote vascularization, increase transmembrane signaling, nutrient supplies, hormones and growth factors at the fracture site and hence may help fracture healing. We present a theory that tests the non-uniformity of the DEPFs. We name this new theorem as non-uniform theorem (NUT). NUT examines the non-linearity of electric field lines for dielectrophoresis. And, for the simulation of the coil types (I, Ɔ, Ͼ), we analytically propose three new equations define dielectrophoresis explicitly. By Wolfram Mathematica, we numerically analyzed the dielectrophoretic forces for a long bone fracture where the main arteries are vertically-oriented and the blood flows downward. The gravitational and the drag forces on the red blood cells determine the steady state blood flow. The dielectrophoretic force added to the system is functional in increase of the blood flow. The ratio of the velocity in the presence of dielectrophoresis to the velocity without dielectrophoresis (called here as the Dielectrophoretic Force Factor, KDEpF) is a precise measure of the functionality of the dielectrophoresis, as it indicates the speeding up blood flow. The dielectrophoretic force reaches climax at very low frequency band. The simulation result is that at 10 Hz, the average value of KDEpF is 2.20, 2.60 and 2.00 for the I, Ɔ, Ͼ coils, respectively. The Ɔ coil results in the best DEPF and therefore would be the configuration to use in an experimental study to determine if DEPF is beneficial for fracture healing.

Contribution ID: 804
17. Biological Effects of Electromagnetic Fields
17.02. Modelling

The mobility of 53BP1 DNA damage foci induced by X-rays, alpha and mixed beam radiation

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DNA double strand breaks (DSBs) are critical DNA lesions which may lead to gross chromosomal rearrangements, mutations and cell death. During DNA repair histone alterations, nucleosome repositioning and changes in higher-order folding of the chromatin fibre cause significant accumulation of proteins in the lesions areas. These protein clusters form nuclear foci which may be visible by light microscopy. In this experiment 53BP1 foci were tracked during the live-cell observation to study their mobility which affects the probability of the successful lesion repair. U2OS osteosarcoma cells were irradiated with 1 Gy of alpha particles, 1 Gy of X-rays and a combination of these two: 0,5 Gy of alpha particles and 0,5 Gy of X-rays and were analysed along with control sample. Random walk behaviour of the foci was observed and the sub-diffusion model was used to describe focus mobility. Mean square displacement analysis of the foci indicates that the mobility increases together with the LET (linear energy transfer) of the radiation. Mixed beam-induced foci show a low degree of mobility, possibly contributing to an augmented misrepair of damage.

Contribution ID: 1149
17. Biological Effects of Electromagnetic Fields
17.02. Modelling

Evaluation by numerical modelling the electrodynamic effects caused by radiofrequency identification (RFID) system readers to the user of hearing implant

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Hearing loss can be sufficiently compensated by bone conduction implants of various types. Hearing implant user may experience environmental exposure to electromagnetic fields during work, including exposure from radiofrequency identification (RFID) systems. The most common worldwide RFID systems use frequency bands: low frequency (30-300kHz), high frequency (3-30MHz) and ultra-high frequency (860–960MHz).
The aim of this study was to evaluate the impact caused by hearing implant on electrodynamic effects in user, expressed as localized specific energy absorption rate (SAR) in body (head and trunk), averaged in any 10g of continuous tissue. This impact was expressed as the ratio between the SAR in the tissues of the user (near the implant), and in the tissues of a regular person (without the implant), exposed under the same conditions.
The numerically modelled bone conduction hearing implant was inserted into the numerical model of head. Thickness of skin, fat, skull and brain layers in the phantom were modelled with respect to

values reported from the group of people being implanted. The considered source of electromagnetic field exposure was desktop antenna of RFID system reader. Numerical simulations standard uncertainty was estimated to be approximately ± 25%, within the range accepted by international standards.
It was found that the use of bone conduction hearing implant significantly increase the level of electrodynamics effects in the implant user - caused by electromagnetic field from RFID readers. The use of such hearing implant may be a contraindication for the work activities involving exposure near the RFID readers.
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Contribution ID: 1634
17. Biological Effects of Electromagnetic Fields
17.02. Modelling

From cell to tissue properties – modeling skin electroporation with pore and local transport region formation

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Transdermal drug delivery is non-invasive, quick and it avoids gastro-intestinal degradation. Since skin is a barrier few drugs can penetrate, various enhancement methods are used to improve drug delivery, among them, electroporation. It is believed that electric pulses cause formation of regions of increased electrical conductivity in the stratum corneum through which the transport occurs – i.e., local transport regions. Because the electric conductivity of stratum corneum decreases, the electric field can penetrate deeper and cause electroporation of cells in lower layers.
Current models of tissue electroporation either describe tissue with its bulk properties or include cell level properties, but model only a few cells of simple shapes in low-volume fractions or two-dimensions. Skin is modeled with rough approximations of bulk properties of separate layers. Even if the formation of the local transport regions is included, electroporation of cells in lower layers is not.
We constructed a three-dimensional model of realistically shaped corneocyte (for stratum corneum), keratinocyte (for epidermis) and papillary dermis in realistic volume fractions and calculated equivalent dielectric properties of skin layers before electroporation. We modeled local transport regions and increase in their radii or density in the stratum corneum and pore formation on keratinocytes and lipid spheres of the papillary dermis.
Our model was validated with voltage-current measurements. We accurately described measurements during application of long low-voltage pulses and voltage drop on the skin during application of short high-voltage pulses. However, during application of short high-voltage pulses, additional processes increased the electric current.
Our model connects processes occurring on cell membranes, and skin layer with the tissue and even organ. Similarly, electroporation of any tissue could be modeled, if the geometric and dielectric properties of single cells are known.
This research was supported by the Slovenian Research Agency and was conducted in the scope of the LEA-EBAM.

Contribution ID: 437
17. Biological Effects of Electromagnetic Fields
17.03. Measurement and assessment

Automated sunglasses lens solar exposure station

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This work is part of an investigation for improving the parameters of sunglasses standards worldwide. Results of our previous works led to the extension of the upper limit of UV protection to 400nm on Brazilian standard ABNTNBR15111:2013, and have shown that worldwide standards should include the ocular safe limits established by the World Health Organization in its tests requirements. In addition, we have shown and published that the solar simulator resistance to irradiation test is ineffective and, therefore, this standard requirement should be revised. In our experiments, preliminary results have shown that UV protection on sunglasses changes over long solar exposure time. This work investigates long-term solar exposure effects in sunglasses lenses with respect to spectroscopic changes and material resistance as well. A survey conducted in Brazil (85.000 answers) has shown that the profile of the Brazilian wearers indicates that the sunglasses should last for 2 years, with average daily use of 2 hours. This is equivalent to an estimated radiant exposure of 365.3 MJ/m2 that should be evaluated for assuring ocular health. Therefore, we have developed an automated system for exposing sunglasses lenses to this solar radiant exposure. The system exposes to the sun a set of 120 lenses, in the vertical use position, in two different locations in Brazil, 2770 km apart, comprising a latitude span of 15 degrees. The system registers the UV index and other weather variables, like temperature, dust, and relative humidity of the air. A dedicated rain sensor has been built and automatically prevents the lenses to be exposed to rain. Also, there is an automated software control for exposing of the lenses as well as allowed manual intervention. An application for remote controlling of the station has also been de-veloped. Lenses are spectroscopically tested as required by ISO12312-1:2015 and analyses are being made.

Contribution ID: 439
17. Biological Effects of Electromagnetic Fields
17.03. Measurement and assessment

Prototype device for traffic light tests in sunglasses

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Wearing inadequate sunglasses while driving may lead to dangerous misunderstandings in objects and traffic lights recognition. Sunglasses standards propose transmittance requirements to categorize wether sunglasses fit as suitable and safe for driving. Transmittance tests are time-consuming and laborious. Also, it requires a spectrophotometer and a skilled technician to be performed. The aim of this study was to develop and to build an easy-to-use, quick and accurate device for luminous and traffic lights transmittance tests which runs the tests by itself in a way anyone can operate it without any training. A microcontrolled prototype was developed and built using a white LED and a four-channel sensor combination. This combination generated luminous and traffic lights weighting functions similar to standard ones. Using our prototype and a gold standard (VARIAN Cary 5000 spectrophotometer), luminous transmittance and relative attenuation quotients for traffic lights were measured in 128 sunglasses lenses. Bland-Altman method was used to assess concordance between both measurement methods. The bias was insignificant for all measurement and the limits of agreement were broad for luminous transmittance and for relative attenuation quotient for blue light detection, and narrow for the others. Thus, within the predefined tolerance, prototype measurements are equivalent to gold standard ones for relative attenuation quotients for red, yellow and green light detection. Despite not all prototype measurements being equivalent to gold standard ones, results were accurate; only 5 from 128 lenses were defectively classified as to suitability for driving (2 for luminous transmittance, 1 for red

light quotient and 2 for blue light quotient). Our prototype offers easy and quick assess for the public to test their own sunglasses including the information if they are suitable for driving according to ISO standard ISO12312-1:2015. This prototype is available for the public at University of Sao Paulo, in Brazil.

Contribution ID: 640
17. Biological Effects of Electromagnetic Fields
17.03. Measurement and assessment

Calculation of solar ultraviolet radiant exposure through sunglasses and compliance with safe limit recommendations

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Ultraviolet (UV) radiation comprises the region of the electromagnetic spectrum spanning from 100 to 400 nm. Ultraviolet radiation upon the eyes is related to many ocular diseases. The World Health Organization along with the International Commission on Non-Ionizing Radiation Protection (ICNIRP) have established safe limits on the exposure of eyes to UV radiation. Those exposure limits are: 1) UV radiant exposure should not exceed 30 J/m^2 when irradiance is spectrally weighted using an actinic action spectrum; 2) unweighted radiant exposure in the spectral region 315 to 400 nm should not exceed 10 kJ/m^2. Sunglasses play an important role in preventing eye injuries related to Sun exposure. We have calculated the direct and diffuse solar UV irradiance in a geometry that refers to an individual wearing sunglasses. In this case, the direct beam irradiance is incident upon a vertical surface, with a well-known dependence on the incident angle with the normal direction to the surface, described by Lambert's cosine law. The diffuse irradiance refers to the radiation scattered from the atmosphere and from the ground. The calculations use the open source SMARTS2 spectral model, in which we have assumed a clear sky condition, aside from information about site location, date, time, ozone column, aerosols, and turbidity. In addition, we have measured the spectral transmittance of three typical sunglasses lenses and the global solar irradiance was weighted with the spectral transmittance profile for each lens. Following the ICNIRP safe limit guidelines, the weighted UV radiant exposure incident upon the eye through the lenses, within an 8-h period, were calculated for each day of the entire year. Our calculation indicates that one sunglasses fully meets both ICNIRP safe limits. Two of them meet the first ICNIRP guideline whereas fail to meet the second one. Similar analyses for additional lens samples are under way.

Contribution ID: 744
17. Biological Effects of Electromagnetic Fields
17.03. Measurement and assessment

Set up for irradiation and performing spectroscopy for human lenses

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Introduction: In the environment with natural solar irradiation, the part of the electromagnetic spectrum that should be most attentive when it comes to eye health is the ultraviolet. Studies with both animals and cells have shown that chronic exposure of the eyes to ultraviolet radiation-UVR-causes significant damage to the eyes structures, particularly the cornea, lens, and retina. Unfortunately, still today, there is controversy regarding the harm caused to the human eye due to exposure of the ocular environment to UVR. Therefore, it is necessary to carry out studies specifically on human eye structures in order to verify if the excessive exposure to UV radiation

actually causes damage to the eyes. But there is great methodological difficulty with the use of human lense, which leads to the increase of controversial results, so common in the scientific literature, that involves the subject related to UVR and human eye.
Aim: Development to a device for that the human lens can be irradiated in a solar simulator and analyzed in spectrophotometer.
Methodology: A lens support has been developed using 3D printer.
Results: In order to arrive at the final prototype, three different types of supports were developed. Only one of them proved to be effective in accommodating human lense without significant tissue degradation. From the development of this support, human lenses can be irradiated in a solar simulator and analyzed in a spectrophotometer without being degraded.
Conclusion: The development of this support allows human lense to be irradiated in a solar simulator and analyzed in a spectrophotometer. We believe that the development of this support will contribute in a promising way for future research with human lens, assure reliable results. Financial support: FAPESP (2014/16938-0).

Contribution ID: 791
17. Biological Effects of Electromagnetic Fields
17.03. Measurement and assessment

Differential microwave chip for characterization of biomolecules at ISM band

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Electromagnetic waves interact with the matter in non-invasive and non-intrusive ways, which are the basic advantage of microwave material sensing. Dielectric properties of organisms, where the water concentration varies from 50 to 90 %, are often dominated by water dielectric signature. Additional dielectric signature is due to biomolecules. For small biomolecules such as amino acids, Stokes-Einstein-Debye relation for a rotational diffusion dictates that the dielectric loss due to biomolecules should display a peak of within the industrial, scientific, and medical (ISM) band. Hence we propose that a microwave sensor, when loaded with the water-like sample, should be designed to operate at the ISM band for the characterization of small biomolecules. However, the sensitivity of the sensor with respect to the minimal change in the concentration of biomolecules is the main limiting factor during measurement. Here, we present a highly sensitive microstrip technology based biosensor that works on the differential principle. The proposed differential microwave chip provides a large dynamic range in the concentration measurement of the biomolecule solution at laboratory condition.
Authors acknowledge major financial support from the Czech Science Foundation, project no. 15-17102S. Authors participate in COST Actions BM1309 and CA15211 and project between Czech and Slovak Academies of Sciences, no.SAV-15-22.

Contribution ID: 1549
17. Biological Effects of Electromagnetic Fields
17.03. Measurement and assessment

The new IEC safety standard on magnetic nearfield emission limits

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There are several guidelines on magnetic field exposure hazards, e.g. by ICNIRP, IEEE and the European Commission. These do however not cover the particulars of nearfields, i.e. fields having a strong curvature near the source. Since it is known that the interaction with human tissue is

weaker for such fields, there is a need in industry to quantify proper safety limits. Such work was initiated in the IEC Technical Committe 27 some years ago and the work led to a positive vote by the participating counties on a document which was published in 2017, as IEC TS 62997.
The publication contains less severe requirements on the particular induced electric field strengths than the abovementioned guidelines and standards, typically by a factor of more than two, depending on the proximity of the bodypart to the field source. The publication also contains practical guidelines, by a large number of useful data obtained by numerical modelling, and experimental verifications by volunteer tests. All these are then mainly with induction coils, a practical example being that 4 kA at 15 kHz will not cause any hazard even to a hand almost touching the coil.
An annex describes various conditions under which quasistatic conditions can be assumed. They are limited by the penetration depth effect in tissues, which is in turn frequency dependent. The practical upper frequency limit at which neither this effect nor wavelength effects occur is about 6 MHz, which is also the upper frequency limit of the IEC standard.

Contribution ID: 376
17. Biological Effects of Electromagnetic Fields
17.04. Therapeutic applications

ApOtEl: development of a software for electroporation based therapy planning

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Electrochemotherapy is a local technique for the treatment of tumors, based on electroporation phenomenon, where cell membrane permeability increases due to local delivery of short and sufficiently intense voltage pulses to the target cells and tissues. The success of this technique is closely linked to the electric field distribution, and depends on several characteristics, such as type, number of electrodes, configuration and distances between electrodes, as well as the electrical resistivity of the tissues involved. The appropriate local electric field distribution is one of the most important conditions for an effective electroporation based therapy. In order to guarantee more effective and secure procedures for electrochemotherapy application, a software, called ApOtEl, was developed using MATLAB®. It optimizes the needle-type electrodes positioning configurations, through the study of the analytical electric field, using Laplace equation in a homogeneous bi-dimensional environment. The optimization was based on requirements chosen to guarantee the tumor total coverage and to minimize healthy neighboring tissues damage. A cost function was created to orientate the electrochemotherapy application, and the best option available in all configurations generated by the distance variations between electrodes and positioning orientations was determined. The software provides, by the entry of tumor dimensions, the optimized distances for positioning needle-type electrodes, as well as the representation of the electric field distribution and intensity. Representation of the electrodes positioning and instructions for the procedure to facilitate the procedure planning are provided.

Contribution ID: 487
17. Biological Effects of Electromagnetic Fields
17.04. Therapeutic applications

Apoptosis of vascular smooth muscle cells induced by photodynamic therapy with indocyanine green

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Efficacy of Photodynamic therapy (PDT) in the treatment of intimal hyperplasia is hampered by low tissue penetration of most photosensitizers by short excitation wavelength. Indocyanine green (ICG), a near-infrared (NIR) photosensitizer, is excitable at near-infrared (780 nm) allowing tissue penetration up to 15 mm. This study aimed to evaluate the effects of PDT with ICG on the viability of vascular smooth muscle cells (SMCs), A10 cells, and to define the cell-death pathway. UV/VIS absorbance and fluorescence emission spectroscopic detection showed that the intracellular ICG concentration increased with the amount of ICG in the incubation solution and reached maximum at 8 hrs. Cell viability analysis found that the half maximal inhibitory concentration (IC50) of ICG was 8.89 μM with 4 J/cm2 NIR irradiation, whereas no toxicity was found without light irradiation. Malondialdehyde assay revealed lipid peroxidation of A10 cells after PDT. Both Annexin V/Propidium iodide and Hochest 33258 stains indicated the presence of phosphatidylserine on the external surface of the plasma membrane and chromatin condensation at IC50 of ICG after PDT. The ratio of sub-G1 cells was also increased after PDT as shown by flow cytometry. Our results indicated that the induction of apoptosis of SMCs might be one of the mechanisms ICG-mediated PDT.

Contribution ID: 1543
17. Biological Effects of Electromagnetic Fields
17.04. Therapeutic applications

Time interval between electroporation and ionizing irradiation influences the amount of radiosensitizing effect in vitro

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Introduction: Recent studies have shown the radiosensitizing effects of electroporation (EP) as a physical radiosensitizer for ionizing radiation (IR). The amount of sensitizing effect depends on some factors the most important of them is the time interval between the EP and IR. The present study aims to in vitro investigate the radiosensitizing effect of EP exposure prior to IR and also evaluate the effects of time intervals between EP and ionizing irradiation on the amount of radiosensitizing effect.
Methods: Chinese hamster ovary (CHO) cell lines were used in vitro. The cells were divided into 10 groups including one untreated group, IR and EP treatment alone groups, seven EP-IR groups with 10, 20, 30, 40, 50, 60, and 70 min time intervals between EP and IR. The dose enhancement factors (DEFs) for 6 MV X-rays IR were comparatively investigated between the groups using MTT assay. The IR was 6 MV X-rays generated by Varian 2100 C/D linear accelerator. The EP was a single square shape electric pulse of 1200 V/cm and pulse duration 100 μs. All of the experiments were performed three times and the averaged values were calculated for further analyses.
Results: The EP significantly induced radiosensitizing effect and the magnitude of effects depends on the EP-IR time interval. The viability rate of the cells in the combined EP-IR treatment groups for intervals of 10, 20, 30, 40, and 50 min was significantly lower than the IR alone group. The highest DEF was observed for 10 min time interval between EP and IR.
Discussion: The radiosensitizing effects of EP persist long enough after EP application ranging 10-50 min, which allows safe application of EP as a radiosensitizer before IR in clinical setting.

Contribution ID: 1860
18. Clinical Engineering
18.15. Keynote lecture

KEYNOTE LECTURE: Biomedical and Clinical Engineers: live and learn

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A Clinical Engineer is defined as “a professional who is qualified by education and/or registration to practice engineering in the health care environment where technology is created, deployed, taught, regulated, managed or maintained related to health services. Other related terms used for the CE role in developing countries include biomedical engineer and rehabilitation engineer” (http://cedglobal.org/definitions/).
I had the priviledge of chairing the Clinical Engineering Division of the International Federation for Medical Biological Engineering for three years (2015-18) and to learn a lot from the past mistakes, that often prevented this beautiful profession from achieving the world recognition that it deserves.
I will discuss the main actions taken in the last years, as well as the many skills and abilities that today’s and tomorrow’s engineers will have to master to face the new challenges that, day after day, the complex world of healthcare is preparing for us all.

Contribution ID: 53
18. Clinical Engineering
18.01. Health Technology Management

Facilitating long-lasting access to medical devices in Sierra Leone through transnational funders: an exploratory case study

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Background
Transnational funders provide up to 80% of funds for medical devices in resource-limited settings. Given that 72% of devices in these settings are reportedly abandoned, it is estimated that for every $1 that funders spend, 65 to 90 cents are wasted. The objective of this study was to understand from the perspectives of recipients and funders how best to facilitate long-lasting access to devices in resource-limited settings while minimizing waste.
Methods
An exploratory case study was developed in March 2016 with a review of the Government of Sierra Leone’s (GoSL’s) donation guidelines; semi-structured interviews of frontline and administrative staff, and representatives of funding organizations; and direct observation.
Results
GoSL guidelines on donating medical devices are not linked to relevant enforceable regulations. Key informants underscored the importance of communication, collaboration, quality, and matching devices with existing infrastructure. Photographs confirmed that externally-funded devices continue to be abandoned in large quantities at GoSL-run hospitals.
Conclusion
To ensure long-lasting access to medical devices, funding organizations should incorporate principles of good governance while the GoSL establishes coherent and enforceable policies that facilitate communication and collaboration between funders and frontline staff, and guarantee that incoming devices match the existing infrastructure in its healthcare facilities.

Contribution ID: 167
18. Clinical Engineering
18.01. Health Technology Management

Evaluation of healthcare technology application by clinical engineering perspective in low & medium income countries

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This paper presents and discusses the application of healthcare technology (HT) performance in the healthcare system by clinical engineering perspective in low and medium income countries. In the recent years, a healthcare system (HCS) has increasingly become healthcare technology (HT) driven due to the rapid growth of sophisticated medical devices and hence it is very much necessary to evaluate the performance of healthcare technology application (HTA). On the divergent, we have seen that HT performance comes under the spotlight of clinical engineers (CE) and clinical engineering departments (CED) in the healthcare system of a country. Despite the further development of regular evaluation of HT application is yet desired by clinical engineering in the developed world, low and medium countries are unknown with a relation among CE, CED, HTA, and HCS. As a result, HCS of low and medium countries like Bangladesh is found as very much unpleasant. In this article, we examine the number of clinical engineers and number of hospitals with clinical engineering departments. We collect data from low and middle income countries (e.g. Bangladesh, Bhutan, India, Myanmar, Nepal, and Pakistan) to evaluate the application of healthcare technology. We compare the data of CEs and CEDs with standard HT practice with CEs and CEDs. This study explores the necessity for implementing the appropriate HT to enhance the present healthcare system through CEs and CEDs. As a result, the present healthcare stakeholders of these countries understand to introduce adequate numbers of CEs and CEDs for enhancing the present unpleasant HT performance. Moreover, our study will encourage universities of these countries to produce CEs. As a result, a safer and cost-effective healthcare system will establish in these countries. Finally, it is shown that clinical engineering approach is very necessary to evaluate of healthcare technology application in low and medium income countries.

Contribution ID: 196
18. Clinical Engineering
18.01. Health Technology Management

The AIIC manifesto: clinical engineers for patient safety and the well-balanced governance of biomedical technologies

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Biomedical technologies are increasingly important and essential in healthcare processes. The quality of their governance and maintenance, and the proper monitoring of these activities, is a guarantee of efficacy and safety for patients and practitioners. For this reason, the Italian Clinical Engineers Association AIIC has established, expressed and proposed nine indispensable principles that clarify issues regarding tenders for the outsourcing of maintenance activities.

It may seem that this only concerns aspects of economic governance of the technological innovation system, but it is in fact a fundamental requirement to ensure that citizens can receive safe medical treatments. On the other hand, issuing outsourcing tenders without the conditions set forth by AIIC would bring citizens to be treated in a context of poor personal, organizational and clinical safety.
AIIC has proposed this manifesto for patient safety and the well-balanced governance of biomedical technologies to the Central and Regional Institutions, the structures of the National Health System, the Scientific Community, and the Representatives of Citizens and Patients, in order to quickly raise attention to the dangers of lack of security and poor healthcare quality that threaten our Country at a time when Europe has embarked on a clear path of safety and quality throughout the world of healthcare innovation.

1. Yes to Italy fully in line with Europe
2. Yes to the necessary professionalism
3. Yes to different organizational solutions
4. Yes to precise responsibilities on technology
5. Yes to essential levels of technological performance
6. Yes to internal clinical engineering as a strategic service
7. Yes to safety, no to outsourcing without control
8. Yes to clever strictness
9. No to excessive discounts

The manifesto has been presented by AIIC on the occasion of the Second Global Clinical Engineering Day and was signed by a large number of Italian Scientific Associations.

Contribution ID: 369
18. Clinical Engineering
18.01. Health Technology Management

The supportability of medical devices

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Clinical Engineering/Health Technology Management (CE/HTM) is spending more time trying to get medical device manufacturers to provide support for inhouse servicing than ever before. Many manufacturers and even healthcare institutions seem to minimize the value or even the existence of CE/HTM programs. It is important to note that these programs operate to save hospitals and healthcare money and also serve to provide quick and necessary support for healthcare technology in the clinical setting. They are now being challenged by many of their commercial partners. Almost every other acquisition of medical equipment now requires the need to negotiate support for inhouse services and is met with a balance of success and failure. It appears manufacturers are designing equipment without considering the customer’s option to service it. These customers include medium to large hospitals that have the capacity, economies of scale, and know-how to create and sustain CE/HTM departments. At the same time, there are many companies that provide good support for inhouse servicing. Their examples of appropriate support strategies may serve as a baseline for most other companies to make their products serviceable and to ensure CE/HTM is qualified and properly equipped to perform the required service. This paper highlights most of the issues surrounding the notion of Supportability in the CE/HTM world. These issues affect independent service organizations (ISOs) in a similar way. There are efforts to manage the supportability issue and ideas on how certain barriers might be dealt with. The paper attempts to recognize these and the rationale behind certain behaviors. There are standards and regulations, or an absence of them, that either help or hinder the issue.

Contribution ID: 676

18. Clinical Engineering
18.01. Health Technology Management

HB-HTA of Total Laboratory Automation systems

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Introduction & background: Total Laboratory Automation (TLA) systems manage specimen tubes from pre-analytical to post-analytical tasks in order to carry out automatically analysis of Clinical Chemistry and Immunochemistry. The core of TLA is the automatic chain that connects the several modules (e.g. centrifuges, decappers, analyzers, …). Number and typology of modules vary as user request. [1]
Methods: Preliminary workload management analysis of Laboratory are necessary in order to understand distribution of samples during day, week and year. [2] Those data combined and properly weighted with other Key Performance Indexes as sample transportation, tubing consolidation, safety analysis are the main drivers for a correct design of the entire TLA system.
After the installation of such system in Fondazione I.R.C.C.S. San Matteo Hospital in Pavia and its full-scale operation, it will be carry out a functional and economical analysis. In particular we will focus on the full-service type of contract and we will evaluate the price for test strategy of payment.
Conclusions: From the functional analysis we expect an increment in safety and efficiency and a better monitoring of TLA system. Moreover, we expect that price for test will reduce cost for the Foundation as payment will be bounded to medical reports and the cost of calibration samples and redundant samples will be eliminated.
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Contribution ID: 830
18. Clinical Engineering
18.01. Health Technology Management

Hospitals with and without clinical engineering department: comparative analysis

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Argentina, being a federal country, the Health Public System is responsibility of each State Ministry of Health (MoH). This means that all Provinces have the obligation to serve citizens who need attention, despite their have health coverage or not. In turn, there are four levels of attention in Buenos Aires province, first and second levels are provided by City government, whereas third and fourth levels are provided by 97 provincial Hospitals.
In these hospitals technical support of medical devices, preventive and corrective maintenance, has been and is carried out by the vendors´ technical services (manufacturers and distributors), or

by companies that are dedicated to the technical service of medical equipment. These services don´t include the permanent presence of technicians or engineers in the hospital.
There is an exception to the procedure mentioned in 18 hospitals, which, by means of an agreement between the MoH and the National Technological University, have implemented clinical engineering departments. The department activities are carried out by graduates and undergraduate students, who perform tasks within the Hospital every weekday in an office assigned for that purpose, and with the support of the University structure.
The object of this work is to establish qualitative and quantitative differences between two hospitals with the same characteristics of health services, number of beds, equipment complexity and built surface, one with department of clinical engineering and the other with contracted services, both with the modalities explained. For this purpose there were measurements of the time that medical devices have been out of use for damage, repair costs, customer satisfaction surveys of users, administration personnel and management.
The results will be presented to the authorities of the MoH so that they evaluate the advantages, and can advance and substantiate the consolidation of clinical engineering departments in all health centers under its responsibility.

Contribution ID: 1174
18. Clinical Engineering
18.01. Health Technology Management

Health technology management using GETS: maintenance performance in a public healthcare institution

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Background: A web-oriented software (GETS) for health technology management was previously developed aiming at establishing clinical engineering (CE) nuclei (NEC) at public health institutions. Functionally a NEC comprises 5 processes subdivided into microprocesses (states) controlled by a finite state machine. Transitions between microprocesses are associated to activities. A string of states is a trajectory that contains the standard history of each service order (SO) solved by the CE team. The present report presents results of the analysis of maintenance performance by a recently established NEC at a hospital of the Brazilian Public Healthcare System.
Methods: A previously designed performance indicator (ICEB [0, 1]) was used. At any newly established NEC, it takes long before the number of SO is large enough to ensure robustness; thus ICEB sensitivity was first tested for adequacy. ICEB values for the whole NEC service and for selected equipment types were calculated. Actions (e.g. evidence-based contract renegotiation, personnel training) were taken when low ICEB was detected, followed by reevaluation six months later. Trajectories were used to identify bottlenecks and general profile of service delivery.
Results: Three types of trajectories comprised 91.4% of the SO, and ~50% of the total involved third-party contractors. ICEB robustness (<5% change by adding a new trajectory) was guaranteed when SO number was >20. Considering the SO total, ICEB was 0.59 and 0.86 before and after interventions, respectively. The ICEB for intensive care pulmonary ventilators, heating humidifiers and air-O2 dosers also increased after intervention, from 0.60, 0.42 and 0.52 to 0.84, 0.82 and 0.90, respectively. The same occurred with in-house service performance on physiologic monitors (ICEB = 0.22 vs. 0.61).
Conclusion: The information provided by GETS (e.g., ICEB) proved to be useful as alerts and to follow up the effectiveness of actions taken by the CE team.
Finacial support: MS, Finep/Brazil

Contribution ID: 1227
18. Clinical Engineering
18.01. Health Technology Management

Role of 3D printing in clinical engineering

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The 3D printing industry grew by 35% in 2014 with increasingly high use in the industrial, consumer, academic, and inventor market. Medical applications include customized knee, hip and other Implants using metal 3D printers, surgical planning models built from 3D image scans, 3D printed models for teaching in healthcare, the use of 3D printing in clinical simulation centers, and, perhaps the most exciting area, bio-printing living tissue using cells as “ink”.
Clinical engineering uses have included test jigs, medical and clinical engineering training aids, clinical simulation lab equipment, clinical research support, ancillary parts and assemblies, and functional parts (with manufacturers approval). Our clinical engineering department has utilized high resolution 3D printing for nearly 10 years for parts replacement, test devices, surgical planning assistance and research instrument development.
The presentation will start by discussing the background on 3D printer technology along with the advantages and disadvantages of each technology and the process of creating the 3D image file via scanned data, medical images or CADD. Case studies will be presented for key areas of clinical engineering involvement: education including use in clinical simulation labs and medical teaching, creating of replacement parts such as those no longer available or extremely expensive, supporting the surgical planning process through anatomical and device prints, and use of the 3D printer for test jigs and tools. More advanced topics such as a recent project at the University of Vermont to convert a standard 3D printer to a bio-printer via our department working with regenerative medicine and materials engineering faculty and engineering students will be presented. The practical topic of 3D printer resources management including modeling and support material inventory control, project cost projection tracker, and staff training in CADD and will complete the presentation.

Contribution ID: 1254
18. Clinical Engineering
18.01. Health Technology Management

Mathematical modeling used for biomedical technology management

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When we have to deal with the challenge of managing medical technology, it is important to take into account the knowledge associated with this technology, this leads us to the investigation of one of its most important points, the conservation of it, for which we must provide main attention to its scheduled maintenance. In order to manage the conservation of medical equipment efficiently, it is necessary to have tools that allow the generation of different management indexes, and for this, it is essential to use the information obtained throughout its useful life.
In the past, maintenance programs were established based mainly on the recommendations of the equipment manufacturer, which is nowadays known that it is not always the most adequate maintenance.
It is possible to develop mathematical models to define maintenance programs using indicators such as uptime, failure rate, incidents in patients, average time between failures, return time after repair, fault codes, etc. This will result in major improvements in the adoption of adequate

scheduled maintenance intervals, with the aim of creating programs that are not only effective, but also efficient.
The use of maintenance programs based on mathematical models emerged in recent years and is in investigation phase.
The Efficient maintenance maximizes the value of health technology resources, something that is especially important when resources are limited. Only in this way patients will have access to medical equipment able to make an accurate diagnosis, an effective treatment and an adequate rehabilitation.
This research work consists in the development and application of new mathematical models used for the planning of maintenance programs, especially in life support equipment, through which we can guarantee some more efficient maintenance strategies, taking into account the safety and performance of them.

Contribution ID: 1258
18. Clinical Engineering
18.01. Health Technology Management

Clinical engineering challenge: medical device cleaning and disinfection damage

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Cleaning and disinfecting medical equipment requires a balance between insuring patient safety from infection, supporting staff safety and work efficiencies, and reducing damage to medical equipment. To show the tradeoffs encountered, device failures caused by cleaning products and practices ranked number 10 on the ECRI Institute's Top 10 Health Technology Hazards for 2017 but the second rated hazard was the possibility of healthcare-associated infections (HAIs) resulting from inadequate disinfection and cleaning of devices.
Clinical engineering is typically responsible for all medical devices including those sterilized and high level disinfected, example flexible scopes, but is most affected by damage to medical "equipment" such as infusion pumps where the surfaces and sometime internal components are cleaned and disinfected between patient use. Manufacturers recommend specific cleaning and disinfection solutions. Unfortunately, there is little standardization in the industry resulting in a broad range of solutions required to be stocked by healthcare organizations. Damage may occur with these recommended solutions or even with a more common 10% bleach solutions. The damage is typically to plastics, flexible components, labeling, and other parts. Corrective actions such as stopping the use of prohibited disinfectants by using only authorized solution on each device, standardizing on a "safe" disinfectant, or persuading device manufacturers to standardize are not likely or good options. In the author's teaching hospital, a large segment of equipment classified as damaged has been found to be related to disinfection and cleaning solutions resulting in high costs, but, of greater concern, is the reduced reliability of equipment and potential adverse events resulting.
Case studies will be presented showing examples of cleaning and disinfection damage and unique solutions including development of protective devices using 3D printing technology, automated testing systems for assessing solutions effects on devices, and UV light disinfection systems.

Contribution ID: 1266
18. Clinical Engineering
18.01. Health Technology Management

Development of a methodology of evaluation for medical equipment replacement for developing countries

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Currently, decision-making in hospitals and health institutions in developing countries about the replacement or withdrawal of medical equipment mainly involves a series of subjective positions about the time at which these actions should be carried out. It is for the foregoing that not always have the technical, clinical, or economic basis on the request for the withdrawal of any equipment. There are several quantitative methodologies in the world that evaluate a considerable amount of parameters about the equipment and with this determine the status in which it is, however, these methodologies are difficult to apply especially in the public healthcare system of countries in development due to the ranges of evaluation of the parameters are focused on countries that acquire the technology as it goes to market, or even are technology manufacturing countries. It is due to the above that in this project a methodology is designed to evaluate medical equipment so that it can be used in countries that do not have the degree of substitution of developed countries. It is hoped that with this methodology it will be possible to anticipate equipment obsolescence and make the corresponding substitution at the best time according to the possibilities of each institution, based on quantitative data. The methodology is based on the evaluation of eight parameters that include the technical, economic and clinical part of each equipment.

Contribution ID: 1382
18. Clinical Engineering
18.01. Health Technology Management

LA&C summit 2017 - forwardings and results of latin american and caribbean meeting on clinical engineering and health technology management

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With the participation of 96 representatives from 18 countries (12 from the Americas region and 06 from the other parts of the world) and representatives of IFMBE, the Latin American & Caribbean Meeting on Clinical Engineering (CE) and Health Technologies Management (HTM), promoted by PAHO-WHO and Ministry of Health of Brazil, was held in September 2017 in São Paulo, Brazil. Twenty-seven presentations were made, and it was verified that CE is active in around 90 countries in the world with several successful cases, but it still requires a greater engagement of professionals, organizations and governments to advance in new approaches that go beyond the traditional hospital context. Acting throughout the entire life cycle of technology, from the innovation, evaluation, incorporation to the replacement, working together multidisciplinary teams and focusing on patient outcomes, are currently required needs. Lists of essential medical devices; technical specifications focusing on significant outcomes for patients; technology reuse and replacement practices were also highlighted as priorities. As a key element for the advancement in regulation, evaluation and management, providing the exchange of technical information and prices practiced, it was highlighted the importance of establishing a global standard of nomenclatures on medical devices. The main forwarding as a collaborative and continuous work strategy with synergy of efforts and sharing of results was the creation of a Americas Regional Working Group focused on the best practices of EC and HTM, generating knowledge and generating indicators from of real-world evidence as feedbacks to innovation, regulatory, evaluation and investment policies. Improvements on CE-HTM means promoting health systems sustainability and universal coverage with greater efficiency and safety.

Contribution ID: 1714
18. Clinical Engineering

18.01. Health Technology Management

Looking for a healthcare technology management model in the Peruvian health system

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The poor state of infrastructure, energy systems, medical and hospital equipment, information systems and organization, especially in public sector in developing countries, has sensitized health authorities and professionals in the search for alternatives, whether conventional or even leapfrogging or design thinking or out the box. A new health technology management model is proposed based on six main processes: A. Technology planning: Needs analysis, preparation of plans to current and future context, investment planning. B. Technology Acquisition: appropriate technology assessment, application of current regulations and functional installation. C. Management of technological assets: Functionality and operability of technological resources, preventive and corrective maintenance. D. Management of technological risks: Hazard identification and risk assessment, techno-surveillance: metrological verification, infection control, quality control and adverse events evaluation. E. Development of human resources in technology: biomedical & clinical engineers, medical physicists, hospital architects, hospital engineers, biomedical technicians and others. F. Applied research and project management: Research to solve problems and for hospital technological development. If it is admitted that health technology is the key to solving the serious problem of quality of health services, an adaptation of the health system is expected. Since a holistic perspective the task is to implement an organization branch to address the technological aspects, having responsibilities, functions and processes of a health technology management system, considering that technology, with its tangible and non-tangible components, it must be constituted as a coherent and functional conglomerate to provide appropriate health services. In this context, it is worth noting the need for clinical engineer to be involved in the clinical services design due to the requirement to recover the current state of the technological environment, and to make up for the lack of hospital architects and engineers, as well as being a valid interlocutor between clinical work and infrastructure and hospital facilities.

Contribution ID: 1775
18. Clinical Engineering
18.01. Health Technology Management

Healthcare Technology Strategy and Capital Planning. Experience of a hospital of developing country

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The Biomedical Engineering Department of the National Cancer Institute of Mexico has implemented and adapted a strategy planning methodology for all major-medical devices, that has allowed us not only to plan, but also to obtain the resources of the federal government and NGOs Institutions to execute important projects.
Using that methodology we have been able to obtain at least the following medical devices: one 18 MV cyclotron (to produce FDG-18 and other research particles), two advanced linear accelerators, two low energy linear accelerators (replacement of two cobalt units), one portable linear accelerator (Intraoperative Radio Therapy used in nine type of neoplasm), 2 PET-CT, 1 PEM, 2 MRI, the replacement of a High Dose Rate Brachytherapy equipment, Neuro-navigation system, other IT systems and many others devices that represent 60 million dollars, amount that for a developing country is difficult to achieve.

It is due to the above that this methodology allows us to plan medical equipment and obtain resources so that it can be used in countries that do not have the degree of substitution and acquisition of developed countries.
The methodology used includes: Costs Associated with a Medical Technology, Life Cycle Cost of Ownership, Life Cycle Cost analysis, Present Value, Net Present Value, ROI as a social benefit, adjusted for a Non-Profit Healthcare Institution like the National Cancer Institute, in which patients have minimal resources for diagnosis and treatment. And their minimal recovery fees are the source to make these projects happened

Contribution ID: 171
18. Clinical Engineering
18.02. Quality, productivity and benchmarking

Application of engineering concepts in sterile processing department

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Sterile Processing Department (SPD) is a functional unit in a hospital destined for processing and controls the healthcare products regarding to the health services. This unit has as priority function provided medical material free from contamination. This function is carried out through the following steps: reception, decontamination, cleaning, disinfection, preparation, sterilization, storage and distribution. This paper displays the process management in the SPD, showing its stream mapping, some nonconformities and bottlenecks. Some tools were applied to understand how the processes were performed and to show how it could be improved by applying engineering tools. Measurements were collected from specific spots throughout the process to measure the lead time of some stages, which were selected according to their importance for the processing. After the measurements acquisition, they were classified into two categories (non-added value activities-NAVA and added value activities-AVA). The time of the NAVA were summed, as well as the AVA. Then, the WIP (Work in Process) and the PCE (Process Cycle Efficiency) were calculated. It was found the highest PCE was 55,29% and the highest WIP was 76,80%. It is important to highlight WIP represents wastes, despite some kind of wastes are inherent to the process. The study also discovered by a cause and effect matrix the four reasons most important to increase the lead time were absence of standardization and training, the operator performing and the quantities of instruments. Points of improvement such as PDCA and Standard Procedures will be established to achieve the highest quality. Goals such as increasing the PCE more than 70% will be pursued, besides training will be developed to improve the knowledge. New methods and culture will be adopted to create a more collaborative, efficient and engaging environment.

Contribution ID: 757
18. Clinical Engineering
18.02. Quality, productivity and benchmarking

Comparative analysis of healthcare facilities infrastructure and equipment evaluation tools

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A tool was developed in 2014 for an assignment for the Government of Mongolia to assess 36 hospitals. A survey was completed and a multivariate analysis was then performed to obtain a unique grade for each facility. The tool had two major disadvantages: 1. It took over one year to get

it completed for 36 facilities and 2. It was very much focused on Mongolian hospitals and as a result it was not possible to reuse the tool.
The proposed objective was therefore to find a publicly available tool to assess the overall condition of a healthcare facility taking into consideration at the same time its infrastructure and its equipment; that the tool could be used in different countries; that it would not require a long data collection effort and that it would not take much processing time.
The review of the bibliography shows that in most cases researchers develop their own tools to do these evaluations and the tools are not used again.
Three public tools that could be used to assess the overall condition of a healthcare facility were found:
1) Hospital Safety Index (HIS) calculator from WHO. The focus of this tools is the safety of the facility and not the overall condition but it was considered a useful tool.
2) The survey included in the DIN 13080 Supplement 3 section. The focus of this tool is the architecture of the building.
3) The Healthcare Facilities Maintenance Estimator developed by Carlien Steyn (IUUS project managed by CSIR for the DoH in South Africa. This last tool was developed to estimate the maintenance cost of a south African hospital based on its size, location and condition.
A review of these three tools was done and a new tool is proposed as a combination of the three of them.

Contribution ID: 1246
18. Clinical Engineering
18.02. Quality, productivity and benchmarking

Methodological proposal of diagnosis in healthcare physical asset management based on ISO-55000 in Colombia

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There is an obligation in the Health Services Providers to manage the physical assets that they own, in order to guarantee in concordance with the other assets (human, financial, intangible and information). And these can assure the quality of care and the safety of the patients, users and employees of these institutions. To this end, work processes and methods have been developed to guarantee the basic conditions of the quality of care (habilitation), as well as superior quality standards (national and international accreditation). We propose a methodology for healthcare physical asset management based on the international standard ISO-55000/1/2, focusing on infrastructure, industrial equipment, biomedical equipment and information technology, which are under the protection of the current departments of Clinical Engineering. We implemented a methodology that has been applied in different sectors such as aeronautics, automotive, oil; and in this case it was adapted to the health sector in Colombia. A validated diagnostic survey was conducted by consulting international experts in asset management and the creation of an application protocol for Health Institutions. This survey consists of 49 questions related to these topics: Organization, Strategy, Planning and delivery of the investment, Risk management, Performance management, Information management, and Facilitating technologies. The study was carried out in hospitals in Medellin in order to know the current status of hospital physical assets

management and identify opportunities for improvement. These actions look for to support the generation of an adequate balance between efficiency, costs and risks associated with infrastructure, biomedical equipment, industrial equipment and information technologies. Through this work, we try to take advantage of the benefits of asset management and promote the technological transfer of this methodology to other national and international health institutions.

Contribution ID: 261
18. Clinical Engineering
18.03. Telemedicine in Developing Countries

Countrywide diagnostic services through telemedicine

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Abstract
Through the telemedicine, advantageous telediagnostic systems can be developed to improve the health care of remote populations that don`t have access to specialists. However, evidence on how such innovation technology can enhance countrywide diagnostic services is limited. The usability of telemedicine to improve the coverage of diagnostic services in public health in Paraguay was investigated. This descriptive study was carried out by the Telemedicine Unit of the Ministry of Public Health and Social Welfare (MSPBS) in collaboration with the Department of Biomedical Engineering and Imaging of the Health Science Research Institute (IICS-UNA) and the University of the Basque Country (UPV / EHU) to evaluate the utility of a telediagnostic system for countrywide coverage in public health. For this purpose, the results obtained by the telediagnosis system implemented in 56 public countryside hospitals were analyzed and compared to a "face to face" diagnosis. In that sense, 293,142 remote diagnoses were performed between January 2014 and September 2017. Of the total, 37.29% (109,311) corresponded to tomography studies, 61.44% (180.108) to electrocardiography (ECG), 1.26% (3,704) to electroencephalography (EEG) and 0.01% (19) to ultrasound. There were no significant differences between the remote and the "face to face" diagnosis. With the remote diagnosis a reduction of the cost was obtained, that supposes an important benefit for each citizen of the interior of the country. The results show that the telemedicine can enhance significantly the countrywide coverage of diagnostic services and health programs, maximizing professional time and productivity, increasing access and equity, and reducing costs. However, before carrying out its systematic implementation, a contextualization with the regional epidemiological profile must be performed.

Contribution ID: 811
18. Clinical Engineering
18.03. Telemedicine in Developing Countries

Improved access to diagnostic services for remote populations through telemedicine

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Clinical background:
Populations living in remote areas did not have access to specialist care and quality diagnostic services and thus depended on the low response capacity of their local health system. There were subsequent equity issues between urban and rural populations. In this context the telemedicine applications should be directed to gain the prevalence of pathologies towards developing better equity in the provision of services in remote locations without access to specialists. This study, have evaluated the results of a telemedicine system in remote public hospitals in Paraguay, in order to show how the response capacity of the local integrated health service delivery networks has been improved by providing access to tertiary level diagnostic services by specialists.
Methodology: Descriptive study, where the results using telemedicine for diagnosis in remote public hospitals were evaluated as tool to improve access to diagnostic services countrywide between 2014-17. For these purposes, type and frequency of pathology diagnosed was determined.
Objective: this study aims to evaluate the utility of telemedicine as tool for improving access to diagnostic services in remote populations.
Results:
A total of 311,562 telediagnoses were performed in 57 hospitals. The 191,435 ECG diagnosis performed in the 55 hospitals were mainly normal (62.1%), unspecified arrhythmias (12.5%), and sinus bradycardia (10.4%). 115,924 teletomography tests were performed in 12 hospitals, where 54.4% corresponded to head as a consequence of accidents (motorcycles) and cerebrovascular diseases, 13.8 % chest, and the rest the other anatomical regions. Regarding the 4,184 EEG tests performed, antecedents of seizure (54.3%), evolutionary controls (14.0%), and headache (11.5%), were mainly diagnosed. The 19 ultrasound studies corresponded to prenatal controls.
Conclusion: despite the results of the telediagnosis implemented in the public health to improve access to diagnostic services countrywide, a widespread use-assessment should be analyzed before a investment into these tools is adopted.

Contribution ID: 1222
18. Clinical Engineering
18.04. Information and communication technologies and clinical engineering (CE-IT)

Augmented Reality Technology as a tool for better usability of medical equipments

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The use of medical equipment may be compromised by lack of knowledge of users about important information and operational characteristics that may cause adverse events. Clinical engineering has as an important function to guide and qualify users in adapting to the use of technology to obtain safer and more reliable health technology processes. The new augmented reality tools, whose main objective is to overlap virtual information in reality through technology, are a good alternative to develop solutions focused on the orientation and qualification of users. This paper presents a proposal to develop a platform for support in the orientation and teaching of medical device users. With this augmented reality platform, through the use of mobile devices, the user can access in real-time information on procedures of adjustments, characteristics, ways of use and control of the medical equipment. This prototype developed for the pulmonary ventilator uses augmented reality in order to enhance its interactions with computer applications more

naturally, it seeks to present information about the different ventilation modes, equipment initialization procedures and interactive contents to the user through links and videos. Modern pulmonary ventilators present challenges to users due to the need of knowledge, such as configurations and ways of using parameters; the patient's trigger in the assisted ventilation mode; use of assisted aspiration; pressure alarm setting. These actions are not usually carried out adequately generating possible adverse events, being this situation one of the main objectives of the use of the technology in the platform for the user support. The preliminary results obtained in this prototype characterize this solution as a support tool for activities developed by Clinical Engineering to improve processes in health care.

Contribution ID: 1480
18. Clinical Engineering
18.04. Information and communication technologies and clinical engineering (CE-IT)

Management and Design of Successful, Safe, and Reliable Integrated Medical Device, Information and Communication Systems

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For the past two decades, medical devices and ICT systems have been evolving and converging. Not only have new digitally-enhanced device capabilities been created by this convergence, but entire new classes of device, such as Software as a Medical Device have emerged. The Digital Hospital of the 21st Century has already begun to take shape in many countries, and remarkable new diagnostic and therapeutic interventions are already occurring. At the same time, there are many new planning, design, implementation, and maintenance strategies needed to catch up with these innovations. This presentation will discuss several new technology assessment, cybersecurity, quality and safety management, and life-cycle cost control techniques that are being applied to assure successful adoption and use of converged technologies and systems.

Contribution ID: 41
18. Clinical Engineering
18.05. International standards and regulations of medical devices

Establishing traceability chain of infusion and perfusor pumps using legal metrology procedures in Bosnia and Herzegovina

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Establishing the traceability chain of measurements for medical devices commonly used in everyday patient treatment was the main objective of this paper. This should directly ensure that through periodical calibrations of etalons and independent inspection procedure of medical devices according to international standards, safe and accurate diagnosis and treatment can be created.
This study is designed to cover 850 perfusors and 700 infusion pumps used in public and private healthcare institutions, during a period of one year. Testing procedures were carried out according to international standards and legal metrology legislative procedures in Bosnia and Herzegovina.
The results show that the average measurement uncertainty of infusion pump is u1, while for perfusor pump is u2. These obtained results combined with other relevant documents, references and competences create the traceability chain. Additionally, as consequence cost benefits analysis

proved yearly savings of 50% if healthcare institutions follow legal metrology procedures compared with unnecessary manufactures attests.
Research emphasizes importance of establishing traceability chain in protection of public health. Results offered also implications for adequacy of etalon calibration and preventive maintenance performed on medical devices. Based on collected measurement data, web based application with database of infusion and perfusor pumps used in healthcare institutions in Bosnia and Herzegovina was created.

Contribution ID: 614
18. Clinical Engineering
18.05. International standards and regulations of medical devices

Development of a Chair-based Cuffless Blood Pressure and a Work for Standardization

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We have attempted an unobtrusive cuffless BP monitoring system based on pulse arrival time (PAT) for facilitating long-term home BP monitoring. The proposed system consists of an electrocardiograph (ECG), a photoplethysmograph (PPG), and a control circuit with a Bluetooth module, all of which are mounted on a common armchair to measure ECG and PPG signals from users while sitting on the armchair in order to calculate continuous PAT. Considering the good linear correlation of systolic BP (SBP) and the non-linear correlation of diastolic BP (DBP) with PAT, a new BP estimation method was proposed. Ten subjects underwent BP monitoring experiments involving stationary sitting on a chair, lying on a bed, and pedaling using an ergometer in order to assess the accuracy of the estimated BP. A cuff-type BP monitor was used as reference in the experiments.
Results showed that the mean difference (MD) of the estimated SBP and DBP were within 0.2 ± 5.8 mmHg ($p<0.00001$) and 0.4 ± 5.7 mmHg ($p<0.00001$), respectively, and the mean absolute difference (MAD) of the estimated SBP and DBP were 4.4 mmHg and 4.6mmHg, respectively, compared with references.
To generalize a cuffless blood pressure, the standardization and/or regulations are important issues Several healthcare industries are interested in the cuffless blood pressure monitor. If products are easily find in the market, the standardization is needed as a point of safety both mechanical and electrical. Furthermore, medical devices are required accuracy and reproducibility. IEEE standard 1708-2012 followed the accuracy and reproducibility of international standard organization/American Association of Medical Instrumentation (ISO/AAMI) and European Society of Hypertension (ESH) protocols

Contribution ID: 1502
18. Clinical Engineering
18.05. International standards and regulations of medical devices

Impact of the new Regulation on medical devices in terms of safety checks

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Introduction: The aim of this study is to evaluate the impact of new legislation on medical devices in terms of technical maintenance and inspections. Further, the comparison of changes compared to the previous legislation and the benefits and cons of the new law for the various stakeholders.

The practical objective is to determine the appropriate opportunities for planned preventive maintenance of selected medical devices.
Methods: The changes introduced by the new Regulation (EU) 2017/745 of the European parliament were determined based on discussions with healthcare facilities, medical equipment manufacturers and authorised repairers. To determine the appropriate opportunities for planned preventive maintenance were calculated the total cost for the two authorised service centers and compared with the total cost for internal staff of the medical facility.
Results: In new regulation on medical devices were found some drawbacks, which are presented in this study. Results comparing the cost efficiency were, for three different healthcare providers, diverse. Motol University Hospital was, based on the results, recommended that planned preventive maintenance of medical devices should be done with internal staff in this facility. Saved an annual amount equal to 1,505,239 CZK. Homolka Hospital was recommended to carry out planned preventive maintenance by authorised service organisation, the annual difference in total costs compared to internal employees is equal to 149 271 CZK. Kladno Hospital was, after considering all factors, recommended to control medical devices by internal employee in this facility. Annual saved amount in this case is equal to 310,869 CZK.
Discussion: Contribution of this study is highlight the imperfections of the new legislation that could lead to an amendment of the Regulation (EU) 2017/745. The practical benefit of this thesis is a methodology that allows healthcare facilities to choose more cost-effective option for planned preventive maintenance.

Contribution ID: 28
18. Clinical Engineering
18.06. Innovation and design of surgical and medical devices

Experience in design of temporary external pacemaker the case mexican institute of social security (IMSS)

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Introduction: The Cardiac pacemaker is an electronic device used to stimulate the heart to beat at a programmed rate. Patients whose heart is beating too slowly will require a pacemaker.
Materials and Methods: This work describes the development and design of a bipolar external pacemaker for temporary pacing, including important practice implementation. The prototype pacemaker was designed for analogue sensing and stimulation by of oscillator’s circuits with the lowest possible amount of power consumption using one 9V battery. It was successfully tested under clinical conditions.
Results: We evaluated the first prototype systems, both in routine and emergency use, the pacemaker prototype was tested on 2 patients (1 routine and 1 emergency) Overall, successful. The maximum current used was limited by the degree of pain experienced. These data suggest that the benefit derived from transcutaneous pacing is limited. The pain experienced by patients may be diminished by appropriate analgesics and sedation, thereby allowing a greater pacemaker output particularly in an emergency situation.
Conclusions: Our manually-controlled external stimulator, a versatile experimental device. The unit Is output is a rectangular, biphasic pulse, variable in width, period and peak voltage 10-50 milliseconds, 0.1-1 millisecond, Vo 0-9 Volts.
Stainless steel electrodes are supplied, each constructed of a dual stainless steel stranded wire covered with silicon rubber.
Pretending to be useful in IMSS health care programs, which treats myocardial infarction or attack as the death of the heart cells by obstructing an artery; which is a risk factor that trigger multiple cardiovascular conditions that in the experts opinion are regularly associated with risk factors such

as overweight, high blood pressure, diabetes and smoking, as well as sedentary lifestyle and stress.

Contribution ID: 81
18. Clinical Engineering
18.06. Innovation and design of surgical and medical devices

Smart tourniquet system for military use

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Extremities are the most frequently injured regions of body encountered with the combat casualties. The extremity hemorrhages constitute the leading cause of preventable deaths in the first aid period. Thus, tourniquets are indispensable devices for combat casualty care. There are some military tourniquets, which are produced worldwide and can be manually applied by the wound to prevent blood loss. However, in military applications, there is no tourniquet system comprising these features that can be used with one hand, can be applied quickly and transmits information. We have developed a tourniquet system which applies the required pressure to the extremity of the person by moving a belt connected to the pulley with a motor. When the arm or leg buttons on the device are pressed, the system is activated. Once the belt is fitted to the extremity, the system automatically starts the tourniquet process and is continued until the bleeding is stopped. The information of the blood flow and force applied are acquired via the feedback from the motor encoder and the force sensor. The system starts the tourniquet process and the bluetooth transmits the location and application time of the tourniquet. The receiver informs the headquarters via the military communication standard. In this respect, it is possible to be informed about exact location of the injured soldiers in the hot zone. In order to test the developed tourniquet, we have produced the leg phantoms which consist of femur bones and plastics similar to in actual dimensions of the human leg and artificial veins. Tourniquet operation was applied to the point where the tourniquet-operated blood flow stopped. It is thought that the developed system will be used in military applications and internal security.

Contribution ID: 140
18. Clinical Engineering
18.06. Innovation and design of surgical and medical devices

Analyzing energy requirements of meta-Differential Evolution for future wearable medical devices

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Recent advances in clinical engineering include development of physiological models to deliver optimized healthcare. A physiological model comprises a number of equations to relate biomedical signals. Each equation contains a set of coefficients. Determining the coefficients is a complex task as the models are non-linear. Therefore, development of the models must be accompanied by a development of methods to determine their coefficients. With the advent of wearable medical devices, we have to consider energy requirements of the models and methods. Considering an illustrative case of diabetes mellitus type-1 patients, we already demonstrated that Meta-Differential Evolution outperforms analytical methods, when determining coefficients of glucose

dynamics. In this paper, we analyze convergence of the Meta-Differential Evolution, running time and associated power consumption on a single board computer with a system-on-chip – Cortex-A8 AM335x. The results confirm feasibility of using Meta-Differential Evolution with a low-power device, if we obey implications outlined in this paper. Specifically, we recommend splitting the process of determining the coefficients into two phases. First phase determines the initial, per-patient optimized coefficients. Second phase is an energetically efficient update of these coefficients with new, continuously measured signal of the patient. Meta-Differential Evolution searches for optimal coefficients by evolving a number of generations of candidate coefficients, using a number of evolutionary strategies. We demonstrate that proposed two-phase approach significantly reduces the number of candidate coefficients to be evaluated, while achieving the desired accuracy. This positively reflects in the lifetime of wearable device's battery.

Contribution ID: 583
18. Clinical Engineering
18.06. Innovation and design of surgical and medical devices

Development of a novel self-calibration thermometer using low melting-point metal

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A sensor with self-calibration function is ideal and many attemptswere made in various fields, such as visual sensor, inertial sensor, and so on. In the field of body temperature measurement, semiconductor type thermistor has been widely used. However, in thermistor, the problem of so-called "aging" do exists. Despite of this, commercially available thermometers are calibrated only once before put on the market. This means, to precisely measure body temperature, recalibration is indispensable. To solve this problem, we have been trying to develop a novel self-calibration thermometer.
As a temperature standard, we utilized Gallium (Ga) metal because of its stable melting temperature (29.7646 deg.Celsius). Ga has been used for calibrating various types of thermometers. However all of those are bulky instruments and impossible to install into a tiny thermometer head.
To realizing a self-calibrating thermometer, we newly designed a Ga metal coated thermistor. For makeing a thin Ga layer onto the surface of glass bead head (o.d.: 1.5mm, length: 2mm) of a thermistor (NXFT15XH103FA2B050, Murata Manufacturing.), 5N Ga (Sigma-Aldrich) was melted and dip coated. Then, to protect the Ga layer, polyurethane was dip coated and air dried.
This prototype thermometer was inserted in the axilla of a healthy adult and expected results shown below were obtained; The thermistor output was gradually increased from room temperature until it reached to about 29.5 deg. Celsius. Then, the output became almost flat for about 30-50 seconds, and increased again and reached to about 35 deg. Celsius. The experiment was repeated several time and reproducibility was quite good. Using this flat region, we can easily calibrate the thermistor, and this re-calibration could be performed every measurement with "automatic" manner. We are now planning to blush up this prototype sensor by incorporating a micro capsulation technique of Ga.

Contribution ID: 661

18. Clinical Engineering
18.06. Innovation and design of surgical and medical devices

Towards autonomous surgical suturing: augmented stitching of coronal incision

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We introduce an analytics-driven instrument that performs surgical suturing procedure in a fast semi-automatic fashion. Particularly, to develop our platform we have focused on the so-called "coronal access" suturing as on one of the most frequent and important procedures in the maxillofacial, plastic-, and neuro- surgeries. The coronal incision runs from the tragus of one ear, over the temporal and parietal regions of the head, to the tragus of the other ear, allowing access to all areas of the head (except for the lower jaw). In today's practice, stitching the open scalp flaps is a particularly time-consuming task due to the complex geometry of the incision and due to the general fatigue of surgeons after the operation (4-9 hours, on average).
Our platform comprises three major components: the electro-mechanical apparatus, the stitching needle, and the vision system. The electromechanical apparatus is a computer-controlled driver that can alternate speed and direction of the needle-accepting slot (axial rotation unit); the stitching needle has a shape of a spring, with the proximal end to be inserted into the needle-accepting slot, and the distal end to accept the surgical thread through the needle eye; and the vision system contains a standard RGB CCD camera with a changeable imaging optics. The spring needle is made of steel (X18H10T) with a diameter of 0.8-1.2 mm and a length of 40-45 cm. The computer-controlled axial rotation unit drives the needle through the flaps for the scalp; accepts the thread near the end of the incision, and then stitches the wound by reversing the rotation direction. The suturing lasts about 5 minutes and provides a continuous aesthetic seam. We have validated the instrument on porcine (n=5) and post-mortem human models (n=5). The ongoing effort focuses on analytics of the vision data in order to build a fully-automatic prototype.

Contribution ID: 766
18. Clinical Engineering
18.06. Innovation and design of surgical and medical devices

A cloud-based web application for chromatic pupillometry

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The Italian Ministry of Education, University and Research has funded a research project of national interest on hereditary retinal illnesses in subjects up to 16 years of age. Four University partners are participating in this project to identify patients eligible for the pupilometric protocol and its data collection. The protocol concerns the evaluation of chromatic pupillometry ie the study of pupil movements during a luminous stimulation emitted by a binocular chromatic pupillometer. Thus, the need to create a single parameter reading center is achieved through the creation of a cloud platform for storing the data collected by two clinics.

The application handles all the information captured as signals, images and parameters about the trend of the pupil diameter throughout the stimulation. The web platform is based on MS SQL Server 2008 R2 database engine and deployed using MS Visual Studio 2017 both for client and server sides.
The HTML5 based client is designed to have a coherent and functional interface while the RESTful server side is based on WEBAPIs. The connection between client and server is performed AJAX calls that exchange background data between web browser and server with an update of the page without explicit reload.
The web application provides the end user with the analysis of pupillometry values by displaying a table containing the parameters of maximum diameter, minimum and maximum contraction speed and a time graph of pupil diameter both realized with a Javascript library (D3) that allows arbitrary data, in this case coming from a file, to be associated with a Document Object Model (DOM) object model.

Contribution ID: 788
18. Clinical Engineering
18.06. Innovation and design of surgical and medical devices

Toward a novel medical device based on chromatic pupillometry for screening and monitoring of inherited ocular disease: a pilot study

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Chromatic pupillometry is a relatively novel research tool for the evaluation of retina function and may be a novel way to diagnose and monitor inherited retinal diseases in paediatric population. Nevertheless, although the method is clinically feasible in paediatric populations, as shown by several non-ocular studies, only few studies, on a small size sample of paediatric ophthalmic subjects, are available. Moreover, to the best of the authors' knowledge, no medical device based on chromatic pupillometry was CE-marked for diagnosis and / or monitoring of inherited ocular disease. Therefore, we designed a pilot study in order to evaluate clinical feasibility and utility of chromatic pupillometry. The study sample consists of sixty patients, affected by inherited ocular diseases. A pupillometric system, including definition of pupillometric protocols, have been set up. The results of the pilot study will be presented in order to show reproducibility and repeatability of chromatic pupillometry parameters and to evaluate differences in chromatic pupillometry parameters between case and controls.

Contribution ID: 974
18. Clinical Engineering
18.06. Innovation and design of surgical and medical devices

Analysis of left ventricular unloading by double lumen arterial cannula during ECMO assessed by mathematical modeling

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Introduction: Extracorporeal membrane oxygenation (ECMO) is increasingly used for the therapy of rapidly progressing or a severe cardiogenic shock. However, flow-dependent left ventricle (LV) overload is a well-known complication of ECMO, which significantly deteriorates LV performance. A number of approaches have been suggested to deal with LV unloading. Each of these methods require extra intervention, which increases invasiveness of the method and thus does not respond to current trends in the mini-invasive performance. Therefore, the development of the mini-invasive method of left heart decompression is a significant issue in ECMO therapy.
The aim of the present study was to present an alternative mini-invasive method of the left ventricular unloading during ECMO therapy.
Methods: A draft was created in AutoCAD software. The Modelica modeling language was used for modeling and simulations. Initial parameter values were derived from measurements on a female swine. The flow value in drainage lumen of the double lumen arterial cannula during various extracorporeal blood flow (EBF) values (from 1L/min to 5 L/min) were investigated.
Results: The simulations on a created model have indicated that 10 F drainage lumen of the double lumen arterial cannula for VA-ECMO is capable to withdraw 0.374 L/min during EBF 1L/min, 0.441 L/min during EBF 2L/min, 0.481L/min during EBF 3L/min, 0.532 L/min during EBF 4L/min, 0.560 L/min during EBF 5L/min.
Conclusion: The double lumen arterial cannula for VA-ECMO is less invasive approach than current existing methods for the left ventricle decompression during ECMO. The double lumen arterial cannula is capable of achieving left ventricle decompression and blood return while requiring a single puncture. The double lumen arterial cannula presents an alternative and perspective solution to achieve the LV unloading during ECMO.

Contribution ID: 1243
18. Clinical Engineering
18.06. Innovation and design of surgical and medical devices

Innovation in the ventilation system for noise reduction in neonatal incubators

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Neonatal incubators (NI) were designed to provide preterm newborns with an artificially controlled environment and very close to the conditions of the maternal uterus. Neonatal Intensive Therapy Units (NITUs), such conditions favor the recovery of the same. Allied to a bibliographical research carried out measurements were made inside the dome of a NI and the results show that the sound pressure levels, or noises, are much more intense than the levels stipulated by the norm NBR IEC 60.601.2.19 of ABNT. These measurements revealed that the NI air convection system motor is the main source of excess noise. In view of the above, a project was developed with the objective of significantly reducing the noise level inside the dome by modifying the air convection system. Thus, a quantitative study was developed, based on the experimental method, where a ventilation mechanism was redesigned, constructed and tested, which operated from the network of medical compressed air, present in the NITUs and maternity rooms. Respectively, before and after the modification of the air convection system, the data of relative humidity, air velocity, atmospheric pressure, air temperature and noise [(64,9 ur / 33,15ur); (0,27 m/s / 0,28m/s); (1.013,98 HPa /

1.013, 60 HPa); (36,5º C / 36,3º C); (45,99 dB(A) / 30,23 dB(A)], Were collected by electronic meters that registered the conditions of the internal environment of the dome of an NI with a passive humidification system. On average, more than 5.000 data were collected for each of the physical variables measured in the environment and the results found showed an optimal performance of the modified NI. Noise measurements showed that there was actually a significant reduction of 15.76 dB (A), corresponding to a 34.27% reduction of internal noise, measured before the modification of the ventilation system.

Contribution ID: 1799
18. Clinical Engineering
18.06. Innovation and design of surgical and medical devices

Digitalisation in hospitals – smart medical sterile containers increasing patient safety

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Digitalisation, a keyword representing a huge trend in industry, consumer market but also the healthcare. But how can a hospital benefit from connectable devices which cause higher acquisition costs than the regular devices? The answers are the possibilities given by the connection itself, providing additional data and increasing automatization of time consuming tasks. One example for this are the medical sterile containers which store medical instruments, implants and devices. A big issue is the search for a specific container inside a big storing room or trying to determine what is the exact contents of a particular container. This can cause long searching times and unnecessary openings of not needed container sets.
To provide a solution of this issues, the presented work is about the implementation of a reliable identification system of medical sterile containers, providing additional data like content, sterile state and possible damages of the container itself by connecting the unique container ID with a database. To update the connected database, the container needs to be equipped with a sterilisable sensor system, detecting possible damages like drops or rollovers during transports. Furthermore, sensors for sterilisation parameters can be implemented to indicate a successful sterilisation process.
Another increase of safety and decrease of inefficient tasks is the possibility to localize a container inside a hospital with mobile devices. This can be achieved by adding beacon-like modules transmitting their current position to other devices. Hereby, a digital real-time map and the container locations can be created and used by the staff searching specific sets.
The use of smart medical sterile containers can increase the safety of the patients by warning the clinical staff about possible contaminations as well as ease the daily work of the clinical staff by reducing search times and providing needed data without checking the container manually.

Contribution ID: 1801
18. Clinical Engineering
18.06. Innovation and design of surgical and medical devices

Improving patient safety with permanently sealed sterilisable electrical surgical instruments

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The risk of contamination during the surgery procedure is one of the most important issues both in clinical practice and the design process of new surgical devices. The surgical instruments need to be sterilised before each procedure. However, the electrical devices like surgical saws and drills cannot be sterilised as a whole because of the battery packs which could explode inside the autoclave. Due to this fact, the battery needs to be stored separately and is not sterile. The procedure of installation or replacement of non-sterile battery into a sterile device is complicated, time consuming and involves the risk of contamination.
As a solution for these problems we consider a novel approach to the electromechanical surgical device design and maintenance. Firstly, the appropriate chemically stable cells have to be chosen. We decided to use Lithium Phosphate cells due to their extreme safety. The cells are then insulated with aerogel-based insulation. The battery pack is integrated with wireless power transfer system to provide a sterile charging possibility. The whole device is then sealed with the polypropylene-based material to provide water resistance. The wireless power transfer is limited to 20W to provide user safety and reduce the risk of misuse and its side effects. Additionally, the integrated Bluetooth module brings the possibility to check the state of battery charge and the sterile status of the device remotely. Our approach opens the door to whole new handling of medical electric devices. It may lead to significant simplification of the whole maintenance procedure and reduce the danger for patients.

Contribution ID: 506
18. Clinical Engineering
18.07. Disaster preparedness for clinical engineers

Implement and development a disaster recovery planning in hospital from clinical engineer view

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Recent disaster- and conflict-related crises have demonstrated the overwhelming need for skilled professionals who are able to respond adequately to complex emergencies.
A coherent and holistic approach to disaster risk management is not without challenges. Decision have to be based on a politically, economically, socially, culturally, and environmentally sustainable foundation and rooted in sound development policies. Risk reduction needs to underpin and guide decisions in Preparedness, Response and Recovery planning and programmes.
Clinical engineering (CE) is a professional who supports and advances patient care in hospital by applying engineering and managerial skills to healthcare technology. The planning has been written to cover principles, procedures, methods and terminology from the CE view in a hospital.
The planning includes a wide range of topics such as: Communications in emergencies, needs assessment and monitoring They were fixed initially the equipment that will be required to support the hospital's operations after evacuation of the building (eg cardiograph, portable radiology, etc.). New equipment with a defined position and marking was selected. A stricter maintenance program was put in place and all staff were trained to use it. Effective plans also consider securing resources, possibly including stockpiling supplies and earmarking funds. Legal framework and memorandum for support from other hospital in a close distance. It also involves the education and training of officials and the voluntary groups at risk, the training of intervention teams, and the establishment of policies, standards, organisational arrangements and operational plans to be applied following a disaster.
Disaster preparedness and response involve forecasting and taking precautionary measures prior to an imminent threat when advance warnings are possible. Preparedness planning improves the

response to the effects of a disaster by organising the delivery of timely and effective rescue, relief and assistance. Preparedness involves the development and regular testing of plans.

Contribution ID: 1851
18. Clinical Engineering
18.07. Disaster preparedness for clinical engineers

Development of strategic plans in an oncological unit in case of disasters for clinical engineers

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The Oncology Units have become important health care centers, since cancer is a global health problem. Therefore, it is important that a Clinical Engineer is prepare for a natural disaster such as earthquakes.
It is of the utmost importance that the clinical engineers of the oncology units must been prepared for any disaster, whether natural or chemical; natural disasters occur anywhere and it is necessary to have a strategic plan in which the main activities to be performed in oncological units are identified.
In this risk prevention plan, preventive measures will be shown in case of earthquakes focused on the use of ionizing sources referring to open and sealed radiological sources that are managed in oncological units, preventions and recommendations in diagnostic imaging devices, containment plans for radiological safety during earthquakes, civil protection associated with clinical practices and individual analysis for the preparation of life support medical devices in case of a problem in an oncology unit.
The oncology units depend greatly on the areas of Nuclear Medicine, Radiopharmaceutical and Radiopharmaceutical Preparation, for these services, actions and strategic plans for disasters were developed, focused on clinical engineers who are in charge of verifying the adequate functioning and the adequate facilities. In addition, the strategic plan for the oncology unit will be presented in terms of basic health, electricity, medical gases, LP gas and health supplies.

Contribution ID: 416
18. Clinical Engineering
18.08. Clinical process analysis and optimization

Using the Monte Carlo stochastic method to determine the optimal maintenance frequency of medical devices in real contexts

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Periodic preventative maintenance policy is where device parts are maintained preventatively at fixed time intervals (T) and any intervening failures are repaired. With regard to the establishment of a T value, one solution is to determine the T value from maintenance data records taken from real contexts where medical devices are installed. The purpose of this study was to implement and validate a Monte Carlo Algorithm (MCA) to determine the best T value that optimizes the achieved availability of equipment types. We (1) collected 796 maintenance works orders from 18 medical devices installed in a 900-bed hospital; (2) we fitted the probability distributions for each of the

inputs of the achieved availability mathematical model (the mean preventative and corrective service time (in hours) of the medical devices); (3) we generated a set of random inputs following a Weibull distribution of the achieved availability mathematical model; (4) we calculated the achieved availability for every random input generated; this process was repeated for "m" iterations (an accuracy of 1%, 95% CI, alpha=0.05); (5) the trends of the mean achieved availability for different maintenance T intervals versus mean time to failure (MTTF) for all the equipment types were plotted; finally, (6) the best T value with the maximum value of the achieved availability of a medical device type for a specific MTTF was the optimal target. The mean simulation time for all the cases was 12 minutes (19532 simulations on average). The MCA was able to determine the best T value, optimizing the achieved availability in 82.35% of cases (Pearson-Chi-Square=17.0, df=1, p=0.000). In conclusion, the results showed that on average the T maintenance intervals determined by the MCA were statistically significantly different from the original T values suggested either by the clinical engineering department or third-party maintenance providers (MCATmean=1.7 times/year, OriginalTmean=2.3 times/year, p=0.007)

Contribution ID: 574
18. Clinical Engineering
18.08. Clinical process analysis and optimization

Evaluation of benefit of low dose CT in the diagnosis of Charcot arthropathy

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Diabetes mellitus (DM) is accompanied by many complications (nephropathy, neuropathy, ischemic heart disease etc.), while the foot ulcer falls among the most serious ones. The main problem for the right diagnosis of this syndrome is an appropriate choice of a diagnostic scenario.
The aim of this study is to analyse the current possibilities of DM diagnostics using particular imaging modalities, and to compare them with a three-phase skeletal scintigraphy complemented by a low-dose CT. The principal method of this work was the cost effectiveness (C/E) analysis of individual diagnostic modalities in relation to a timely detection of the disease completed by a sensitivity analysis. The result of a multiple-criteria decision analysis calculated by means of the TOPSIS method was used as the effect for the C/E calculation. Nine basic criteria entered the analysis.
The values of the final effects of individual modalities are in favour of the skeletal scintigraphy and the leucoscan plus the low-dose CT. Furthermore, total costs were calculated for individual diagnostic approaches from the perspectives of a medical facility and of a health insurance company. In both cases, the lowest costs were reached for the magnetic resonance, which has also significantly influenced the final value of the cost effectiveness. In the sensitivity analysis, variations in the skeletal scintigraphy and/or leukoscan sensitivity did not affect the final order of the diagnostic modalities provided unchanged weights of the criteria. The same conclusion was also in the case of the magnetic resonance. A change in the order was detected for the skeletal scintigraphy with the low-dose CT and for the leukoscan in the case of a decrease in specificity by 40 or more percent.
The study opens a topical issue and forms a basis for a broader discussion concerning Charcot osteoarthropathy diagnostics within the professional community.

Contribution ID: 979
18. Clinical Engineering
18.08. Clinical process analysis and optimization

Use of modelling simulation to monitor the performance of a pediatric emergency department

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Hospitals are complex systems in which different departments interact with each other to deliver services to patients. The analytical models use mathematical representations to facilitate the understanding of a complex process. The models can be simulated with an imitation of the operation of a system and its internal processes, usually over time, and in appropriate detail. Simulation is used for both predicting the performance of new systems by means of a deep examination of system components, their behavior and time-based interactions as well as predicting the effect of changes into existing systems.
Since emergency departments (ED) are unpredictable and frontline of health care service delivery, their detailed description and analysis are highly needed in order to design improvement actions.
In this study, we will present the modelling simulation of the ED of Santobono Pediatric Hospital in Naples, Italy which admits more than 100k/year patients. The tool used for the simulation modelling is SIMIO (SIMulation modeling framework based on Intelligent Objects). SIMIO's models are realistic and looks like the real system in fact it provides an object-oriented approach with an integrated 3D animation that helps assure more robust, understandable models and better communication with hospital staff.
The dynamic simulation of ED process followed the standard steps: (i) conceptual design process developing a detailed understanding of the system with stakeholders' involvement, (ii) input analysis characterizing the system inputs using sample observations, (iii) model development with the definition of an executable model that was verified and validated to check its correctness. Finally, with an (iv) output analysis a set of information were extracted. Specifically the achieved simulation data was used to assess performance metrics (e.g., average waiting time, number of patients in the ED waiting room) and design new organisation and patient flow (e.g., change the number of nurses, add new exam rooms).

Contribution ID: 1024
18. Clinical Engineering
18.08. Clinical process analysis and optimization

Study of phenylalanine near infrared spectra for PKU determination

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Phenylketonuria (PKU) is a genetic disorder characterized by accumulation of Phenylalanine in blood and a tendency to have very light skin (low melanin). Babies are screened for PKU 2–7 days after birth, using dried blood spot samples drawn by neonatal heel prick. This method generally have an analysis time of a few days, complicated manual sample preparation and the heel-prick test carries risks that include bleeding and infection. The aim of our study is to develop an in vivo method to determine the phenylalanine.

We have investigated the spectral properties, in the NIR spectral range of L-Phenylalanine dissolved in deionized water and also dissolved in a mixture of 70% red blood cells and 30% saline. This range was chosen due to the reduced photon absorption, which allows much deeper penetration, affording the possibility of an in vivo Phenylalanine determination.
Phenylalanine levels in PKU, may reach 100mg/dL, but are usually greater than 30mg/dL. Therefore, we have prepared samples with varying concentrations of L-Phenylalanine (ranging from 10mg/dL to 500mg/dL). Samples were measured in transmission mode in the interval 0.9 to 1.7microns using a NIRQuest Ocean optics spectrometer and analyzed using eFTIR software. Data was also analyzed by the Unscrambler software for PLS and SVR algorithms.
We have shown that L-phenylalanine can be detected in saline and in blood in the NIR spectral range, with C-H and N-H overtones at 1495 nm, 1520 nm, 1560 nm, 1620 nm and 1670 nm. In addition the spectral overtones data were confirmed also by the spectral second derivation and PLS regression coefficients graph. SVR R-square for validation group was found to be 0.84.
In order to develop an in vivo method for PKU determination, VIS spectroscopy must also be used for the detection of melanin. The current stage of this research addressed the L-phenylalanine only.

Contribution ID: 1448
18. Clinical Engineering
18.08. Clinical process analysis and optimization

Convex magnet generating a uniform magnetic force for magnetic immunostaining

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Magnetic immunostaining using a magnet and antibody-labeled fluorescent ferrite (FF) beads can significantly promote the immunoreaction by magnetic force, so that the reaction can be completed during operation. Because the beads are localized on the magnet’s edge in magnetic immunostaining using a flat-magnet, the immunostaining cannot be performed correctly. We propose a convex magnet that generates magnetic force for uniformly attracting antibody-labeled FF beads toward antigens on an entire tissue section.
We numerically calculated magnetic force in the perpendicular and radial directions, and evaluated the convex magnet configuration by changing the curvature radius in the magnet surface from 35 mm to 115 mm at a 20-mm interval. The curvature radius of the flat magnet is infinite. The radius and height of the magnet are 18 mm and 24 mm, respectively.
In the flat magnet, variation of maximum magnetic force in the staining area in the perpendicular direction relative to the value at the magnet center was ~144%; moreover, that in the radial direction relative to minimum magnetic force in the entire staining area was ~6.4%. In the convex magnet with a 55-mm curvature radius, variation of magnetic force in the perpendicular direction was ~31% —much smaller than for the flat magnet. In other curvature radii, the variation was ~47% or higher. With curvature radii of 35 mm and 55 mm, variations of magnetic force in the radial direction were ~5.3% and ~5.7%, respectively, showing no significant variation between both values. Results indicate an optimal curvature radius of 55 mm.
The optimum convex magnet configuration for generating uniform magnetic force was determined by evaluating the curvature radius in the magnet surface. We will evaluate curvature radii in more

detail between 35 mm and 55 mm and perform magnetic immunostaining using the proposed magnet.

Contribution ID: 70
18. Clinical Engineering
18.09. Medical devices incident analysis and management

Study and proposal on adverse events related to implantable cardiac devices

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Currently, several innovative technologies, applied to the cardiovascular system, save countless lives and improve the quality of life of thousands of patients, however, there are also cases of patients suffering adverse events related to devices that fail or are inadequately applied.
These situations, which constitute the negative side of technology, are largely due to the use by inadequately trained personnel and in some cases by poor manufacturing quality of the devices. One of the current tasks of clinical engineers is to contribute to the avoidance of such events, either by participating in the training of personnel who apply technology to patients and also in the important task of technology surveillance, aimed at detecting, reporting and protocolize studies about .technology evaluation
While it is true that HTA is not an exclusive task of clinical engineers, it is also true that these are the professionals who most need to know about the technical characteristics and applications of the various devices. This work deepens the study of various adverse events, including some fatal, produced in the most used technological devices applied to the cardiovascular system, particularly STENTS, pacemakers and implantable defibrillators that increase their use every day throughout the world. Adverse events occurring in different parts of the world are analyzed considering their cause and the consequences for patients, in order to obtain useful information for the reduction of casuistry. So that conclusions are obtained aimed at preventing and avoiding such adverse events

Contribution ID: 844
18. Clinical Engineering
18.09. Medical devices incident analysis and management

Evaluation of downtime of linear accelerators installed at radiotherapy departments in the Czech Republic

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For the needs of the State Office for Nuclear Safety (national regulatory authority), the National Radiation Protection Institute (NRPI) performed the study evaluating linear accelerator (linac) downtime and other parameters related to linac breakdown (e.g. treatment cancellations, patients transferred to other linac, patients treated with modified dose fractionation) at radiotherapy departments in the Czech Republic. Thirteen radiotherapy departments with at least one linac (out of twenty one departments in the Czech Republic) voluntarily participated in the study covering 29 (out of 47) linacs. Downtime was evaluated for a one year period from July of 2016 to June of 2017.
The methodology used in the study is as follows: NRPI designed an Excel spreadsheet form which was sent electronically to medical physicists at radiotherapy departments. In this form, data related to linac failure were filled in (e.g. time of occurrence of linac failure, of report to service organization, of service engineer arrival, of linac being fixed, of interruption of clinical operation).

The completed forms were evaluated by NRPI. Downtime was defined as time when linac cannot be operated during normal operating hours.
Unscheduled downtime per linac per year ranged from 4 hours to 222 hours (mean = 73 hours, median = 61 hours). Downtime percentage calculated as ratio of downtime and total sum of operating hours per year ranged from 0.2% to 7.6% (mean = 2.8%, median = 2.2%). The number of treatment cancellations per linac per year ranged from 0 to 661.
Unified methodology enabled objective comparison of linac downtime at particular radiotherapy departments. The study showed usefulness of having minimally two matched linacs at a department. This enables transfer of patients to other linac and decreases the number of treatment cancellations. Results of this study could also help departments to negotiate better service contract (agreement on maximum guaranteed downtime).

Contribution ID: 972
18. Clinical Engineering
18.09. Medical devices incident analysis and management

The application of the total cost of ownership approach to medical equipment - case study in the Czech Republic

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Czech hospitals purchase the most expensive medical technology using public procurement process and they often make their purchasing decisions based on the lowest bid price. However, the management of hospital in most cases is naware that the purchase price is only a minor part of the total cost of ownership of the equipment. This study intended to assess the nature of the Total Cost of Ownership (TCO) method in applications to medical equipment in the Czech Republic, and to carry out TCO analysis for selected medical equipment units. In order to evaluate the awareness and utilization of TCO in Czech hospitals, a quantitative research method (questionnaire) was used. The questions were addressed to the investment departments of the hospitals. To accomplish the research objectives, a TCO analysis for selected medical devices (X-ray machine, SPECT/CT and ultrasound scanner) was conducted. For each equipment four cost items were considered: acquisition costs; service and repair costs; operational costs and the costs of disposal. The results of questionnaire survey demonstrate that the TCO method was unknown to most of the respondents (67%) and the respondents usually make decisions based on the purchase price of medical equipment. All respondents who have already used the TCO method indicated that this method was useful to them. The results of the case study imply that the operating costs for the selected devices over five years are comparable to the purchase price. SPECT/CT scanner was the only one unit, where the acquisition cost was higher than the operational. In case of purchase of expensive medical technology, health care facilities often make decisions on the basis of the lowest bid price. According to the calculated TCO, this parameter is not the only important cost driver in the life cycle of medical quipment in hospital.

Contribution ID: 1241
18. Clinical Engineering
18.09. Medical devices incident analysis and management

Endoscopy equipment processing improvement to decrease failures and management costs

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The procedures performed by endoscopy techniques are an essential element in health care, in institutions of high complexity level as Pablo Tobón Uribe Hospital. The design and operation of flexible endoscopes, contribute to a high proportion of failures by number of uses of these equipments, causing he downtime of the equipment and delays in the delivery of the service; as well as a financial risk associated with high costs of repair and replacement, inherent to this technology.
It was proposed an intervention project in conjunction with the healthcare area, to mitigate these risks. Within the framework of the project, it was made an observation of the process to diagnose the causes of damage; then it was done a technology surveillance and sectorial technology perspective of the main causes of damage of endoscopes and standards related to handling and maintenance, furthermore the identification of common elements and best practices; finally it was defined a low-cost action plan based on the needs of the Hospital and the objective established.
The action plan includes periodic training, acquisition of containers and supplies for protection of the distal end, restructuring of the processes during the different stages of the use and reprocessing of the endoscopes, acquisition of elements to facilitate the transport of the equipment, and redesign of the final storage system and the facilities of the service to reduce the risks of damage and contamination of the equipment.
Based on the bibliography and the historic data of causes of failures, a positive impact is projected with the reduction of USD$27,192 annual which correspond to 56% of preventable damages, with an investment of USD$5,000. This is a tangible contribution to the financial sustainability of the institution.

Contribution ID: 1501
18. Clinical Engineering
18.09. Medical devices incident analysis and management

Design model for risk assessment for home-care lung ventilation

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Introduction: This study consists of several objectives. The first of these objectives is to assesss the risks associated with the whole process of treatment via home-care lung ventilation. The main source for describing such risks was composed of foreign studies. Another objective is to compare risk assessment methods based on the current situation
in the Czech Republic and the world.
Methods: Selected methods of Failure Mode and Effects Analysis (FMEA), Health Failure Mode and Effects Analysis , (HFMEA), Fault Tree Analysis (FTA) and Root Cause Analysis (RCA) were compared with the use of comparative analysis and subsequently examined in the specific areas of home-care lung ventilation.
Results: The final objective is to create a design model for risk assessment in the field of home mechanical ventilation, based on the based on the existing knowledge. This model includes both prospective and retrospective analysis. Their appropriateness of use is documented in this thesis and according to their specificities they are used in a variety of areas.
Discussion: Implementation of risk analyses in this area can contribute to increase the safety and quality of provided care and at the same time help to promote the option for more support of the program of home-care lung ventilation.

Contribution ID: 1694
18. Clinical Engineering
18.09. Medical devices incident analysis and management

Tenting prediction of the ligamentum flavum for preventing dural puncture in the epidural needle insertion

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In order to predict how much the human ligamentum flavum (LF) will be deformed during insertion of an epidural needle, a finite elemental analysis and an experiment were done. From our previous results on Young's modulus of the porcine LF (0.056 MPa), a mock skin analogue made of silicone rubber was employed as test specimen. The width of the vertebral bones could be simulated by the height of the test specimen. In this study, test specimen of four millimeters high was substitute for the porcine LF, whereas that of six millimeters high was substitute for the human LF. Insertion speed of an epidural needle was 0.8 mm/s. Mesh size for the finite elemental analysis was 0.5 mm. Insertion force and deformation of the LF were compared between analysis and experiment. As results of analysis and experiment for the specimen of 6 mm in height as model of the human LF, lower insertion force and lower Mises stress inside the specimen, and larger deformation were observed.

Contribution ID: 1280
18. Clinical Engineering
18.10. Forensic clinical engineering and risk management

Adverse event investigation methodology when product is involved

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When investigation of an adverse event that involved product is conducted according to acceptable failure analysis methodology the outcomes from such process is predictable and intended care, better patient safety, improve product and work processes, and identification of needed mitigation tools that can further prevent future impacts.
First, the investigator must be trained and educated in forensic engineering topics. Such a person is equipped to conduct multidisciplinary investigation and assessing the failure, identifying its characteristics and the root cause of the event. As failure comes in many shapes and sizes it can encompasses physical, human intervention, process, organizational culture/rules, and non-physical such as software. It may have contributing factors from defective product design, processing, manufacturing error, marketing, use, and user.
Acceptable failure analysis has the following steps: (1) clear understanding of the investigation goals, (2) data collection to have clear understanding of the failure, (3) pursue all of root causes, (4) rank the likelihood of each, (5) identify the most likely cause, (6) objectively identify all possible corrective actions, (8) select the optimal one, (9) evaluate its effectiveness.
The investigator must have knowledge of clinical environment and the procedures performed there, be able to interview healthcare professionals, product design and manufacturing personnel, marketing and regulatory personnel, operations administrators, patient and their family, and other healthcare staff. Other important related skills are related to experience in studying the environment where failure occurred and its relationship to the event, to product operation and servicing, physics, metallurgic and to testing tools able to diagnose variety of chemical structure, material mechanics, visual interpretation, and other sensory responses.
The audience will benefit from illustration of each of the methodology steps and testing tools with failure case studies analysis performed by the author over 30 years period.

Contribution ID: 165

18. Clinical Engineering
18.11. Clinical engineering certification, training and education

Experiences in postgraduate training in Clinical Engineering

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Experiences in postgraduate training in Clinical Engineering
In Argentina, the Engineering Faculty of the National University of Entre Ríos (FIUNER) offers, since 2015, a two years post-graduate Specialitation in Clinical Engineering. It is intended for graduates in Bioengineering and Biomedical Engineering and it aims to provide, those who decide to attend it, an updated and specialized training in a field of knowledge in continuous evolution. Clinical Engineering is the branch of engineering that promotes the patient's care, ensuring: a proper treatment, at a reasonable cost, through a rational and efficient use of technology, making a safe use of it. The following publication aims to present the career, its contents and study programme, as well as socialize the experience gained; having already completed, the study of the first cohort of it.

Contribution ID: 394
18. Clinical Engineering
18.11. Clinical engineering certification, training and education

Necessity is the mother of improvisation: how radiotherapy engineers in Nigeria are forced to rise to the challenge

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The acute shortage of teletherapy machines in low and middle-income countries (LMIC) like Nigeria is well-documented. With a population of over 190 million, the country is serviced by only eight machines – a far cry from the IAEA benchmark of at least 1 machine per million population. In addition to this, Co-60 machines appear to be the most viable option for the resource-poor country despite the global shift to LINACs.
Of the three centres using telecobalt units in Nigeria, the University College Hospital (UCH), Ibadan has the highest patient throughput which overstretches the machine and results in frequent breakdown. Whereas studies show that the average downtime for LMIC is 1%, an analysis of the machine breakdown in UCH between 2013 and 2017 reveals an average downtime of 48%; with the longest lasting for 20 months. The common causes of breakdown in the centre are motor faults and defective SMD components, usually resolved by replacement in 60% of the cases. However, paucity of funds to purchase spares and the delay experienced in shipping places a burden on the scarcely-trained engineers who have risen to the challenge of repairing and improvising the faulty parts. This is in spite of their competence level. Like an emergency response team they reduce downtime and answer the distress call of cancer patients who are in need of radiation therapy.
Training of in-house radiotherapy engineers should therefore never be an afterthought because of the solutions they bring to the maintenance challenges of radiotherapy centres in the much-disadvantaged LMIC. Engineers too are stakeholders in cancer care and adequate training will further improve their contribution. The UCH experience can serve as a template for how radiotherapy service engineers in LMIC can rise to the challenge of a depressing situation.

Contribution ID: 423

18. Clinical Engineering
18.11. Clinical engineering certification, training and education

Internal survey is under way but all together we can make it better

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Recent few national requests for international advice and help from the leadership of the Clinical Engineering Division of the International Federation for Medical and Biological Engineering (CED/IFMBE) in establishing a clinical engineering (CE) certification/registration program, and in legislating participation of clinical engineers in medical procedures, initiated lively and productive discussion. A short list of open questions was spontaneously formed, and soon after transformed into an internal survey for the CED/IFMBE leadership.
The survey on two fundamental questions - 'What is CE?' and 'How can we (IFMBE with its partners) advance CE globally?' - has been e-mailed to 63 members and collaborators of the CED/IFMBE, and additionally to 16 members and collaborators of the Health Technology Assessment Division of the IFMBE (HTAD/IFMBE). Two survey questions actually consist of five sub-questions each, and this work presents a feedback of the CED&HTAD/IFMBE leadership related to eight of those sub-questions requiring just very short and quick answers as a minimum.
The survey response rate is only 32% so far. CE is not equal to biomedical engineering (BME) for 100% respondents, but is rather a subset of BME for 88% respondents. CE is neither equal to health technology management (HTM) for 100% respondents, but it rather encompasses HTM for 67% respondents. CE practitioners are health professionals for 92% respondents, while CE is not only for engineers for 72% respondents. The answers on questions 'Do/can we legislate?', Do we register?', 'Do we certify?' and 'Do we support accredited CE undergraduate programs?' are positive in 46%, 78%, 87% and 89% cases, respectively.
After completing, analyzing and synthesizing the results of this survey, consensual white papers of the CED/IFMBE in regard to particular topics are expected to be published and specific practical and concrete actions to be taken.

Contribution ID: 486
18. Clinical Engineering
18.11. Clinical engineering certification, training and education

Reduced cost training program in minimally invasive surgery

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Since the first Minimally Invasive Surgery (MIS), this procedure has been grown in worldwide hospitals, due to better patient outcome, reduction of recovery time and less adjacent tissue injury, if compared to open surgery. Despite these advantages, the CAPEX and OPEX must be evaluated by Health Technology Assessment and the surgeons performance must be improved. This work describes a reduced cost Training Program (TP) composed by three levels of theoretical and practical activities to improve the skills of the surgeons in MIS. The basic level is composed by one hour of theoretical class of structure of videosurgery set and accessories (optics and instruments) and for eight exercises to develop fine motor coordination and 3D - 2D perception: Peg-Transfer, deepness perception and control, fine 3D control, Endobag simulation, traction and force control, fine cut with scissors, needle positioning and needle application in simulated tissue, where the score is obtained by time to execute the exercises. The intermediary level consists in one hour of theory with 6 hours of practices in electrosurgery (chicken leg) and 4 hours of laparoscopic suture

in Neoderma simulation pieces, and the score is obtained by the quality of final cut and suture. The last, the advanced level, consist in a hysterectomy in animal (pig), using as approval criteria, to assure that the animal must be alive at the final of the procedure and take off all surgical pieces indicated by the supervisor. The investment for the basic and intermediary levels was, around, US$ 12,000.00 and for the advanced level US$ 180.00 per procedure. This TP has been applied in a multidisciplinary program involving medicine and clinical engineering areas in a University Woman Hospital, where 20 resident physicians started the program and 10 completed all levels, aiming to improve the patient safety undergoing surgery at a school hospital.

Contribution ID: 767
18. Clinical Engineering
18.11. Clinical engineering certification, training and education

IFMBE/CED proposed recognition of certification/registration programs in clinical engineering

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The IFMBE/Clinical Engineering Division (IFMBE/CED) has reviewed existing certification/registration programs in clinical engineering to develop a plan for recognition of these programs. The CED has worked on the certification/registration issue several times since 1979 and all of these efforts have also been reviewed. A proposal has been developed to recognize programs that are certifying or registering individuals in the practice of clinical engineering by IFMBE/CED. This would not be a program to recognize the individuals. Also proposals are developed to aid societies in developing these programs in different ways. These include development of a National Examining Authority (NEA). Certification programs based on credentials only and programs based on exams and credentials are described. Registration programs based on credentials including experience are described. The recommendations are that certification/registration programs should meet individual countries needs and how clinical engineering is practiced in a country. It is not recommended that an engineering degree be required since all clinical engineering practitioners do not have engineering degrees. A proposal is also recommended for certification of individuals who are in countries or regions that do not have a certification or registration. This certification would be based on credentials including experience only.

Contribution ID: 904
18. Clinical Engineering
18.11. Clinical engineering certification, training and education

Healthcare Technology Management (HTM) by Japanese clinical engineers ~ The importance of CEs in hospitals in Japan

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Japanese clinical engineer (CE) is a significant and unique profession compared with other nations with its dual clinical and technology focus and national licensing. The CE system of licensing was established in May 1987 under the Clinical Engineers Act. CEs are required to complete 3 to 4 years in designated schools and pass a national examination. It is a professional medical position responsible for the operation and maintenance of life-support and non-life-support medical device systems under the direction of physicians.

In Japan, CEs support and operate various life-support medical devices. Technology developments have led to significant improvements in performance, making devices easier to break and requiring specialized maintenance. Some of our healthcare technology management (HTM) initiatives include:
1. Rental equipment: oversee use and conduct in-house testing and repair, avoiding faulty units.
2. Ventilator maintenance: a multi-year track record of assessing and replacing defective parts in-house, contributing to prompt repairs and reduced costs.
3. Battery-equipped devices: created a more efficient system for charge management.
4. Intermittent pneumatic compression device dedicated tester: reducing the incidence of thromboses and embolism in patients.
Keywords—Japanese clinical engineer, national licensing, healthcare technology management

Contribution ID: 1463
18. Clinical Engineering
18.11. Clinical engineering certification, training and education

The profile of clinical engineering in espírito santo, brazil

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As a result of high rates of non-operating equipment due to the lack of maintenance and proper training, Clinical Engineering has been growing considerably in Brasil since the 1990s and, therefore, its demand. In the state of Espírito Santo (ES), the reality is different from that found in large cities, such as São Paulo. Besides of the lack of Clinical Engineers working in the management of technology and patient safety, in several hospitals there is no active or effective maintenance plan. On account of that, this article has the following purposes: to verify the presence of Clinical Engineers in ES; to analyse the team composition and the presence of predictive and preventive maintenance procedures; and to compare the proportion of CT and MRI equipment in ES with national and international data. For this, data gathering of 70 hospitals registered in the National Registry of Health Establishments was carried out in order to obtain a list of existing equipment in the places and the way that maintenance service of such equipment is performed, as well as the composition of the team. The result obtained shows that: 38.57% of the local Hospitals have their own service; 38.57% have outsourced services; 17.14% have their own and outsourced service; and 5.71% do not have equipment maintenance sector. In addition, the are 0.85 MRI equipment and 0.43 CT for each 500 thousand and 100 thousand, respectively, in the Universal Healthcare Service (SUS), values below that determined by ordinance MS 1101. Thus, these data corroborate the need of increase the supply and training of professionals in Biomedical Engineering and Clinical Engineering areas in order to promote additional study in the technological management practices of such equipment.

Contribution ID: 264
18. Clinical Engineering
18.12. Decision support systems and clinical engineering

Bed management in hospital systems

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The paper presents a design for a bed management web-application to efficiently provide for the allocation of beds inside hospitals to reduce the diversions (transfer of patient in other ward or hospital) and thus the number of outliers (patient admitted in not-right ward) which may cause a

longer length of stay. Information system helps the role of Bed Manager to improve the performances of the hospital-care flow optimizing the clinical paths. The system itself analyzes the interaction between patients, admission status and personnel in order to reduce the length of stay and the cost of care for hospitals. The application is designed to be linked to an existing facility manager system to gather information about the number of beds and their physical location in each room.

Contribution ID: 268
18. Clinical Engineering
18.12. Decision support systems and clinical engineering

Navigation algorithm for the evacuation of hospitalized patients

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The paper presents a model to support evacuation plans design for fire emergency management in healthcare facilities. It relies on existing path analysis algorithms such as Dijkstra and fire propagation simulation, also evaluating the level of criticality typical of healthcare facilities such as patients' speed based upon their illness and admission and architectural structure of wards. The algorithm automatically evaluates the safest evacuation path (which may not coincide with the shortest) for single typology of patient (ambulating, partially-ambulating, completely non-ambulating, auto-sufficient or not) and inpatient unit (ICU, ordinary ward, short-observation unit) in relation to the position of the fire trigger. The results of the algorithm are shown by using SVG-rendered graphic of existing hospital's layout.

Contribution ID: 418
18. Clinical Engineering
18.12. Decision support systems and clinical engineering

Using data mining techniques to determine whether to outsource medical equipment maintenance tasks in real contexts

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The maintenance tasks are an essential part of medical device technology management systems. However, there is a wide variety of medical devices, and the resource allocation for carrying out the maintenance tasks is difficult to achieve; therefore, one could ask: Should a clinical engineering department outsource or not outsource the maintenance tasks for medical devices? The purpose of this study was to determine in what cases the maintenance tasks of medical equipment should be outsourced (or not). In doing so, we used a data mining technique called decision trees; we (1) collected 3940 maintenance works orders from 62 medical devices installed in a 900-bed hospital; (2) we randomly selected 60% of the maintenance works orders to train 8 different decision tree schemas (J48 (pruned and unpruned), functional tree (FT), random tree (RT), alternating decision tree (ADT), logistic model tree, decision stump, and forest PA); (3) the remaining 40% of the work orders were used to test the decision tree schemas. The relative absolute error and root relative squared error were used to evaluate what the tested decision tree schemas had learned; finally (4)

we chose the decision tree schema with the lowest relative absolute error. Overall, the decision tree schemas performed well. 75% (6/8) of the decision tree schemas had less than 10% relative absolute error. 87.5% (7/8) of the decision tree schemas had 99.04% correct classifications (whether to outsource or not the maintenance tasks). The different decision tree schemas tested showed that the most important variables when deciding whether to outsource or not the maintenance tasks were: Medical device type, risk class (I, IIA, IIB, III), complexity, obsolescence level, maintenance frequency, and service time (ST, in hours). The best decision tree schema was FT with 2.97% relative absolute error and 99.04% correct classifications.

Contribution ID: 650
18. Clinical Engineering
18.12. Decision support systems and clinical engineering

A Decision Support System for Chronic Obstructive Pulmonary Disease (COPD)

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Obstructive chronic obstructive pulmonary disease (COPD) is a respiratory disease characterized by a chronic air flow limitation and associated with major economic and social problems. In an attempt to find a solution to these problems, numerous systems of clinical decision support for the management of patients with COPD have been developed in recent years. In particular, systems based on machine learning algorithms have been developed with the aim of monitoring the health status of patients and foreseeing and preventing exacerbations and hospital admissions. An in-depth research into scientific literature has shown that, in the state of the art, these goals have not yet been met and the performance of the current systems is not clinically acceptable. The aim of this work is the design and implementation of a new clinical decision support system that can at least partially fill the gaps present. The first step in the work was to try to replicate the performance of support systems for similar decisions, already present in scientific literature. Using the physiological parameters acquired by 414 patients using respiratory function tests, two predictive models were made using the same machine learning algorithms (neural network and support vector machine). The performance obtained was comparable to those of the scientific literature. The next step was to create a new predictive model, with superior performance to previous models. The machine learning algorithm chosen is C5.0. The performance obtained was significantly better than the two previous models. The new predictive model was implemented within a user interface, implemented in Java programming language, the COPD Management Tool. The software developed allows the evaluation and classification of the results of respiratory performance tests, with excellent performance, compared to the current state of the art and can therefore be used in many clinical applications.

Contribution ID: 752
18. Clinical Engineering
18.12. Decision support systems and clinical engineering

Support in the Medical Equipment Incorporation Decision: Hyperbaric Oxygen Therapy Adjunct for Diabetic Foot Ulcers Therapy

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This paper presents a study to assist of a Decision Support Systems and Clinical Engineering Health Technology Management. The methodology is based on methodological guideline for the

evaluation of medical equipment addressing its main domains (Clinical, Admissibility, Technical, Operational and Economic) in order to verify the incorporation of Hyperbaric Chambers in comparison to the outsourcing service for the injuries treatment diabetes carriers in Santa Catarina, Brazil. HBOT arose under the hypothesis that various diseases and conditions can benefit from increased oxygenation of perfused tissues. Its application is still very controversial, often generating doubts and making it difficult to make decisions about its incorporation into the use of public health services. Consequently, several discussions about the right to health judicialization limits in these cases sometimes affect decisions that overlap the incorporation process that follows predetermined stages of studies and clinical evaluations. As a result, the Systematic Review, Randomized Controlled Trials and clinical reports were selected in the clinical domain. In the operational and technical domain, it is performed a comparative of equipment with its technological resources and service, seeking to analyze parameters that influence in its performance. In the economic domain, through the total cost of ownership, it was estimated its direct and indirect costs related to the equipment's acquisition and inherent to the life cycle sustainability. HTA studies for medical equipment present several barriers due to the lack of evidence and quality information, it is expected that this work can generate scientific evidences of knowledge and instruments to enable new research involving hyperbaric chambers, as well as contribute to decision-making or other concomitant programs, due to the application of resources in a planned and adequate decision.

Contribution ID: 1281
18. Clinical Engineering
18.12. Decision support systems and clinical engineering

Identification of components for a decision support system in clinical research management

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Introduction: Clinical research is a basic element in the development of the health of the countries the leaders of the scientific project must carry out many activities to obtain the best results. It must comply with times and excellent management of projects.
Sources of information, human resources, laboratory equipment, financial resources, consumables, protocols, agreements, patients, infrastructure, reagents, samples, computer systems and analysis software are elements to support the decision of the project leaders.
Objective: Identify the technological tools that allow timely monitoring of each element, as well as obtain a management model for the research project that integrates the relationship between the different elements.
Material and methods: For this project we decided to focus on the investigation of Parkinson's disease, first we defined the research protocols specifically for the investigations that study the symptoms and their evolutions in the initial stage, identifying the changes that occur in the patient for each kind of change we selected the technological tool that helps to monitor its evolution through the ordinary things that the patient uses frequently (internet of things).
With the specific protocols we to use the methodology for the best practices in clinical research and define all the resources required with their relationship, generating a model based on decision support.
Result: We will create a decision support system that will allow us to be a tool in project management, helping leaders in their job.
Conclusions: Using information technologies in science we can get better results in less time, have more control, make better decisions, spend less resources, disseminate results more quickly and help more people with their disease.

Contribution ID: 646
18. Clinical Engineering
18.13. National societies and international cooperation

First steps for the european clinical engineering societies network

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In 2017 European Union (EU) reviewed its regulatory framework on health technologies, approving two main Regulations on this field: Regulation 2017/745 on Medical Devices and Regulation 2017/746 on In Vitro Diagnostic medical devices. Furthermore, the new EU General Data Protection Regulation, applicable from May 2018, affects significantly medical devices market. This renovation on health technologies regulations is framed in the EU strategy to be part of a European Single Market. The Single Market is at the heart of the European project and it involves not only health technologies, but also goods, services, people and of course the common monetary system. According to the WHO publication “Human Resources for Medical Devices”, there are about 50 Biomedical engineering professional associations in the European Region (comprehending also other States out of EU). That means in each European Union Member State there is at least a professional society. Moreover, there is no common certification program establishing certification standards for Clinical Engineers in all EU Member States.
Some European Clinical Engineering Societies started to build connections organizing a virtual round table during the 2nd Global Clinical Engineering Day on October 21st. Representatives from AIIC (Italian Clinical Engineers Association), BMTZ (Dutch Clinical Engineers Association), AFIB (French Biomedical Engineers Association) and Ministry of Health of Albania, promoted their own societies and exchanged experiences of their Countries.
WHO Collaborating Centre for Research and Training in Clinical Engineering and Health Technology Management is actively involved to gather European Clinical Engineering Societies, helping AIIC to organize a meeting during its 2018 National Congress in Rome. The first aim of this initiative will be to create the European Network for the 3rd ICEHTMC hosted in Italy in 2019. Subsequently the new network could develop a strategy for the official acknowledgement and certification for Biomedical and Clinical Engineers in the EU.

Contribution ID: 1239
18. Clinical Engineering
18.13. National societies and international cooperation

Responding to pressing clinical engineering needs: the case of creating the Colombian college of clinical engineering

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The lack of alignment among different stakeholders caused challenging barriers for the development of Clinical Engineering (CE) in Colombia. To improve this situation, four years ago a group of leaders began to painstakingly promote collaboration. They started team work among the government and Hospitals to generate HTM policies, established strategic regional communication groups called nodes for the generation, exchange, and integration of knowledge and best

practices. Simultaneously, several universities created synergy to produce networking spaces and organize CE international events.
Ten leaders of those initiatives, linked to three hospitals, three universities and one government institution, sought with the support of the American college of Clinical Engineering (ACCE), a strategy to boost an associative group in CE to respond to the current reality in the country: the creation of a clinical engineering organization. In August 2017, they founded the Colombian College of Clinical Engineering (COLCINC), and in November 2017, COLCINC became a legal Colombian organization.
There was an enthusiastic reception of this organization from the CE community. 120 engineers from 10 states across the country have pre-registered. During October 21, Global CE Day, COLCINC participated in activities to disseminate technical documentation, and promoted integration and visibility of CE in Colombia and the world.
The official launch will be done in 2018, and plan to have by then an official collaboration agreement with ACCE, a portfolio of products and services including digital packages of technical documentation, and a program for education, and mentoring activities.
COLCINC is responding to Colombian needs and plans to contribute to the global CE practice, including in patient safety, and sharing the success story of integrative organizational initiatives than can help other clinical engineers' contributions to promote health in the world.

Contribution ID: 655
18. Clinical Engineering
18.14. Clinical engineering success stories

A comprehensive in-service training program targeting laboratory equipment critical to the HIV clinical cascade in Kenyan high HIV burden counties

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Issues
Kenya's network of 2,500+ public health labs perform basic tests, with advanced testing done at national central labs. The country's efforts to increase its number of accredited labs is hindered by a severe lack of resources and a limited workforce capable of maintaining vital equipment. Most biomedical engineers and technicians (biomeds) lack the capacity to conduct routine equipment maintenance and repair. This greatly impedes accurate diagnostic services and is a significant problem for the country's HIV/AIDS response.
Description
In 2015, American International Health Alliance (AIHA) launched an in-service training program for National Public Health Laboratory Services (NPHLS) biomeds and four counties with high HIV burden: Kisumu, Siaya, Homa Bay, and Migori. Training is designed to strengthen capacity of the target biomed workshops by upskilling biomeds in equipment maintenance and repair to support HIV diagnostics. AIHA engaged technical experts from University of Texas Medical Branch and worked with Kenyan partners to develop a training and mentorship program for equipment critical to the HIV clinical cascade. The project has fostered the ability of lab and biomed teams to work together and conduct join site-level mentoring.
Lessons Learned
Biomeds who completed training are now able to effectively perform routine service, maintenance, repair and verification in labs. In 2017, NPHLS launched a rapid response intervention to prepare 43 labs for accreditation within 100 days. AIHA supported the trained biomeds to service 22 labs across 14 counties. This small team serviced 385 pieces of equipment successfully at a significant cost savings.
Next Steps

Biomeds have often been excluded from lab settings in Kenya, but can play a vital role as the country works toward lab accreditation. This comprehensive, needs-driven approach has increased Kenya's capacity and yielded sustainable results that decreased costs and increased quality of lab services.

Contribution ID: 793
18. Clinical Engineering
18.14. Clinical engineering success stories

Colombian clinical engineers regional nodes, leaders perspective

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The millennial clinical engineer generations have the challenge of finding innovative tools for knowledge sharing. Colombia has a strategy in place to share information and knowledge in a fast way, without any restriction of costs, and accessibility, denominated Clinical Engineers Regional Nodes (CERN).
CERN are non-formal and spontaneous regional organizations, they have broken hierarchical structures paradigms, to contribute to information accessibility and promote Clinical Engineering (CE), becoming a successful real time networking and benchmarking model for CE.
CERN arouse in 2013, in the Colombian Southwest region. Then, in 2014 with the support of Ministry of Health (MoH), these meetings were strengthened with all CE stakeholders, with objectives of safety improvement, accessibility and availability of Medical Devices. In 2015 they were fostered in other 4 regions.
Currently, CERN are autonomous in 6 regions, with the support and participation of government entities such as MoH, sanitary agency-INVIMA and assessment institute-IETS. They cover 40% of the national territory, with 250 members from 120 hospitals, 15 universities and 12 local health authorities. They meet 4 times per year and they have permanent contact through social media.
CERN key factors are: the identification of a common situation which concern the region; the identification of motivated leaders with knowledge, credibility, cooperative work skills; the relationship with government, and the creation of mutual benefit relationships with tangible work plans. The barriers which have been overcome are the credibility of the stakeholders, furthermore the communication and geographical barriers.
The CERN in short time, have achieved CE innovation, standardization of processes and methodologies, the participation in tests to validate of MoH products. Likewise, the feedback to government of CE real needs in Colombia.
CERN is projected as a strategy to contribute to decisions-maker in health technology policies and contribute to the education, and positioning of the EC.

Contribution ID: 825
18. Clinical Engineering
18.14. Clinical engineering success stories

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The health system that hospitals are inserted in is complex. As it is also complex to perform the management of hospital medical equipment and facilities, applying concepts of maintenance engineering, clinical engineering and hospital engineering. The planning, implementation, control and evaluation of performance of these services must be implemented through documentary formalization. As a reference, among other legislation in each country, is ABNT NBR 15943 - Guidelines for a management program for health infrastructure equipment and health equipment. In this way, this work aims to propose the implementation of this Management in hospitals, from the Basic criteria cited in the Standard, through the improvement and application of good practices. The method used is described in NBR 15943. As a result one has to apply the general and specific requirements as well as methods, etc., through the knowledge available in bibliography, by adaptations to the proposed models or by new developments. In this way the methods with criteria of prioritization of investments in hospital technologies, hospital equipment selection criteria, preventive maintenance planning and calibration criteria, as well as selection of outsourced services are presented as results. Going through the implementation and presentation of methods of budget planning and monitoring of operational expenses related to labor and hospital maintenance material, performance control through performance indicators, including those related to the performance of eng. hospital and compared to the strategic indicators of the hospital. The applications of multiparametric methods of evaluation of technological obsolescence are shown, as well as discarding flows and reverse logistics of electromechanical hospital equipment, etc. It is believed that this form of hospital engineering contributes to the qualification of the performance, effectiveness and outcome of the medical and hospital services provided by the health care establishment, by increasing the availability, reliability, safety and performance of hospital equipment and facilities.

Contribution ID: 1237
18. Clinical Engineering
18.14. Clinical engineering success stories

Model HTM application in failure analysis for Air Compressors in the Dental Service of Primary Health Care

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This study presents an failure cause analysis in medical air compressors in dental services of primary health care in Santa Catarina, Brazil. The study classifies failures, from 2007 to 2016, associated with the three domains of the methodology developed for HTM: Human Resources (DHR), Infrastructure (DI) and Technology (DT). Of these failures, 58% were associated in the DT, 31% to the HRD and 11% to the DI. Data collection was from the HTM Information System of the IEB-UFSC CE and the application of HFMEA. To 103 compressors analyzed, distributed in four districts with 63 health units. This analysis identifies that failures in the DT are related to wear of parts due to their lifetime. In the DI, the causes were the lack of electrical protection and inadequate electrical wirings in disagreement with manufacturers and technical standards. In HRD, the lack of a manual purge procedure is a cause of failure. As a result, a checklist for functional equipment verification was implemented during the CE technical inspection, which identifies fault conditions and associated domains. For DT, a preventive maintenance program was implemented to replace oil and shorter service life. In order to reduce the failures associated to the DI, adjustments were made in the compressor shelters with installation of electrical protection and resizing of the electrical system. For the failures associated with the HRD, didactic materials were developed for training with a proposal to improve operational routine, best practices and a program of installation of automatic purger in units of greater demand for dental service. The results of these actions led to a reduction in the occurrence of failures and in the procurement process of new air compressors. These actions validate the application of HTM model developed for Primary

Health Care presenting important contribution in the improvement to the healthcare system.

Contribution ID: 84
19. Radiation Oncology Physics and Systems
19.01. Brachytherapy

Prototype design of module beta sealed source applicator for superficial treatments

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Purpose: This study aimed to determine the design and isotope of module type sealed source applicator for superficial treatments.
Methods/Material: Dose distributions were evaluated by the Monte Carlo method to optimize the structure and materials of a module type sealed source applicator. Monte Carlo simulations were performed using the MCNPX code. Both cylindrical and hexagonal models were chosen as a basic type of applicator. Various isotope (e.g. Beta emitter: P-32, Sr/Y-90, V-48, Xe-133 and W-188, Low-energy photon source: I-125, Pd103, Yb-169 and Sm-145) were selected as source.
The capsule was designed in consideration of shielding and encapsulation. The wall thickness of each applicator was set to 1 mm and 2mm. Ten applicators were configured to evaluate the dose distribution of arraigned sealed applicator. Dose distribution was calculated at 0.25 cm. Dose uniformity was evaluated at each depth. Dose uniformity was defined as a ratio of area bounded by 80% isodose curve to that by 10% isodose curve. The dose distributions were normalized at 0.25 cm depth along the central axis of the centered applicator.
Results/discussion: Minimum percent dose of hexagonal models was higher than that of cylindrical models for all isotope. Hexagonal models has better dose uniformity than cylindrical models. For same model, beta emitter source has more uniform dose distribution than low-energy photon. Applicators with 1 mm wall thickness have higher Percent dose and more uniform dose distribution than those with 2 mm wall thickness regardless of isotope and model. In case of hexagonal model with 1 mm wall thickness and Sr/Y-90 isotope, dose uniformity was 0.751 and minimum percent dose between each applicator was 45.1% and best result was shown.
Conclusion.: When skin surface was treated by sealed source applicator array, hexagonal model have a better dose distribution with beta source.

Contribution ID: 248
19. Radiation Oncology Physics and Systems
19.01. Brachytherapy

In-vivo dosimetry for brachytherapy

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With the advent of new treatment device technologies, patient safety and quality assurance are witnessing a revival of attention and becoming an important focus to ensure the safe and effective delivery of radiation therapies. An important aspect of a comprehensive quality assurance and

safety is in-vivo dosimetry. This presentation will focus on in-vivo dosimetry and its role in brachytherapy.
Traditionally, in-vivo dosimetry, using detectors such as TLDs, MOSFETS and diodes, has been limited to dose measurement performed externally (i.e. skin) or to monitor the dose that may be delivered to implanted devices such as implantable pulse generators (pacemakers) or cardioverter defibrillators. Transmission detectors such as EPIDS are gaining popularity in EBRT. Two Vision 20/20 articles (1, 2) pointed out that the specific role of in-vivo dosimetry needs to be defined better and well established in clinical routine in order to reach sufficient sensitivity and specificity for detection of treatment errors.
Currently, the good candidates for real-time in-vivo dosimetry are MOSFETs, RLs, PSDs, and recently inorganic scintillation detectors (ISDs). Future research will have to be focused on further developing systems that would have the ability to sample the dose rate in real time while the radiation treatment is being delivered to the patient. The most recent innovations for these technologies will be briefly presented along with new avenues to facilitate identification of errors during treatment delivery.
(1) Tanderup K, Beddar S, Andersen CE, Kertzscher G, Cygler JE. Vision 20/20 Article: In vivo dosimetry in brachytherapy. Med Phys 40(7):070902 (15 pages), 7/2013.
(2) Mijnheer B, Beddar S, Izewska J, Reft C. Vision 20/20 Article: In vivo dosimetry in external beam radiotherapy. Med Phys 40(7):070903 (19 pages), 7/2013.
(3) Kertzscher G, Beddar S. Inorganic scintillation detectors based on Eu-activated phosphors for Ir-192 brachytherapy. Phys Med Biol 62(12):5046-5075, 6/2017.

Contribution ID: 337
19. Radiation Oncology Physics and Systems
19.01. Brachytherapy

Need of redefining the Organ’s at Risk (OARs) for Co-60 brachytherapy source.

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In recent years Co-60 with enhanced specific activity has allowed the design of miniaturized sources that are comparable to conventional Ir-192 sources. Applicators are the same in shape and diameter, and the application techniques are similar. Co-60 is characterized by a higher mean energy (1.25 MeV) in comparison with Ir-192 (0.355 MeV). Consequently, dose deposition in water is based on different contributions from the photoelectric and Compton effect. This is illustrated by the radial dose functions where Co-60 proceeds up to several percentage points below Ir-192 for distances of up to at least 20 cms however increases significantly after it. In Present study LiF chips and wax phantom is used for measurement of the dose values at large distances from different brachytherapy sources including Co-60 and Ir-192 which showed that for distances up to 20 cms, the dose values from Ir-192 source are slightly higher (average ratio of 1.13 at 10 cm and 1.04 at 20 cm), but for distances larger than 25 cms, the dose values from a Co-60 source are higher (average ratio of 1.17 at 30 cm and 1.69 at 45 cm). That suggests higher integral dose for Co-60 sources and higher distant dose deposition, so additional attention should be paid when estimating the dose to the organs at risk far away from source. In general practice of Ir-192 brachytherapy planning takes care only doses to rectum, bladder as they are major concern due to the sharp dose gradient of Ir-192 but because of high energy dosimetric properties of Co-60 source there is an urgent requirement of redefining OARs for Co-60 brachytherapy source. The detail results are communicated in this paper.

Contribution ID: 455

19. Radiation Oncology Physics and Systems
19.01. Brachytherapy

Treatment Planning and Delivery of Intraoperative Radiotherapy for Recurrent, Previously Irradiated Abdominal and Pelvic Tumors

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The primary treatment for colorectal cancer is chemoradiotherapy. Irradiation to doses in the range 45-60 Gy are used. Some of these patients recur locally. Treatment options for this group are limited. Surgical re-resection is associated with a high failure rate. Re-irradiation may be a useful adjunct but the proximity of previously irradiated normal structures makes further external beam radiotherapy challenging.
Advances in miniaturization of radiation producing devices emitting low energy x-rays makes re-irradiation both, economical and feasible. The Intrabeam™ system produces 50 kVp x-rays. This makes it useful and safe to use in a regular operating room. A program for re-irradiation of recurrent, previously irradiated colo-rectal and pelvic tumors based on use of this system has been established at our institution.
To date a small series of patients have been treated. The doses delivered are in the range 10-20 Gy. Dose limiting structures surrounding the recurrence site are readily shielded with custom shields made of tungsten impregnated plastic. These are wrapped in sterile material and inserted prior to irradiation. The dose is then delivered at the time of surgery. The technique appears to be safe and preliminary results are encouraging. This presentation will outline the technology used, the treatment planning and delivery technique employed and preliminary results are presented. Side effects appear to be tolerable. We intend to continue to build on this experience and evaluate clinical outcome in due course.

Contribution ID: 471
19. Radiation Oncology Physics and Systems
19.01. Brachytherapy

Three-dimensional finite element-based deformation of the prostate boundary in transrectal ultrasound-guided brachytherapy using implanted seeds as control points

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During radioactive seed implantation of the prostate, transrectal ultrasound (TRUS) imaging is used for visualization of the prostate boundary. However, compression of the prostate due to ultrasound probe pressure is usually not accounted for, which may affect the dosimetric outcome of the treatment. Here, we model prostate boundary deformation using the Finite Element Method (FEM) with implanted seeds as control points.
For this study, seven patients underwent the following supplementary intraoperative imaging interventions: (1) A TRUS volume study was performed after half of the seeds had been implanted, for prostate boundary delineation and identification of a sub-set of seeds used to register subsequent image sets to the ultrasound images, (2) Five fluoroscopic images acquired at different incident angles at the end of the implant while the patient was still in the lithotomy position, once

with the ultrasound probe inserted and again with the probe retracted. Three-dimensional seed coordinates were reconstructed from the fluoroscopic images. Subsequently, the probe-in implanted seed cloud was rigidly registered to the probe-out seed cloud to account for prostate translation and rotation caused by retraction of the probe and then the residual displacement of each individual seed was used as an input to the FEM algorithm to infer the prostate contour in the absence of the probe.
The original and deformed prostate contours were registered to the implanted seed locations. The respective dosimetric outcomes were evaluated using VariSeed software. V100% (Volume of the prostate which receives 100% of the prescribed dose) and D90% (Dose received by 90% of the prostate volume) values from both contour sets were compared and differed by -1.0% to 0.7% and -1.8 Gy to 2.8 Gy, respectively.
The results of this study so far suggest that prostate deformation has minimal effect on the dosimetric outcome of the implant.

Contribution ID: 537
19. Radiation Oncology Physics and Systems
19.01. Brachytherapy

Challenging dosimetry of photon-brachytherapy in terms of absorbed dose to water

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About 10% of all radiotherapy cancer treatments are performed by brachytherapy (BT). For BT with beta radiation, ISO 21439:2009 Clinical dosimetry – Beta radiation sources for brachytherapy give guidance. But for photon radiation-BT a corresponding recommendation is missing. Detailed recommendations have been prepared by the AAPM TG-43. Their recommendation to perform the calibration of photon radiation BT-sources in terms of the reference air kerma rate is still used world-wide. But, as the BT-dose is prescribed in terms of the biologically relevant quantity absorbed dose to water, it is the task of medical physicists to convert the data by using the AAPM TG-43 formalism. Recently different primary standards have been developed in several national metrological institutes for high-energetic (HE) BT-photon sources, like 192Ir and 60Co, as well as for low-energetic (LE) BT-photon sources, like 125I and 103Pd. Known transfer standards, such as dwell chambers, calibrated in terms of absorbed dose to water in water for every model of photon-Bt-sources to be used, can be utilized for traceability to a primary standard. Secondary standards are still missing.
Photon-BT dosimetry measurements are really challenging as the response R of dosimetry detectors depends on several influence quantities. R can be described as product of the detector-to-water-dose-ratio and the intrinsic response, describing the conversion of the detector absorbed dose to a measurement indication, both dependent on the mean photon energy $\bar{E}$. Instead of complicated Monte-Carlo simulation calculations, $\bar{E}$ can precisely be determined from the BT-photon radiation quality index, the ratio of the primary dose at r = 2 cm to that at r = 1 cm (in water on the transverse plane of the source), easily derived from published attenuation coefficients and primary-and-scatter-separated (PSS-) dose data. Such source reference data for all commercially available photon-BT sources are published e.g. at (http://www.physics.carleton.ca/clrp/seed_database/).

Contribution ID: 560
19. Radiation Oncology Physics and Systems
19.01. Brachytherapy

Calibration seed sampling for iodine-125 prostate brachytherapy

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Implanted iodine-125 seeds can be effectively used for low dose rate brachytherapy treatments for localised adenocarcinoma of the prostate, using intraoperative pre-planning with transrectal ultrasound. This intraoperative technique requires that the activity of the seeds be checked against the vendor-supplied calibration certificate at the beginning of the surgical procedure, to allow extraction of test seeds from the sterile seed cartridge. The AAPM report 098 recommends testing of at least ten sources per implant. In practise, activity checks of multiple sources are difficult to achieve in surgery, due to time constraints (patient anaesthetic) and the expense of the seeds themselves.
This study therefore investigated the reliability of a calibration method that sampled only one seed, by evaluating the consistency of activity of all seeds in three small batches of 10, 20 and 30 iodine-125 seeds and calculating the probability of achieving results representative of each batch, within different levels of uncertainty.
The results of this study can be summarised using standard deviations: for the cartridges containing 10, 20 and 30 seeds, the mean differences between the measured seed activity and the decayed calibration activity were respectively 5.0%, -2.7% and 0.4% and standard deviations from those means were respectively 4.4%, 3.7% and 2.8%. For these seeds, there was a greater than 30% chance that a randomly selected seed would have an activity that differed by more than 3% from the mean activity of all seeds in the cartridge.
Although attractive as an efficiency measure, the testing of just one seed from a cartridge of iodine-125 seeds has a significant probability of producing an activity measurement that is not representative of the activity of the other seeds in the cartridge, potentially leading to substantial inaccuracies in implant dosimetry.
1. Butler et al (2008) Med Phys 35(9): 3860-3865

Contribution ID: 754
19. Radiation Oncology Physics and Systems
19.01. Brachytherapy

Some modest suggestions for quality assurance of brachytherapy treatment planning

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We previously utilized failure modes and effects analysis to identify sources of error in our HDR brachytherapy treatment planning that could lead to patient harm. A compilation of such events (misadministration or medical event) from the website of the Nuclear Regulatory Commission of the USA (NRC) is presented to lend credence to that earlier analysis. In addition, several examples will be provided to illustrate how some current software packages perform in providing adequate plan quality assurance. Results from our own nomogram based on the volume enclosed within the prescription dose will be presented for several types of cases (single and multiple catheter). A recent example of a reported medical event for an HDR gynecologic treatment will be analyzed in detail (root cause analysis) to demonstrate that quality assurance practices should be re-evaluated especially when doing high dose radiation treatments such as HDR brachytherapy. We conclude

that recalculating doses or treatment times using data from the original plan is not a useful exercise as errors in the TG 43 calculation are very unlikely. Having a second qualified person check reference length, dose points, dwell positions, and the 3-d image of the catheter(s) is necessary.

Contribution ID: 822
19. Radiation Oncology Physics and Systems
19.01. Brachytherapy

A new transrectal ultrasound QA phantom for assessing the longitudinal accuracy of seed deployment in LDR prostate implants

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Transrectal ultrasound (TRUS) imaging is useful for guiding needle insertion and seed strand deployment in LDR prostate implant procedures, but it suffers from relatively poor image quality and frequent artefacts. Longitudinal errors in seed deployment can result in an underexposed prostate, overexposure to the urethra or penile bulb, or seeds accidentally implanted into the bladder. The objective of this study was to test the longitudinal accuracy of needle insertion and seed deployment at the Royal Adelaide Hospital in order to improve LDR prostate implant quality.
A new phantom was constructed to simulate implantation. The transparent phantom contains a water-filled balloon surrounded by gelatin with a cavity running through its posterior. The balloon simulates a patient's bladder and the cavity permits insertion of a TRUS probe. With the phantom covered to remove visibility, the user inserts needles into the phantom and deploys strands within the gelatin under TRUS guidance. The phantom's lateral faces are precisely etched at 5 mm intervals for the user to measure longitudinal positions of deployed strands. Transparency of the phantom allows the user to observe etchings on both faces to avoid parallax error.
Simulations of prostate implants using the phantom were first conducted by physicists and then one of our prostate implant urologists. It was shown that TRUS images accurately reflect true needle-tip positions within the QA phantom, with an average deviation of +0.5 mm (where '+' indicates the superior direction). However, initial seed deployment results yielded unacceptably high average errors between deployed and planned strand position at +4.1 mm. Subsequent investigation highlighted a strong systematic error in the urologist's strand deployment technique. Correcting this technique significantly improved longitudinal accuracy of strand deployment to an average error of +1.5 mm. This demonstrates the value of this new phantom for assessing and improving LDR prostate implant accuracy.

Contribution ID: 894
19. Radiation Oncology Physics and Systems
19.01. Brachytherapy

Comparison of electronic brachytherapy with Ir192 for image-guided treatment for cervical cancer in two different centres

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Purpose or Objective

A comparison was carried out with 10 patients with cervix cancer treated with image guided brachytherapy, half of whom were treated with Ir 192 in one center and the other half with electronic brachytherapy with Axxent (Xoft Inc.) in another center. Plans are compared between the two techniques with patients of the same characteristics.
Material and Methods
All plans have been calculated to meet the dosimetric requirements of the EMBRACE protocol. The requirements for inclusion of patients in this post-treatment study are patients with cervical cancer with a tumor volume (CTV-HR) of less than 20 cm3 (7.8-19), because in these cases the volume of tissue receiving the tumor 150% of the dose (V150) in the case of electronic brachytherapy is not too large due to treating with an average energy of 26 kV. The parameters maximum dose at 2 cm3 and 0.1 cm3 average (D2cm3, D0.1cm3) are presented in each risk organ (bladder, rectum, sigma), in addition to V150 and V200 of the body.
Results
The dosimetric results are similar for both cases due to the inclusion of patients with small volumes, these are the only ones that are treated in our hospital with electronic brachytherapy, those of larger volumes are sent to other hospital centers. The average volume is 11.2 cm3 (7.8-19). The doses in organs of risk are slightly lower for those treated with brachytherapy electrically and the V150 and V200 are somewhat larger, although very similar for the average of both techniques.
Conclusion
Whenever the inclusion requirements mentioned above are met, the brachytherapy treatment of cervical cancer with electronic brachytherapy may be a good alternative to treatment with Ir192 in cases in which this type of equipment is not available.

Contribution ID: 957
19. Radiation Oncology Physics and Systems
19.01. Brachytherapy

Clinical evaluation of an MRI-to-Ultrasound deformable image registration (DIR) algorithm for prostate High-Dose-Rate (HDR) Brachytherapy

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Purpose: Identifying dominant intraprostatic lesions (DILs) on Ultrasound (US) images during high-dose rate (HDR) prostate brachytherapy is challenging. Multiparametric magnetic resonance imaging (mpMRI) makes it possible to identify DILs; however, the geometry of the prostate on mpMRI and on the US may differ significantly and thus require image registration. This retrospective study evaluates the efficacy of an in-house, automated deformable image registration algorithm for mpMRI-to-US DIL fusion (MR2US) in comparison with two commonly used registration algorithms: rigid registration, and a b-spline based deformable registration (using Plastimatch).
Materials and Methods: Ten patients with intermediate-risk prostate cancer, each with pre-operative MR and US image datasets, were included in this study. Five radiation oncologists (ROs) with different levels of experience were asked to cognitively register the DIL on the intraoperative US image using the MR contours as reference. Agreement between RO contours and the contours produced by rigid, Plastimatch, or MR2US algorithms were compared using the Dice coefficient and Hausdorff distance; registration time between all contouring methods was also recorded.

Results: The highest DSC on average was found for MR2US fusion (0.70±0.08) in comparison to rigid (0.59±0.07) and Plastimatch (0.50±0.06). MR2US showed statistically significant improvement over rigid in seven of the 10 patients for DSC and Hausdorff distance. On average, Plastimatch had a significantly worse Hausdorff distance (21±6 mm) than MR2US fusion (13±5 mm) and rigid (14±4 mm). The average registration time was significantly lower for MR2US (11 ± 2 s) and Rigid algorithm (7±1 s) compared to both the average RO contours (209 ± 81s) and Plastimatch (199 ± 38 s).
Conclusions: MR2US image registration method using clinical data was demonstrated to be feasible in HDR prostate brachytherapy workflow and showed statistically improved metrics compare to rigid and b-spline deformable registration.

Contribution ID: 1649
19. Radiation Oncology Physics and Systems
19.01. Brachytherapy

Comparison of oncentra brachy IPSA versus a graphical optimization technique when treating cervical cancer patients using ring and tandem applicators

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Purpose : To investigate the differences between an inverse planning technique by simulated annealing (IPSA) versus a graphical optimization technique (GOP) for cervical cancer patients treated with ring and tandem applicators.
Methods : CT data of seven brachytherapy cervical cancer patients was used. All patients were treated with ring and tandem applicators using Oncentra treatment planning. A dose of 30Gy was given for each patient. For each fraction two independent plans were created. The first plan was the plan clinically approved and delivered to the patient. This was optimized using a GOP technique while the second plan was optimized using IPSA. Plans were compared based on total treatment time, an equivalent dose value of 2Gy (EQD2), the dose to the outside surface of the ring and a conformal index value (COIN).
Results: Both techniques achieved similar dose distributions based on D90 HRCTV. For 5 out of 7 patients a lower treatment time, a higher EQD2 value for the HRCTV and a mean value of 3% higher COIN index was obtained using IPSA versus GOP. The bladder was the only organ that showed a lower EQD2 value for 5 out of 7 patients, with the biggest difference equal to a reduction of 6% when IPSA was used. A significant decrease in dose to the outside surface of the ring of 14% and 11% was also observed for two patients. A mean value equal to 6% for the reduction of dose to the outside surface of the ring was also obtained using IPSA.
Conclusions : With IPSA a significant dose reduction to the outside surface of the ring can be achieved without compromising the total treatment time. This reduction in dose is important for cervical cancer patients since it might translate in a possible decrease of vaginal stenosis and fibrosis.

Contribution ID: 1822
19. Radiation Oncology Physics and Systems
19.01. Brachytherapy

Effect of different definitions of prescription point “A” in high dose rate (HDR) brachytherapy for cervical cancer

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Point A has remained a consistent choice for dose prescription so far. However, due to variation in point A location, several definitions of point A have been explored. This study aims to understand the dosimetric impact of different point A definitions in patients of cervical cancer treated with HDR brachytherapy. We retrospectively investigated 55 CT-based plans of 20 cervical cancer patients. Dose of 7Gy in 3 fractions each delivered with Fletcher Williamson tandem and ovoids applicator was prescribed to point A using modified Manchester definition of point A(AM) and American Brachytherapy Society(ABS) guideline definition(AAB). Effect of AM and AAB definitions on parameters including dose to point A, D2cc of bladder, rectum and small bowel, D90 of high risk clinical target volume, V100, total reference air kerma(TRAK) and geometric shifts between both point As was analysed. Results showed average percentage differences of point AM dose and AAB dose with respect to prescription dose as 1.81± 3.09% and 1.18±1.01% respectively($p<0.05$) which was statistically significant. D2cc doses for bladder, rectum and small bowel were found to be 86.71%, 61.86%, 53.57% and 101.43% 71.14% and 63.28% for point AM and AAB based plans respectively. Percentage difference of V100 for AM and AAB based plans was 21.82± 44.57% and between point A and D90 was 27.77±17.74% and 30.76±23.69% on average for the two definitions respectively. Plans normalised to AAB had on an average 6.25% higher TRAK than AM based plans. Significant differences were found for V100, TRAK and D2cc values between Manchester and ABS definitions. Average shift between AAB and AM was 9.6±0.13 mm. This study suggests that prescribing dose to Manchester point A shows a greater variation in point A dose and D90 values as compared to ABS definition. ABS point A based prescription seems to be more stable with respect to applicator placement.

Contribution ID: 132
19. Radiation Oncology Physics and Systems
19.02. VMAT: Planning and delivery/IGRT

Application of dual-energy CT to suppression of metal artifacts caused by spinal implant in radiotherapy

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The objective of the present study was the determination of the potential dosimetric benefits of using metal-artefact-suppressed dual-energy computed tomography (DECT) images for cases involving pedicle screw implants in spinal sites. A heterogeneous spinal phantom was designed for the investigation of the dosimetric effect of the pedicle-screw-related artefacts. The dosimetric comparisons were frst performed using a conventional two-directional opposed (AP-PA) plan, and then a volumetric modulated arc therapy (VMAT) plan, which are both used for the treatment of spinal metastases in our institution. The results of Acuros® XB dose-to-medium (Dm) and dose-towater (Dw) calculations using different imaging options were compared with experimental measurements including the chamber and flm dosimetries in the spinal phantom. A dual-energy composition image with a weight factor of −0.2 and a dual-energy monochromatic image (DEMI) with an energy level of 180 keV were found to have superior abilities for artefact suppression. The Dm calculations revealed greater dosimetric effects of the pedicle screwrelated artefacts compared

to the Dw calculations. The results of conventional single-energy computed tomography showed that, although the pedicle screws were made from low-Z titanium alloy, the metal artefacts still have dosimetric effects, namely, an average (maximum) Dm error of 4.4% (5.6%) inside the spinal cord for a complex VMAT treatment plan. Our fndings indicate that metal-artefact suppression using the proposed DECT (DEMI) approach is promising for improving the dosimetric accuracy near the implants and inside the spinal cord (average (maximum) Dm error of 1.1% (2.0%)).

Contribution ID: 146
19. Radiation Oncology Physics and Systems
19.02. VMAT: Planning and delivery/IGRT

Volume-based algorithm for optimal lung dose preceding automated planning

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Purpose
To prevent potential complications such as radiation pneumonitis and radiation pericarditis in the radiotherapy, the surrounding normal organs must be considered in the well-designed treatment planning. The radiotherapy treatment planning (RTP) can vary in quality due to the experience of the medical physicists and institutional-protocols. It is time-consuming to decide the parameter of optimization. In this study, we aim to create a volume-based algorithm that can provide the gantry rotating angle before the automated planning and rapidly reduce the lung dose.
Material/methods
An anthropomorphic phantom study was simulated in RTP. A planning target volume (PTV)(50Gy in 25 fractions) was contoured with 17cm in length, 7.08cm in width. We set several partial arc angles and its related restricted angles in the RTP. The restricted angle in lung further forms a restricted volume to spare the primary beam. 15 RTP were performed using different restricted angles (from 0° to 280°, with increment of 20°) and the related arc angles. We developed the volume-based algorithm that could automatically calculate the restrict angle, arc angle, predicted lung V5 and related lung dose.
Results
45 RTP included Tomotherapy (n=15), VMAT with 20 iterations (n=15), VMAT with 40 iterations (n=15). The results showed that the increasing of restricted angle would significantly reduce the mean lung dose and slightly decrease mean heart dose. The arc angle, restricted angle, and restricted volume showed strong correlation with mean lung dose (r=-0.998) and lung V5 (r=-0.993). The predicted lung V5 using volume-based algorithm was successfully achieved within 20 iterations by 5 mins during the automated planning.
Conclusion
The volume-based algorithm preceding automated planning successfully provides the optimal arc angle and reduces lung dose. The predicted lung V5 can be achieved rapidly and accurately. We will further validate this volume-based algorithm in all kinds of tumors.

Contribution ID: 202
19. Radiation Oncology Physics and Systems
19.02. VMAT: Planning and delivery/IGRT

Improvement clinical quality of the dual energy volumetric modulated arc therapy planning for head and neck cancer

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Abstract
Objective: To research the benefit of using the dual energy in volumetric modulated arc therapy (VMAT) plan to achieve target volume coverage and organ at risk (OAR) sparing effectively regarding head and neck cancer.
Methods: In this retrospectives study, the six of head and neck cancer patients were selected for the 6MV VMAT plan, the 10 MV VMAT plan and the dual energy VMAT plan in the Pinnacle3 (Philips, Tokyo) treatment planning system. The quality of the VMAT plans were analyzed and were statistically compared according to conformity index(CI), homogeneity index (HI) for targets and mean dose and max dose for the parotid glands, spinal cord and the optic nerves as OAR.
Results: The dual energy VMAT plan demonstrated substantially better dose conformity with CI: 0.83±0.10, 0.93±0.07 and 0.99±0.10, for the 6 MV VMAT plan, the 10 MV VMAT plan and the dual energy VMAT plan, respectively ($p<0.05$), but there were no significant differences were found in all of the plans for HI and OARs sparing. For the right parotid gland, a considerably lower mean dose was found for the dual energy VMAT plan (815.93±501.78 cGy) compared to the 6 MV and the 10 MV VMAT plan (1054.72±636.46 cGy, 955.10±584.44 cGy, respectively), similar findings were obtained for the left parotid gland, the spinal cord and the optic nerves.
Conclusions: The dual energy VMAT plan showed considerably more beneficial than the 6 MV and the 10 MV VMAT plan for achieving better dose distribution with additional a good coverage of PTV and lower OAR doses for all cases. Therefore, the dual energy VMAT plan should be recommended as a feasible option for the complex anatomical structure as head and neck cases.
Keywords: Volumetric modulated arc therapy (VMAT), Head and neck cancer, Pinnacle

Contribution ID: 269
19. Radiation Oncology Physics and Systems
19.02. VMAT: Planning and delivery/IGRT

Dosimetric investigation of a novel gamma ray system for SRS and SBRT

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Purpose: Stereotactic radiosurgery (SRS) has been a successful non-invasive treatment technique for functional abnormalities and small tumors of the brain. Stereotactic body radiotherapy (SBRT) has received widespread applications for early-stage body tumors with optimal dose distributions and fractionation schemes. In this study, we investigated a novel rotating Gamma ray system (GRS) for advanced SRS/SBRT treatments.
Material and Methods: The GRS system named CybeRT (OUR United RT Group, Xian, China) has a ring gantry equipped with a Co-60/MLC treatment head, a focusing head with multiple Co-60 sources with cone collimators, a low-dose kV cone-beam CT and 2-sets of EPID systems. The new machine has a 70cm source-axis distance (SAD) allowing for improved penumbra compared to conventional machines. Monte Carlo simulations were performed to study the treatment heads and to model the MLC/cone collimators, and for phantom/patient dose calculation. CT scans were unarchived for patients previously treated by CyberKnife and linac-based SBRT. Treatment Planning was done using both an in-house Monte Carlo based planning system and the RT Pro planning system (version 1.00.4557, Prowess, Concord, CA).

Results: Our results showed that the GRS MLC can deliver treatment plans with identical dose conformality as that generated with CyberKnife/linacs. The GRS MLC with a 1cm cobalt source resulted in a penumbra in the order of 6mm. Interchanging source size to 2cm allowed for higher dose rate with the expense of larger penumbra. The MLC system reduces time of treatment of some SBRT cases that otherwise require longer time with the cone delivery system. All plans met our clinical acceptation criteria for target coverage and normal tissue tolerances.
Conclusion: The CybeRT system will be a cost-effective machine capable of performing advanced SRS treatments for small tumors with a Co-60/cone system and complex SBRT treatments for large target volumes with a Co-60/MLC.

Contribution ID: 381
19. Radiation Oncology Physics and Systems
19.02. VMAT: Planning and delivery/IGRT

Multi-institutional analysis for knowledge based planning of volumetric modulated arc therapy for prostate cancer

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[Purpose] To evaluate the performance of new assistance tool for the knowledge-based planning (KBP) of the inverse planning of volumetric modulated arc therapy for prostate cancer in multiple institutes.
[Methods] In each institute (A-E) enrolled in this study, the model for KBP was created using > 20 cases and KBP was compared with the manually optimized plans (MOP) in two cases. The bladder in one case (case I) had a volume of 83.8 cm3. Another case (case II) bladder volume of 181.8 cm3.
[Results] The dose to the PTV was slightly inferior in KBP compared with MOP in some institutes although there was no significant difference. In the rectum, the mean ± SD of difference for volume receiving 90% dose (V90) between KBP and MOP was 0.4% ± 1.6% and −0.1% ± 1.5% and for volume receiving 50% dose (V50) was 2.2% ± 6.9% and 2.6% ± 8.0% in cases I and II, respectively. A negative value implies that dosimetric values for KBP were higher than those for MOP. In the bladder, the mean ± SD of difference for V90 between KBP and MOP was 1.3% ± 2.0% and 1.0% ± 0.9% and for V50 was 4.8% ± 5.0% and 3.6% ± 0.9% in cases I and II, respectively. There was no significant dosimetric difference between MOP and KBP in organs at risk. In KBP, the maximum differences in V90 for the rectum were 6.7% and 6.7%, V50 for the rectum were 39.0% and 41.9%, V90 of the bladder were 18.2% and 9.9%, and V50 of the bladder were 12.5% and 6.7% in cases I and II between institutes, respectively.
[Conclusion] In KBP, the difference for V90 and V50 between institutes were more than 5.0% and 10.0%. The KBP performed correctly regardless the plan designs in each institute.

Contribution ID: 504
19. Radiation Oncology Physics and Systems

19.02. VMAT: Planning and delivery/IGRT

A particle-based Monte Carlo algorithm for VMAT optimization

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A novel Monte Carlo (MC) based optimization platform for volumetric modulated arc therapy (VMAT) is presented. The goal of MC based optimization is to generate clinical plans for which the dose distribution is accurately calculated at every stage of the optimization. Previous approaches to non-hybrid MC based optimization have not been widely clinically implemented, due to long computation times for the large number of iterations or beamlets involved. In contrast, in the present approach, a single MC simulation with the beam conformal to the target is required. Moreover, the optimization is not based on static beams for each control point, as in traditional methods, but reflects the dynamic multi-leaf collimator (MLC) and gantry motion of the actual beam delivery. The VMAT beam delivery is simulated utilizing sources 20 and 21 of DOSXYZnrc, which are capable of modelling continuously variable beam configurations. The simulation starts from an IAEA phase space scored at the top of the MLC module. The particle positions in the phase space are mapped to leaf positions. Time-stamped energy deposition events are recorded for each particle in the voxels of the planning target volume and organs at risk. A relation is then established between the space and time (i.e. MU index) coordinates of source particles in the phase space and their contribution to energy deposition in the patient phantom. The dose distribution is then calculated based on these energy depositions and the final MLC sequence is obtained through direct aperture optimization. Results show that MC based optimization produces clinically acceptable plans for prostate, head-and-neck, and lung cancer cases.

Contribution ID: 1745
19. Radiation Oncology Physics and Systems
19.02. VMAT: Planning and delivery/IGRT

Dose-Volume prescribing and reporting

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The Dose-Volume prescribing and reporting in IMRT treatment based on ICRU-83 recommendation
PURPOSE:
IMRT allows the three-dimensional dose distribution using computer based optimization techniques. User-specified absorbed-dose and dose-volume constraints in specified target volume as well as normal tissues. Dose prescription, recording, and delivery play an important role in radiation outcome analysis. Due to forward and inverse planning used in IMRT, the particular solution cannot be reached, and hence, ICRU-83 report provided international guidelines for reporting purposes. This study evaluated the variability in prescribing and recording of dose in patients treated with IMRT)in our institute of different pathologies.
METHODS AND MATERIALS:
Dosimetry data from 100 IMRT patients (head and neck, oesophagus and pelvis region) was collected. The dose-volume histogram of each patient, doses delivered to near minimum dose (D98%), dose 95% , as median dose (D50%), and near maximum dose (D2%), of sites was collected and analysed. The homogeneity index (HI) as a measure of the steepness of target and is a measure of the shape of the dose-volume histogram was calculated for every patient and analysed.
RESULTS

The institutional variability in D50, D95 (i.e. 95% volume must receive 95% dose) and HI is shown in the table below. The average homogeneity index has been recorded to 0.078 and median dose (D50%) was found 100.40 in our institute. D2 is analysed and recorded followed by ICRU 83 report and institutional protocol.
DVH value Ca-head and neck Ca-Prostate Ca-oesophagus
PTV_54Gy PTV_60Gy PTV_76Gy PTV_50.4Gy
D95% 96.21±0.7 96.20±0.8 97.43±0.54 97.01±1.2
D50% 100.94±0.03 100.7±0.03 100.27±0.05 99.65±0.05
HI 0.099 0.089 0.084 0.059
CONCLUSION:
D50% dose was close to 100% , suggesting that prescribing to D50.This variability is significant (P < .01) in terms of treatment site, technique. To reduce dosimetric and associated radiation outcome variability, dose prescription should be unified with international guidelines.

Contribution ID: 231
19. Radiation Oncology Physics and Systems
19.03. VMAT: Verification and QA

Influence of treatment couch in the secondary MU calculation for VMAT prostate treatments

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Purpose:
Monitor unit (MU) verification of the treatment planning system (TPS) using an independent procedure is a very important component of volumetric modulated arc therapy (VMAT) quality assurance (QA) program.
The study was aimed to compare accuracy of monitor unit verification with and without treatment couch, for VMAT prostate treatments.
Materials and Methods:
The accuracy of dose computation by Monaco TPS (v5.10) is checked by independent secondary check software (PTW-Diamond version 6.0). Diamond performs calculation based on modified Clarkson method, which integrates the primary and the scatter components of the radiation dose to a point from all individual and segmental subfields.
Dicom files exported from Monaco include RTplan, dose, patient contour and treatment couch structures. Diamond compares results against the TPS. Also, the couch used was Elekta iBEAM evo Couchtop modeled with a density of 0.1 g/cm3 for inner part of foam and 0.5g/cm3 for the carbon fiber shell.
A total of 60 patients treated with a single arc of 6MV were included in this study. For every patient MU verification was performed with and without the treatment couch.
Results:
From 60 patients, the average of MU difference was 0.04% taken into account the treatment couch and 1.23% without the couch, being the maximum found deviation of 3.41% and 4.65% respectively. These differences were statistically significant (pvalue: 0.00011). The introduction of the treatment couch improves the Diamond results in approximately 68% of the cases.
Conclusions:
We can conclude that including the treatment couch in the Diamond MU calculations results in a better QA outcome than when the table is not included.
We can finish up by saying that incorporate the treatment couch is essential to correctly assess the errors in MU calculations.

Contribution ID: 267
19. Radiation Oncology Physics and Systems
19.03. VMAT: Verification and QA

Clinical use of transmission detectors for in-vivo dosimetry on radiation oncology

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Volumetric Modulated Arc Therapy (VMAT) offers an enormous advantage and at the same time adds great complexity to radiation treatments due to the ability of dose rate modulation, gantry and MLC motion during treatment. In addition, transmission detector array has been proposed to use on clinical situations for in-vivo dosimetry on radiation therapy treatments yielding to the need to test these devices. The array used on this work (Discover detector from Scandidos) consists of 4040 detectors with a 1.5 mm spacing along MLC trajectories and was tested on clinical volumetric modulated arc therapy (VMAT) fields for different treatment sites for regular VMAT and SBRT cases. Attenuation of the array was determine for 6 and 10 MV and 6 and 10 FFF MV beams and included in the VMAT QA creation in the treatment planning system. Random selected cases of VMAT cases for different treatment sites were delivered in a Varian TrueBeam linac equipped with Millenium-120 MLCs. To stablish a dosimetric baseline, the plans were delivered for quality assurance pre-treatment verification using the device Delta4+. Then, deliveries were performed using the Discover detector to track the MLC leaf, gantry angle and collimator angle deviations from the exported plans out of the treatment planning system. The minimum MLC passing rate observed was 99.2%. A gantry angle versus cumulative dose delivery was acquired and was within 1% dose difference. The collimator angle was tracked and was within 0.5 degrees. In summary, the use of transmission detectors as an independent method of verification of the dose delivered by the treatment machine has been tested and initial results in this investigation are promising in their clinical use. A minimal attenuation for all energies, easy incorporation into the treatment planning system and minimal requirement during the patient delivery make them desirable and suitable for in-vivo dosimetry.

Contribution ID: 338
19. Radiation Oncology Physics and Systems
19.03. VMAT: Verification and QA

Dosimetric verification of volumetric modulated arc therapy for total marrow irradiation in Eclipse treatment planning: An anthropomorphic phantom study

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Introduction: With the application of VMAT to treat in total marrow irradiation (TMI), the VMAT plan requires several arc fields which show hot and cold spots between the arcs and the junctions between each PTV subvolume. The study aimed to verify the accuracy of radiation dose in VMAT-TMI plan.

Methods: The treatment planning of Eclipse AAA algorithm version 13.6 was used to calculate VMAT technique for 6 MV photon beams in Varian Medical System machine. The PTV consisted of whole bone marrow from head to mid femur with 10 arcs optimization for the dose prescription of 12 Gy in 6 fractions. The plan was evaluated by TLD100 for dose measuring in various locations. The median dose difference was compared. Gafchromic EBT3 films were also used to verify the planar dose at the overlapping fields and the lung region. All measurements were repeated 3 times. The gamma criteria of 5%/5mm and 3%/3 mm were applied for planar dose evaluation.
Results: In the phantom study, dose conformality to target and normal tissue sparing were observed. The % median dose differences in the H&N, chest, and pelvis regions were -1.33%, 2.03%, and 2.80%, and the junction of H&N-chest and chest-pelvis were 3.01% and the -1.57%, respectively. The %passing rate for gamma criteria of 5%/5 mm and 3%/3 mm in lungs were 96.85% and 89.08% and at the chest-pelvis junction were 96.03% and 84.25%, respectively.
Conclusion: VMAT-TMI treatment planning showed reasonable target coverage and decreased radiation dose to normal tissue. In TLD and Gafchromic EBT3 films measurement, they demonstrated that dosimetric verification with the dose calculation from the treatment planning and the delivered dose achieved great agreement.

Contribution ID: 1034
19. Radiation Oncology Physics and Systems
19.03. VMAT: Verification and QA

Retrospective audit of patient specific quality assurance results obtained using helical diode arrays

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Routine quality assurance (QA) testing of modulated radiotherapy treatment plans can produce large numbers of test results and reports, which should be periodically reviewed and audited as part of continuous quality improvement in radiotherapy treatment delivery. This study exemplifies the important and actionable information that can be obtained from such auditing.
A retrospective audit was performed for existing QA results measured on two ArcCheck helical diode arrays (Sun Nuclear Corporation). Twenty-five volumetric modulated arc therapy (VMAT) and twenty-five helical tomotherapy (HT) treatment plans were re-analysed using SNC patient software (version 6.2) and in-house gamma analysis code (developed in Python). Global gamma analyses were performed on the measured and calculated data (2%/2 mm) to identify the registration shift which provided the greatest gamma agreement index (GAI).
Audit results indicated that when the ArcCheck devices were used for VMAT and HT, 1 mm longitudinal (Y) registration shifts frequently provided better GAI results than no shift. Specifically, the SNC and Python codes both identified a significant trend for longitudinal shifts for both ArcCheck devices (mean values of -1.04 mm for VMAT and -1.13 mm for HT). No significant trend was observed for roll (X) registration shifts.
Measurements performed with physical shifts of the ArcCheck device improved the GAI results with no shift applied, suggesting there may be an actual displacement of the centre of the diode array and the marking lines on the two ArcCheck devices. This behaviour is dependent on gamma evaluation criteria used.
The results of this study confirm the necessity of undertaking regular audits of QA results, as well as the need to consider sources of geometric uncertainty when selecting gamma evaluation criteria and when applying automatic geometric shifts to measured data.

Contribution ID: 1446

19. Radiation Oncology Physics and Systems
19.03. VMAT: Verification and QA

Error prediction of VMAT treatment plannling using machine learning

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To deliver maximum dose to tumor tissue while minimizing the absorbed dose in healthy tissue, intensity modulated radiation therapy (IMRT) have been introduced for photon therapy by multi-leaf collimators (MLC). In case of proton therapy, the MLC have been used to reduce penumbra generated by scatterer in passive scanning. Therefore, it is essential to conduct precise MLC quality assurance (QA) for position and speed of each leaf. In this study, we propose MLC pre-QA method using artificial neural network affordable to time sequence data for prediction of mechanical error of each leaf in MLC. For prediction of MLC mechanical error before radiation treatment, RTpaln dicom file which has information about the treatment plan was converted to Dynalog expected position by in-house program. Second, we construct artificial neural network for predicting actual position of MLC reflecting mechanical error of linear accelerator (Clinac: Varian, Palo Alto, California, United States). The neural network consist of 5 long short term memory (LSTM) cell (4 gates, 128 neurons) and fully connected layers (1024 neuron) developed using open-source software library for machine intelligence (Tensorflow). Finally, the error of predicted actual positions of MLC is evaluated through maximum likely hood function. The evaluation of LSTM network is performed by test set of Dynalog files. The accuracy of training and test set were 98% and 93%, respectively. In conclusion, MLC Pre-QA method based on artificial neural network showed the prediction of mechanical error of MLC and could provide the probability of error that could occur.
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Contribution ID: 542
19. Radiation Oncology Physics and Systems
19.04. IMRT: Planning and delivery/IGRT

Incorporating the local biological effect of dose per fraction in IMRT inverse optimization

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In intensity modulated radiation therapy (IMRT), the dose in each voxel of the organs at risk can be strongly reduced compared to conventional radiation therapy (RT). Due to the sensitivity of late side-effects to fraction size, a smaller dose per fraction in the normal tissues represent an increased tolerance to RT. This expected reduction in biological effect may then be used as an additional degree of freedom during IMRT optimization to improve treatment outcome. In this

study, the comparison between plans optimized with and without a voxel-based fractionation correction was made.
Four patients diagnosed with a head and neck (HN), a breast, a lung or a prostate tumour were used as test cases. Voxel-based fractionation corrections were incorporated into the optimization algorithm by converting the dose in each normal tissue voxel to EQD2 (equivalent dose delivered at 2 Gy per fraction).
The maximum gain in the probability of tumour control (PB), by incorporating the correction for fractionation in each voxel, was 1.3% with a 0.1% increase in the probability of complications (PI) for the HN tumour case. However, in plan optimization and evaluation, when the clinically used tolerance doses were compared with the respective planned EDQ2 (calculated from the 3-dimensional dose distribution) the PB increased by 19.3% in the HN, 12.5% in the lung, 6.2% in the breast and 2.7% in the prostate tumour case, respectively. The corresponding increases in PI were 2.3%, 6.2%, 1.0% and 0.7%, respectively.
Incorporating voxel-based fractionation corrections in plan optimization is important to be able to show the clinical quality of a given plan against established tolerance constraints. Furthermore, to properly compare different plans, their dose distributions should refer to a common fractionation scheme (e.g. 2 Gy per fraction) for which the doses have been associated with clinical outcomes.

Contribution ID: 1259
19. Radiation Oncology Physics and Systems
19.04. IMRT: Planning and delivery/IGRT

Stereotactic radiotherapy choroidal melanoma: analysis of eye movement during treatment, eye simulator design and automated monitoring system development

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Malignant choroidal melanoma is a tumor arising in the layer of blood vessels, choroidal, positioned under the retina. It is a rare occurrence, affecting five to every million inhabitants, but rapidly evolving to metastasis. The radiotherapy is one of the possible treatments for the disease, it consists in the application of small photon beams directed to the PTV, the prescribed dose is delivered in multiple sessions. The success of treatment depends directly, among others biomedical factors, on the precision of the application, as well as the accuracy of repositioning of the patient between sessions. This study aims to (a) analyze the eye's movement during radiotherapy treatment for choroidal melanoma, the methodology used for repositioning the patient between treatment's sessions and the non-invasive method for fixating the patient's eye; (b) automated monitoring software development for patient eye gaze; (c) design of a mechanical eye for calibrating the automated monitoring system. As a result, it is expected to raise the precision and accuracy of application, reducing the damage to healthy tissues and side effects. After analyzing the positions of the iris' center and calculating its displacements relative to the orthophoria point the standard deviation values of 0.368 mm and 0.364 mm were found for the X-axis and Y-axis, respectively. And the analysis by taking the first day of treatment as reference as the center point, the values of 0.62 mm and 1.85 mm were found for standard deviation. The methodology for the fixation of the eye is correct in its objective. However, the repositioning needs improvements in its reproducibility. The mechanical eye enabled the calibration of the monitoring system software, which one is used to compute the centroid of elliptical elements as a human iris.

Contribution ID: 1688
19. Radiation Oncology Physics and Systems

19.04. IMRT: Planning and delivery/IGRT

Correlation between treatment modality and outcomes in liver cancer patients

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Introduction: Pre-treatment image guidance and intensity modulated radiation therapy allowed for decreasing margins for the planning target volume and sharper dose gradients for better sparing of sensitive healthy organs. However, the number of patients who present with recurrence of previously radiation treated cancer is not decreasing in spite of all improvements in technology. In a search for possible reasons, we investigated the correlation between a broad range of patient specific data, radiation therapy parameters and treatment outcomes for liver cancer patients.
Methods: Selected patient information was collected from 195 liver cancer patients treated at our centre. Outcome information included survival, disease recurrence, and blood work. All radiation therapy planning parameters were included in the analysis. Patients were split into two almost equal groups: rotational delivery (RD) and fixed beam delivery (FB). Predictive models were created using Cox regression for both survival and recurrence data.
Results: Predictive model has been developed for liver cancer patients treated with radiation therapy. Even with almost twice the average GTV size, the RD group showed comparable survival and time to recurrence as the FB group. Our data suggest that sufficient dose to the healthy tissue around the tumour improves disease free survival if rotational delivery of radiation is used: Figure 1. Only parameter describing normal tissue irradiation V24 had a significant positive effect on disease free survival (DFS) for the rotational delivery group with a hazard ratio (HR) of 0.495.
Conclusion: In order to prevent disease recurrence, some (optimum to be determined) radiation dose is needed to kill the spread of cancer cells outside the planning target volume. Rotational delivery creating dose splash in all directions does it better than fixed beams.

Contribution ID: 1859
19. Radiation Oncology Physics and Systems
19.04. IMRT: Planning and delivery/IGRT

A dosimetric and Radiobiological Assessment of three Intensity-Modulated Radiation Therapy for the Treatment of Oropharyngeal Cancer

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Purpose: The aim of this study was to assess and quantify the dosimetric plan quality and radiobiological impact between intensity-modulated radiation therapy (IMRT), volumetric-modulated arc therapy (RA) and helical tomotherapy (HT) for oropharyngeal carcinoma.
Patients and Methods: Three cohorts of patients were selected, planned and treated with these three IMRT treatments and all their plans were compared dosimetricaly and radiobiologicaly in case of tumors and all structures.
An in-house software was developed to compute Equivalent Uniform Dose (EUD); a second piece of software was developed related to normal tissue complication probability using Lyman Kutcher Burman models. The risk of cancer induction was estimated from the integral dose(ID) caculation.
Results: Similar dosimetric comparison for the three IMRT was obtained. The hot spot in HT present a Dmax < 105% Dpres. The EUDs values were maximized over PTVs and reduced for all structures treated by HT. All calculated NTCPs were less than 5% and slightly greater than this

value in case of parotid glands. The risk of induction of second cancer depends on the type of IMRT.
Conclusion: HT provides the most uniform doses and better protection of OARs. The variation of EUD, TCP, NTCP and integral dose results depend on the type of treatment, so much care must be done on the choice of treatment especially for young patients.
Keys words: Volumetric Modulated Arc Therapy, RA, Intensity-Modulted Radiation Therapy, IMRT, Equivalent Uniform Dose, EUD, Tumor control probability, TCP, Normal Tissue Complication probability NTCP, Oropharyngeal cancer

Contribution ID: 359
19. Radiation Oncology Physics and Systems
19.05. IMRT: Verification and QA

Statistical Process Control Analysis for Delivery Quality Assurance of Tomotherapy with ArcCheck

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Delivery Quality Assurance of tomotheray is important to assure the patient safety and the output of patient treatment. Ion chamber and films with cheese phantom for tomotherapy QA verification are utilized during acceptance test and commissioning. This methodology is widely adapted among many institution in Korea but the film QA process is time consuming and is required periodic film calibration which may introduce dosimetry uncertainty. The physical shape of ArcCheck phantom is a cylindrical which is suitable for rotational DQA purpose and it is known the feature of its real time measurement is efficient for patient DQA. The gamma pass index and rate to ensure the Tomotherapy DQA are 3mm/3% and 90% at our institution which was recommend in film QA. The aim of this study is establish appropriate tomotherapy DQA gamma index with process capability analysis using a method of statistical process control (SPC). The DQA data treated with Tomotheray HD were analyzed retrospectively using SPC software. In this study, X-MR control chart was used due to the characteristics of pre-radiotherapy QA with individual data and lower control limit(LCL) was used in the SPC calculation. We analyzed process acceptability index which is indicates how close the process center value is to LSL and also the data value distribution based on the set target value. In result of this study, the LCL of ArcCheck DQA is 93.9% which is higher than film DQA. The process capability index is close 1.0 which means stable QA condition of our institution. More study are need for different anatomic site to set the LCL and to verify the SPC index.

Contribution ID: 1042
19. Radiation Oncology Physics and Systems
19.05. IMRT: Verification and QA

Comparative study between IMRT quality control methods

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Background: The intensity modulated radiotherapy (IMRT) technique, as the others irradiation techniques, requires a specific individual quality control (QC). Detectors Like ionization chamber

(CI) CC04, an array of 2D-Matrixx ionization chambers (both from IBA - Dosimetry) and an Electronic Image Device Portal (EPID) were used to QC. Objective: To compare the dose distributions (DD) of the detectors with the values of the planning system (TPS). Method: Eighty one CQ of prostate planning was performed with IC and Matrixx. With the EPID detector, 87 CQ were performed in the gantry, table and collimator positions at zero degrees, but with the same fluency of the radiotherapeutic planning. Results: The percentage difference between the values obtained with IC and Matrixx were 3.01% and 1.75%, when compared to the TPS values, respectively. The obtained DDs were compared by means of the gamma index function, with 3% and 3mm. Thus, acceptance values better than 98% were obtained when comparing Matrixx values with those of TPS. Regarding the EPID, the difference obtained was 99.8%, when the data were compared with those values of the TPS. Conclusion: These results showed conformity with the literature, which could aid in the approval of a radiotherapy plan.

Contribution ID: 1440

19. Radiation Oncology Physics and Systems
19.05. IMRT: Verification and QA

Determination of EPID-based Monthly Quality Assurance Baselines from Long-Terms Linear Accelerator Performance Evaluation

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Monthly quality assurance (QA) on linear accelerators (linacs) has been performed using electronic portal imaging devices (EPIDs) as an independent QA tool, which is more efficient and cost-effective. The monthly EPID-based QA tools in our department verifies beam production, MLC position and collimator angle (Picket fence tests), jaw position (asymmetric jaw functioning test), and linac isocentre (Winston Lutz test). The tolerance levels are set based on AAPM Task Group report 142 recommendations. However, in most of the tests the linacs could achieve higher performance, making the tolerance levels less sensitive. Therefore, the determined baselines can be set as warning state when the measurement exceeds its baseline.
In this study, the EPID-based monthly QA baselines or control limits of linacs' achievability were determined using statistical process control technique. Upper and lower control limits were determined using X-mR control chart to compare the tolerance levels. Four Varian Clinacs have been tested; including dose verification, collimation, Picket fence tests, and Winston Lutz tests since 09/2010, 09/2010, 02/2012, and 03/2016, respectively. For asymmetric jaw tests, the junction dose can be dropped from ±30% to ±11.7%, gap between closed jaw from ±1.00 mm to ±0.35 mm, and position errors from ±0.5 mm to ±0.25 mm. For the Picket fence tests, maximum gap size can be reduced from +3.0 to +2.0 mm, maximum deviation from average with ±1.0 to ±0.35 mm, maximum deviation from expected position with ±1.0 to ±0.45 mm, and maximum collimator error from ±1.0° to ±0.2°. For Winston Lutz tests, the isocenter deviation can be decreased from ±1.0 to ±0.5 mm. For the dose verification tests, the maximum different cross-plane and in-plane profiles can be reduced from 2.0(±1.0)% to 1.0(±0.5)% and 2.0(±1.0)% to 1.3(±0.7)%, respectively. We found that tolerance levels should be tightened to increase the tolerance levels' sensitivity of failure detection.

Contribution ID: 161

19. Radiation Oncology Physics and Systems
19.06. MRI/Linac

Absolute calibration of the Elekta Unity MR Linac using the UK Code of Practice for high-energy photon dosimetry

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Absolute dosimetry for MR Linacs is complicated by non-standard reference conditions, the non-suitability of the UK secondary standard chamber for use in a magnetic field and the effects of the magnetic field on the response of Farmer field chambers.
Measurements were made on a pre-clinical 7MV Elekta Unity MR Linac. Reference conditions were chosen as isocentre (143.5cm SAD), 10cm deep, 10cmx10cm field and gantry angle 90° to avoid output variation from liquid helium levels dropping in the surrounding annulus.
TPR 20/10 was measured as 0.698 at isocentre. Measurements on a conventional linac demonstrated that TPR 20/10 does not vary between SAD 100cm and 143.5cm.
The UK National Physical Laboratory (NPL) provides calibration factors, ND, for the secondary standard NE 2611A thimble chamber in terms of absorbed dose to water. ND was taken for the value of the measured TPR 20/10. Independent intercomparisons were made at 6MV on a conventional linac between the NE2611A and two PTW waterproof Farmer 30013 chambers. The response of these chambers varies very slowly with energy hence it is reasonable to assume this introduces minimal uncertainty.
Ion recombination and polarity correction factors measured on the MR Linac were unchanged by the magnetic field. An additional correction factor to account for the 1.5T magnetic field on the Farmer chambers was measured as 0.986 taking the ratio of TP corrected readings before and after ramp-up of the magnetic field. An orientation parallel to the magnetic field (along the bore of the MR Linac) was chosen to minimise the magnitude of this factor.
An independent audit was performed by the NPL using alanine pellets and Farmer chambers calibrated via a water calorimeter from the Dutch secondary standards laboratory which operates within the MR Linac. This gave agreement with our calibration to within 1.0%.

Contribution ID: 427
19. Radiation Oncology Physics and Systems
19.06. MRI/Linac

Reference dosimetry measurements in a prototype high-field inline MRI-linac

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Reference dosimetry in MRI Linac machines need to be addressed before their use in hospitals. There is a need to understand and correct the effect of the magnetic field (B-field) involved in MRI on the measurement of the radiation dose received by a patient. Among the different MRI-linac concepts, there is an inline 1T MRI-linac prototype at the Ingham Institute for Applied Medical Research, Australia. The aim of this work was to perform dose measurements using ion-chambers and alanine dosimeters as a first step in determining B-field correction factors in the Australian

MRI-linac. The measurements involved determining beam output as well as ion-chamber calibration coefficient, NDw.
A Farmer-type chamber (IBA/FC65-G) and alanine pellets (placed in waterproof Farmer-type shaped holder) were irradiated in a static horizontal 6MV FFF-beam, with detector axis perpendicular to both beam and B-field. Measurements were performed in water tank, with SDD of 2.84m, radiation field 10cmx10cm and depth of 10cm.
Alanine was used as reference detector and corrected for the effect of the B-field based on investigations ongoing at the UK National Physical Laboratory (NPL). For B=0T, chamber NDw was determined at NPL (in FFF-beams) as a function of TPR and interpolated to the TPR value of the MRI-Linac. For B=1T, NDw was obtained as the ratio of dose to water measured using alanine and the corrected chamber reading. B-field correction factor was defined as the ratio of NDw with and without B-field.
The MRI-linac beam output was calibrated using alanine dosimetry over the course of three days and was found to be repeatable within 0.1%. The ion-chamber B-field correction factor was found to be 0.990 ±0.012. Results of this work show that it is possible to determine B-field NDw for ion-chambers using alanine as a reference dosimeter with a standard uncertainty of 1%.

Contribution ID: 725
19. Radiation Oncology Physics and Systems
19.06. MRI/Linac

Comparison of parallel opposed beam profile measurement techniques for MR-IGRT systems

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Introduction: Conventional methods of measuring parallel opposed beam profiles using Gafchromic film were compared to a Fricke-type radiochromic gel (FOX). FOX gel sheets were manufactured to allow for both MRI and optical read-out. The purpose was to investigate the accuracy of beam profile measurements, focusing on cross-plane profiles which have the greatest magnetic field influenced shift, using onboard MRI of irradiated FOX gels for magnetic resonance image-guided radiation therapy (MR-IGRT) applications.
Materials and Methods: Square AP and AP-PA fields of 3x3 cm2 were delivered to each detector (Gafchromic EBT-3 film and FOX gel sheet) at 5 cm depth with an integrated pre-clinical 1.5 T MRI – 7 MV linear accelerator system (MR-Linac, Elekta AB, Stockholm, Sweden). Gafchromic EBT-3 film and FOX gel sheets were optically scanned with an Epson 10000XL flatbed scanner. FOX gel sheets were MR imaged in the MR-Linac with TR/TE = 500/20 ms and 0.31x0.31x3.00 mm3 reconstructed voxels.
Results: The AP 3x3 cm2 field sizes measured at the 50/50 penumbra were 7.4% and 0.2% different from EBT-3 film measurements for FOX read out optically and FOX read out with MRI, respectively. The AP-PA field sizes were 5.7% and 0.6% different, respectively. The overall shapes of the cross-plane profiles measured with FOX gel sheets optically (at a later time post-irradiation resulting in some diffusion) and with MRI (immediately post-irradiation) conformed with conventional methodologies with some MR signal variations and optical artifacts.
Conclusion: The FOX gel sheets demonstrated their usefulness as an alternative to conventional detector measurements for beam profile analysis using onboard MR imaging in MR-IGRT systems. Future work will include improving the fabrication of the gel sheets to achieve uniform sheet thickness and acquiring and reconstructing smoother MR images.

Contribution ID: 1051
19. Radiation Oncology Physics and Systems

19.06. MRI/Linac

Determination of optimal similarity metric for deformable image registration between T2-weighted MR images at different time-points in prostate cancer patient

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Introduction: MR-guided radiotherapy is growing with the MR-Linac system. In this radiotherapy, deformable image registration (DIR) has the great potential for being powerful tool for MR-only planning and evaluation of intra-/inter-fractional motion using MRI image. However, there have been few papers about the DIR accuracy between MR images. Thus, we evaluated the accuracy of DIR between MR images in prostate cancer patients using multiple DIR parameters to find the optimal DIR parameter setting.
Material and Methods: 6 prostate cancer patients treated with IMRT were studied. T2-weighted MR Images at different time-points was obtained using MAGNETOME Trio, A Tim System (Siemens).Elastix, which is open source software package, was employed as DIR software. Three DIR parameters with different similarity metrics were used: Sum of Squared Differences (SSD), Normalized Correlation Coefficient (NCC), and Mutual Information (MI). To evaluate the DIR accuracy, Dice coefficient and Hausdorff distance of bladder, prostate, rectum, and femoral heads were used.
Results: Dice coefficients of prostate and rectum were 0.625±0.118 and 0.596±0.148 (rigid), 0.764±0.096 and 0.689±0.089 (SSD), 0.770±0.077 and 0.734±0.049 (NCC), 0.762±0.067 and 0.675±0.166 (MI), respectively. In addition, the Hausdorff distances were 12.9±3.80 and 13.6±4.20 (rigid), 9.70±2.80 and 11.6±3.00 (SSD), 11.2±3.30 and 12.2±2.60 (NCC), 10.5±2.20 and 12.3±4.30 (MI) [mm], respectively.
Conclusion: We demonstrated that the DIR had higher registration accuracy than rigid registration for MR images. In addition, NCC had relatively better DIR accuracy than other two similarity metrics.

Contribution ID: 1069
19. Radiation Oncology Physics and Systems
19.06. MRI/Linac

Development of hybrid MR/CT compatible phantom: Feasibility study for MR-only based radiotherapy

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Development of hybrid MR/CT compatible phantom was purposed. We hypothesize that one single phantom named hybrid MR/CT compatible phantom used for acquisition of MR and conventional CT image could be applied for MR-only radiation treatment in terms of target delineation and radiation dose calculation. To accomplish our purpose, we designed the essential requirements of hybrid MR/CT compatible phantom. Total 14 different tissue-equivalent materials both for MR and CT image was developed using various chemical component. Also, the uniformity of each sample was calculated. For MR image, percent image unit (%PIU) was calculated for all sample using the largest square-shaped region of interest on sagittal plane. The developed phantom was designed to equip 14 plugs which contained various tissue equivalent materials on MR and CT image.

Measurement, image acquisition using the developed phantom with 14 tissue equivalent samples of MR image and each test sample mentioned above were done using 3.0 T scanner with 32 channel sensitivity encoding head coil and Somatom Sensation 64. For MR image, T1 and T2 measurement was performed. The HU on CT depending on the amount of K2Co3 which was applied in tissue-equivalent materials to modulate HU on CT and its fitted curve are conducted. Therefore, modulation of CT image by adding K2Co3 was successfully demonstrated in our study. The uniformity of each tissue was evaluated by calculating %PIU of MR image and the average and standard deviation of CT image for all sample images and showed acceptable value. A hybrid MR/CT compatible phantom for image acquisition of MR and CT was designed and investigated the relation between MR and CT image for MR-only based radiotherapy. In addition, various tissue-equivalent materials for both MR and CT image to be inserted into the developed phantom were described in this study.

Contribution ID: 1445
19. Radiation Oncology Physics and Systems
19.06. MRI/Linac

Response of ionization chambers in the presence of magnetic fields

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The next generation of medical electron linear accelerators will integrate magnetic resonance tomography (MRI). So it will be possible to take direct images of the moving tumor during radiotherapy treatment. On the other hand, the strong magnetic field have an impact on the trajectories of the produced secondary electrons because of the Lorentz force which effects both the dose distribution in water and the dose response of used detectors. For an accurate patient dosimetry these effects must be taken into account. Monte Carlo methods describe correctly the radiation transport in different media even in presence of magnetic fields and are therefore the gold standard for the evaluation of the impact of magnetic fields on clinical dosimetry.
In the present study the beam quality correction factors kQ and the relative response in magnetic fields of different ion chambers (PTW-31013, PTW-31021, EXRADIN-1ASL, NE2571) was investigated with Monte Carlo simulations using the code EGSnrc. The chambers were modelled in detail according to the information given by the manufacturer and placed in a water phantom (30x30 x30 cm3). The chambers were irradiated under reference conditions following the recommendations of present dosimetry protocols, like IAEA TRS-398, i.e. the field size at the phantom surface was 10x10cm2, the focus-surface-distance 100 cm and the depth of the chamber’s reference point was 10 cm. As photon sources several spectra of clinical medical accelerators with nominal energies between 4 and 24 MV-X were applied. The magnetic field was applied in different directions relative to the beam axis (z-direction) and the chamber’s symmetry axis and was varied between 0 and 3T. All chambers successfully passed the Fano test.
The results show, that depending on the chamber’s volume, the response as a function of the magnetic field varies up to about 8%.

Contribution ID: 39
19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

Compensation of respiration baseline shift by an automatic compensating system

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This study aimed to determine the feasibility of using an ultrasound image tracking algorithm (UITA) combined with a respiration compensating system (RCS) to track and compensate the baseline shift of the diaphragm in real time. Diaphragm motion was observed using the previously developed UITA to perform real-time diaphragm tracking, and 15 patterns of baseline-shift signals were captured and analyzed to offset the diaphragm motion, and thereby reducing the occurrence of tumor baseline shifts during radiation therapy.
Diaphragm motions and various baseline-shift signals were tracked and captured in volunteers using our previously developed UITA. A diaphragm phantom was placed on a respiration simulation system (RSS) that received signals with different patterns of baseline-shift signals to simulate actual human baseline-shift signals. The target displacement was calculated and compensated by the RCS. The phantom displacements were observed using a linear accelerator at the Department of Radiation Oncology, Taipei Medical University Hospital, and the results were also compared with the displacements measured by the UITA and the RSS for correlation verification.
The results indicate a significant correlation between the UITA-calculated and actual displacements, with a correlation coefficient of up to 91% for the simulated respiration baseline-shift signals. After activating the RCS, the obtained compensating effect was more than 65%, and even up to 85%. Moreover, the compensation of 10 extreme patterns of diaphragm baseline-shift signals was improved significantly through the use of RCS, with a peak compensating rate of 88.92% being achieved. Finally, compensation effects ranging from 52% to 74% were obtained in 10 human volunteers.
This study combined ultrasound imaging tracking technology with the RCS to produce a radiation-therapy aid based on a simple mechanism that is easy to set up and which offsets the respiration-induced organ displacement (including baseline shift) with the aid of a noninvasive ultrasound imaging system.

Contribution ID: 78
19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

Performance evaluation of a customized vacuum cushion for patient immobilization in radiotherapy treatment of prostate cancers

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Objective:To evaluate the performance of a customized vacuum cushion for patient immobilization in prostate cancer treatment with comparison to conventional approaches.
Methods:To improve the drawbacks of traditional vacuum cushions, in-house customized vacuum cushions specifically for pelvic immobilization were made with amended features, the customized one was designed for better clinical use for pelvic cancer patients, considering the difficulties of immobilization and the importance of reducing normal tissue toxicity, which has obtained an invention patent holding by our department .it has several separated cavities inside which could work independently when being pumped into the vacuum, which help to eliminate the risk of air leakage. The middle part of the cushions was hollowed out to help patients fix their axial rotation's problem. Multi-layer disposable coverings with skin-friendly and water resisted fabric are attached so cushions can be reused for sustainable purpose.

60 prostate cancer patients were enrolled into this comparative study on three immobilization approaches:couch alone without cushion support (N), conventional vacuum cushion (V), and customized vacuum cushion designed specifically for pelvic immobilization (New-V). Real time CBCT was used to improve effectiveness treatment accuracy. The reproducibility and efficacy of immobilization as well as the impact on dose distribution were comparatively evaluated using interfractional and intrafractional translational and rotational errors by CBCT data, and dose deviations based on re-plannings.
Results:The average set-up errors in anterior-posteriorcranial-caudalmedial-lateral and Rotation of Group New-V were(0.38±0.33) cm, (0.24±0.24) cm, (0.33±0.33) cm and (0.89±0.77) °, respectively.Dose distribution analysis of the PTV before and after iso-center shifting has revealed dosimetric advantage from the New-V group data evaluation.
Conclusion:Three immobilization approaches are all effective in patient immobilization. However the in-house made customized vacuum cushion show best immobilization and dosimetric advantage slightly.

Contribution ID: 87
19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

Dosimetric analysis on the effect of target motion in the delivery of conventional IMRT, RapidArc and Tomotherapy

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One of the methods to consider the effect of respiratory motion of a tumor target in radiotherapy is to establish a treatment plan with the internal target volume (ITV) created based on an accurate analysis of the target motion displacement. When this method is applied to intensity modulated radiotherapy (IMRT), it is expected to yield a different treatment dose distribution under the motion condition according to the IMRT method. In this study, we prepared ITV-based IMRT plans with conventional IMRT using fixed gantry angle beams, RapidArc using volumetric modulated arc therapy, and tomotherapy using helical therapy. Then, the variation in dose distribution caused by the target motion was analyzed by the dose measurement in the actual motion condition. A delivery quality assurance plan was prepared for the established IMRT plan and the dose distribution in the actual motion condition was measured and analyzed using a two-dimensional diode detector placed on a moving phantom capable of simulating breathing movements. In this study, the measurement was performed considering only a uniform target shape and motion in the superior-inferior (SI) direction. In this condition, it was confirmed that the error of the dose distribution due to the target motion is minimum in tomotherapy. This is thought to be due to the characteristic of tomotherapy that treats the target sequentially by dividing it into several slices. When the target shape is uniform and the main target motion direction is SI, it is considered that tomotherapy has merit in the ITV-based IMRT method due to a lower dosimetric error under the target motion condition.

Contribution ID: 162
19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

Evaluation of time delay and fluoroscopic dose in a new real-time tumor-tracking radiotherapy system

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Purpose: A new real-time tumor-tracking radiotherapy system, (SyncTraX FX4®, Shimadzu Corp., Kyoto, Japan) was installed in our institution. It consists of two pairs of X-ray tubes and flat panel detectors. Many studies have been conducted on real-time tumor-tracking radiotherapy systems, but those systems used digital image intensifiers. We sought to assess time delay and fluoroscopic dose in the real-time system.
Materials and methods: We measured time delay using an oscilloscope, which measured the voltage from the linear accelerator and the real-time system signal during simulated respiratory-gated radiotherapy with phantoms, including 6MV with a flattening filter (FF), 6MV flattening filter-free (FFF), 10MV-FF, and 10MV-FFF photon beams. We measured the half-value layer (HVL in mm Al), effective kVp, and air kerma, using a solid-state detector for each tube voltage and current.
Results: The beam-on time delays between the linear accelerator and the real-time system were 140.9 ± 8.47, 119.8 ± 3.81, 126.1 ± 3.23 and 116.8 ± 9.70 msec for 6MV-FF, 6MV-FFF, 10MV-FF and 10MV-FFF photon beams, respectively. The HVL, effective kVp and air-kerma rates from X-ray tube 1 (X-ray tubes 1 and 2 are paired), were 4.72 ± 0.001 mm, 110.83 ± 0.19 kVp and 6.84 ± 0.02 mGy/min for 110 kV X-ray beams at 80 mA, respectively. The HVL, effective kVp and air-kerma rates from X-ray tube 3 (X-ray tubes 3 and 4 are paired), were 5.18 ± 0.001 mm, 110.83 ± 0.05 kVp and 9.96 ± 0.05 mGy/min for 110 kV X-ray beams at 80 mA, respectively.
Conclusions: The time delay of the real-time system is longer than the old system that used digital image intensifiers. The air-kerma from X-ray tube 3 was higher than that from X-ray tube 1. The HVL and effective kVp were almost identical between X-ray tube 1 and X-ray tube 3.

Contribution ID: 607
19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

Simultaneous Real-time Online CBCT acquisition during VMAT-based DIBH-Lung SBRT treatments - Feasibility study using MV beam scatter HU calibration correction.

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Aim:
To capture real time online CBCT during multiple breath hold VMAT delivery of SBRT lung patients using MV beam scatter and HU calibration correction.
Methods and materials:
The study is systematically divided in to following sequence 1) Development of in-house methodology to capture real time online CBCT during VMAT.2) Capturing of the same using CATPHAN 500 phantom in the presence of single arc 1 cm MLC sweeping 6MV -FFF VMAT plan with Small (5cm2) , Medium (10cm2) and large (20cm2) field sizes. 3) Creating CBCT calibration templates sequences for the above field sizes and compared with CBCT with no MV beam using TG-142 image parameters .4) Applying the above calibrated sequences in 3 clinical sites. 5) Finally capturing Real-time Online CBCT acquisition during multiple breath hold VMAT based DIBH Lung SBRT treatments.

Results:
Successfully developed in-house methodology to capture real time online CBCT during VMAT. Calibration was performed with Small (5cm2) , Medium (10cm2) and large (20cm2) field size single arc 1 cm MLC sweeping 6MV-FFF VMAT plans. There were no difference in geometric distortion, Contrast , Slice thickness and pixel spacing between CBCT with and without MV scatter. But Uniformity Index, Spatial resolution , Modular Transfer function , Hounsfield Unit (HU) varied more than 10% in presence of 6MV FFF VMAT beam scatter. HU measurement analysis of CATPHAN shows a maximum variation of 22% for Teflon and 8% for air when compared with CBCT without MV scatter. After applying proper Calibration sequence for respective field sizes the variation of the above parameters have reduced significantly and were found to be within TG-142 tolerance limits.
Conclusion:
Results from the study showed it is possible to capture real time online CBCT during multiple breath hold VMAT delivery of SBRT lung after applying appropriate MV beam scatter and HU calibration corrections.

Contribution ID: 654
19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

GAN-enhanced motion artifact reduction in cone-beam CT images of the abdominal region

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Purpose: There are severe shading and streaking artifacts around the high-contrast objects including the gas pockets and the bony structures in the cone-beam CT (CBCT) images of the the abdominal region due to the respiratory and the intestinal peristalsis. A general motion-artifact reduction solution is not available at present, and the accurate assessment and correction of the target position in the abdominal region prior to treatment delivery will be more challenging. A novel motion artifact reduction method enhanced by the deep learning techniques for the CBCT-image guided radiotherapy in the abdominal region is proposed here.
Methods: The artifacts are categorized to shading and streaking artifacts by the intrinsic mechanisms including the irregularity of the motion artifacts and the unmatched acquisition of the projections, and the two categories are corrected successively. The motion induced shading artifacts exist around the high-contrast gas pockets and the shading contaminated areas are segmented with the well designed morphological operations. The shading artifacts are corrected by the interpolation over the contaminated areas in the pseudo-projection domain after the application of the localized Radon transform. The frequency splitting process powered by a generative adversarial network (GAN) based deep learning framework is then applied to discriminate and extract the streaking artifacts and the related noises from the shading corrected images in the image domain, and the final correction is done by the direct subtraction of the streaking artifact induced pattern.
Results: The proposed method is evaluated on ten abdominal patients. Severe motion artifacts are significantly suppressed. Overall CT number error is reduced from over 90HU to be less than 20HU using our method.
Conclusion: Effective motion artifacts reduction is achieved on CBCT images using the GAN-enhanced motion reduction technique. The increased accuracy of the CBCT images substantially facilitates CBCT-based clinical applications, and it's thus attractive for radiation therapy.

Contribution ID: 658

19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

Four-dimensional transperineal ultrasound system (4D-TPUS) for adaptive image guided prostate cancer radiation therapy

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Adaptive image guided radiation therapy can reduce radiation dose of organ at risk (OAR) as well as satisfy prescribed dose coverage of target. For preventing extra dose irradiated to the patients, we employed four-dimensional transperineal ultrasound system (4D-TPUS). This study was to investigate the feasibility of adaptive image guided prostate cancer radiation therapy by using 4D-TPUS.
During treatment delivering, 4D-TPUS was used to acquire intra-fraction motion data. The data include two parts: 1) the real-time ultrasound images; 2) the real-time shift values of patients' prostate. To calculate the real dose distribution, we develop a deformable registration algorithm in order that the planned dose distribution can be deformed quickly according to the ultrasound images. For each fraction, the real delivered dose of OARs and targets was calculated by using this algorithm. Then, physician can evaluate the integrated delivered dose under clinical criteria, to decide whether an adaptive replanning was required.
From July 2014 to June 2017, the real-time data of 70 prostate cancer patients (total of 2207 fractions) were obtained. The patients can be classified into three groups according to the intra-fraction motion mode: stable (n=50), irregular (n=13) and intention (n=7). The intention group was defined as persistent deviation to the same direction (the maximal displacement should exceed 5 mm). For the stable group, the maximal deviations of target coverage, V50, V60 and V70 of rectum were 1.12%, 2.47%, 1.38% and 0.96% for all fractions, respectively. For the irregular group, there were 8 patients required replanning due to at least one of the maximal deviations were greater than 5% for some fractions. And all the 7 patients in the intention group required replanning due to the same reason. After the adaptive image guided radiation therapy, the delivered dose distribution of all the patients meets the clinical requirements.

Contribution ID: 697
19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

Respiratory Motion Monitoring by Acoustic Transmission

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Purpose:
Complexity of radiation treatment is increasingly reliant on methods of motion management for cancer targets that move during breathing. Not all patients are suitable for motion compensation techniques, so currently patients are assessed for eligibility during regular or coached breathing at the time of CT Simulation. A portable, non-invasive method is proposed for determining a subject's respiratory motion.
Methods:
A 400Hz sound wave was generated by a vibrational transducer speaker (Big Audio) placed over a subject's diaphragm, and recorded by a condenser microphone (Sun Mecha Corporation) located against the chest wall. The acoustic attenuation of sound within the lungs varies with lung filling, and results in a discernible change in amplitude of the received signal. An in-house Python-based application was written for signal processing. The accuracy of this system was determined by

monitoring 8 subjects' respiration simultaneously with the speaker and the gold standard – Varian's RPM system.
Results:
Agreement between RPM and the sound-based system was good, particularly for assessment of breath holds. The sound technique was prone to noise and variation based on what part of the lung the sound was traversing.
Conclusions:
The proposed sound-based measurement of respiration shows potential for clinical use in determining patients' ability to hold their breath, and consistency in breathing period.

Contribution ID: 1035
19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

Optimising a radiotherapy optical surface monitoring system to account for the effects of patient skin contour and skin colour

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Catalyst HD (C-rad, Uppsala, Sweden) is an optical surface monitoring system (OSMS) designed to assist patient setup, monitor intra-fraction motion, and to hold the beam in response to out-of-tolerance patient movements or during respiratory-gated radiotherapy treatments. Catalyst HD uses three ceiling-mounted projector/camera units that project/detect a striped pattern of blue light (405nm) to/from the patient's surface. The operation of the system therefore depends on optical absorbance and reflectance properties, which can vary with surface shape and colour. This study aimed to identify optimal operating parameters for the Catalyst HD OSMS when used to monitor surfaces with different optical properties.
The effects of surface contours and skin colours were evaluated by imaging 3D-printed objects with various convex and concave surfaces, which were painted in six different colours with various levels of red and black saturation (from light pink to dark grey). The degree of surface detection was assessed via the Catalyst HD interface, with different levels of gain (100–600%) and signal integration time (1–7s).
When the test objects were left white (unpainted), the OSMS was able to detect horizontal and convex shapes more consistently than vertical or steeply angled surfaces. After the test objects were painted, the OSMS was unable to detect the darkest objects at all, even with the highest gain and the longest integration times. Mid-grey objects were detectable only when the integration time was increased to 2s. All pink objects were easily detectable at the shortest integration time, with the OSMS performing best when red saturation was highest.
Further work is recommended, as the red undertone of all human skin may lead to improved results for real patients. However, these preliminary results indicate that careful commissioning and optimisation of OSMS systems may be required before they can be used in radiotherapy treatments of a broad cohort of patients.

Contribution ID: 1135
19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

Development of real time abdominal compression force monitoring and visual biofeedback system

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we developed and evaluated a system that could monitor abdominal compression force (ACF) in real time and provide a surrogating signal, even under abdominal compression. The system could also provide visual-biofeedback (VBF). The real-time ACF monitoring system developed consists of an abdominal compression device, an ACF monitoring unit and a control system including an in-house ACF management program.
We anticipated that ACF variation information caused by respiratory abdominal motion could be used as a respiratory surrogate signal. Four volunteers participated in this test to obtain correlation coefficients between ACF variation and tidal volumes. A simulation study with another group of six volunteers was performed to evaluate the feasibility of the proposed system. In the simulation, we investigated the reproducibility of the compression setup and proposed a further enhanced shallow breathing (ESB) technique using VBF by intentionally reducing the amplitude of the breathing range under abdominal compression.
The correlation coefficient between the ACF variation caused by the respiratory abdominal motion and the tidal volume signal for each volunteer was evaluated. The ACF variation was similar to a respiratory pattern and slight variations of ACF ranges were observed among sessions. About 73~77 % average ACF control rate over 5 trials was observed in all volunteer subjects except one (64%) when there was no VBF. The targeted ACF range was intentionally reduced to achieve enhanced shallow breathing for VBF simulation. With VBF, in spite of the reduced target range, overall ACF control rate improved by about 20% in all volunteers except one (4%), demonstrating the effectiveness of VBF.
The developed system could help reduce the inter-fraction ACF set up error and the intra fraction ACF variation. With the capability of providing a real time surrogating signal and visual-biofeedback under compression, it could improve the quality of respiratory tumor motion management in radiation therapy.

Contribution ID: 1157
19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

Tumor motion analysis in lung SBRT treatments with exaCradle immobilization device

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Purpose:
Tumour motion control for lung stereotactic treatments and its toxicity can be improved by means of several techniques. This study analyses preliminary results for target localization in lung SBRT treatments by means of exaCradle dampening device.
Material and Methods:
exaCradle is a multi-dampening system combining eight compression points, personalizing the action for each patient/disease site in SBRT treatments. 12 lung treatments have been analysed in the present study, with treatment courses of 50 Gy delivered in 5 fractions. 4 CT datasets were acquired for each patient (free breathing, maximum inspiration and expiration breathold and ultra-

slow CT acquisition by means of cone beam CT (CBCT) imaging in the treatment unit). All image sets were registered in order to generate the ITV by combining the CTVs contoured for each dataset. PTV was defined as a 5 mm expansion from ITV. Treatments were planned with Monaco 5.1 (Elekta) and delivered with a Synergy (Elekta) linac by means of VMAT techniques. For each fraction, 3 or 4 CBCT scans were performed: pre-treatment (inter-fraction correction, repeated when corrections exceed ITV-PTV margin), mid-treatment (intra-fraction correction) and post-treatment (final evaluation).
Results:
Mean corrections extracted from CBCT imaging were (X, Y and Z corrections, respectively) -0.3 ± 2.8 mm, 1.7 ± 3.7 mm and -1.0 ± 4.2 mm for pre-treatment evaluation, 0.1 ± 1.0 mm, -0.0 ± 1.1 mm and -0.5 ± 1.5 mm for mid-treatment evaluation and -0.1 ± 0.8 mm, -0.4 ± 1.3 mm and -0.2 ± 1.8 mm for post-treatment evaluation.
Conclusión:
Results obtained from CBCT corrections for exaCradle device were compatible with ITV-PTV margin definition. Tumour motion was successfully monitored during the treatment by combining dampening and CBCT imaging.

Contribution ID: 1402
19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

Real-time motion compensation using recurrent neural network (RNN) algorithm for an articulated robotic manipulator system

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The purpose of this study is to evaluate the performance of various prediction algorithms including proposed recurrent neural network (RNN) algorithm for the motion compensation using a robotic couch tracking system.
The robotic couch system consists of an optical tracking system, a 6-DOF articulated robotic manipulator, a three-dimensional (3D) optical tracking system, and a control program for managing the system components. 8 patient’s respiration data were used to training the RNN algorithm. The couch tracking system was designed to measure the robotic couch motion and respiratory motion simutaniously and calculate the compensated motion using various prediction algorithms. We performed simulation test using respiratory data of 12 patients to investigate the feasibility of the RNN algorithm. For comparison, linear extrapolation (LE), double exponential smoothing (ES2) with averaging, were also implemented. Root-mean-square error (RMSE) and improvement ratio (compare with not applied prediction algorithm) were used to verify the accuracy of the compensation.
We confirmed that prediction algorithms worked well with the RNN algorithm showing the best results. The simulation study showed 75.5% average improvement ratio with the RNN algorithm in 12 patients. Compared to the RNN, an average improvement ration were shown in the 43% of ES2 and 33% of LE.
Our results suggest that the articulated robotic manipulator couch system with the prediction algorithm using RNN can be widely used in the field of radiation therapy.

Contribution ID: 1755
19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

Efficacy of self-control respiration monitoring system to reduce respiratory motion during hypofractionated intensity-modulated stereotactic radiotherapy for prostate cancer

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Background
It is important to reduce planning target volume (PTV) margin to avoid potential side effects of organs at risk including the rectum and the bladder during hypofractionated intensity-modulated stereotactic radiotherapy (SRT) for prostate cancer. In this study, efficacy of a respiration-monitoring system in reducing respiratory motion of the prostate was evaluated.
Materials and Methods
Pelvic cine-MRI scans, in sagittal and coronal planes, were acquired in 15 volunteers in supine positions. Respiration movements of the prostate and seminal vesicle (SV) in sagittal images (anterior-posterior [AP] and superior-inferior [SI] directions) and the prostate in coronal images (right-left [RL] direction) were measured between the inspiratory and the expiratory phases under free breathing and intentionally shallow breathing controlled by the self-monitoring system (Abches, APEX Medical Inc., Tokyo).
Results
The respiratory motions in SI direction for the prostate and the SV were significantly decreased under shallow breathing compared to free breathing. The respiratory motion values under shallow breathing and under free breathing for prostate were 0.29 ± 0.27 mm and 0.90 ± 0.68 mm ($p = 0.005$), respectively, and those with SV were 0.41 ± 0.29 mm and 1.11 ± 0.63 mm ($p = 0.001$). On the other hand, there was no significant difference in the AP or RL direction of either organ. When the internal margin (IM) was calculated by average ± 2SD, the IM in SI direction could be reduced by 1.5 mm for the prostate and 1.4 mm for the SV under shallow breathing.
Conclusions
Respiratory control with self-monitoring reduced respiration movement of the prostate and the SV, especially in SI direction, and will reduce the optimal PTV margin during SRT for prostate cancer.

Contribution ID: 1795
19. Radiation Oncology Physics and Systems
19.07. Motion compensation: Imaging and delivery

Assessment of breath hold position accuracy and reproducibility in voluntary deep inspiration breath hold using visual feedback for left-breast radiotherapy

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Purpose: Deep inspiration breath hold (DIBH) for left-sided breast cancer has been shown reduces heart and left anterior descending (LAD) coronary artery dose. DIBH requires the patient to hold an adequate breath-hold position during daily radiotherapy (RT) fraction. The purpose of this study is to assess the breath hold position accuracy and reproducibility by introduction of DIBH with visual feedback (VFB) system.

Methods: Thirty patients who underwent left-sided radiotherapy with voluntary DIBH (vDIBH) were reviewed. Data from 24 patients who underwent vDIBH with VFB were compared to data from 6 patients who underwent vDIBH without VFB. Assessment of accuracy and reproducibility during RT with vDIBH was evaluated used by cine image. Cine image were acquired daily during the tangential field treatment with vDIBH. The distance between field edge and chest wall at central beam axis were manually measured on cine image and digital reconstruction radiograph (DRR). The displacements of chest wall during RT were assessed by subtracting the measurement made on cine image from the DRR measurement. The overall average distance for vDIBH with VFB and without VFB cohorts were compared to assess the position accuracy and reproducibility. These values were used to compute the mean (M), as well as systematic (Σ) and random (σ) error. Statistical analysis was performed using a Student's t-test with $p<0.01$ considered significant.
Results: The displacement of chest wall (mean +/- 2SD) was 0.60±2.50 mm for vDIBH with VFB and 1.12±2.96 mm for vDIBH without VFB, respectively. There was significant difference between vDIBH with VFB and vDIBH without VFB ($p<0.01$).
Conclusion: In DIBH for left breast radiotherapy, improvement of breath hold position accuracy and reproducibility was confirmed by the introduction of VFB and the utility of DIBH using VFB was shown.

Contribution ID: 108
19. Radiation Oncology Physics and Systems
19.08. Stereotactic radiosurgery

Assessment of MR stereotactic imaging accuracy for three different MR scanners by three different methods

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Geometric accuracy of stereotactic MR imaging is one of major requirements for any successful intracranial stereotactic procedure. In this study we evaluate image distortion for three different MR scanners and also test and compare three different methods of measurement. Following three different phantoms are used for MR image distortion measurement in this study: 1) in-house made cylindrical Perspex phantom with 59 and 63 glass rods for axial and coronal inserts, respectively, 2) commercial PTGR phantom consisting 21 three-dimensional cross-hairs filled with contrast medium and 3) CIRS 3D Anthropomorphic Skull Phantom filled with matrix of 3 mm diameter rods spaced 1.5 cm apart. For all three phantoms rods or points with rigid geometrical positions are well imaged by different scanning MR protocols. All phantoms can be also fixed in the Leksell stereotactic frame and thus stereotactic imaging procedures can be reproduced following exactly the same steps as for a real patient, including also the stereotactic image definition in the Leksell GammaPlan. Three different Siemens MR scanners were measured in this study: 1.5 T Avanto, 1.5 T Symphony and 3T Skyra. The measured distortions proved satisfactory accuracy precision for stereotactic localization for all three scanners. The mean radial distortion for these MR scanners for a major imaging protocol (T1 weighted 3D imaging) measured by PTGR phantom were 0.8 mm, 1.1 mm and 1.1 mm, respectively. Similar results were obtained also by other two phantoms. Generally in all experiments with various phantoms there was detected dependence of the MR image distortion on the type of the MR scanner, slice orientation and imaging protocol. Image distortions are also property of each particular scanner, the worst distortion was observed for 3T Skyra.
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Contribution ID: 125

19. Radiation Oncology Physics and Systems
19.08. Stereotactic radiosurgery

An advanced image-guided rotating Gamma ray system for intra- and extra-cranial SRS/SRT

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Purpose/Objective(s): Cobalt beams have exhibited superior dosimetric advantages for stereotactic radiosurgery/radiotherapy (SRS/SRT) of intra- and extracranial tumors compared to higher energy x-rays due to the sharper beam penumbra and the use of non-coplanar multiple source arrangement. This work investigates the potential clinical benefits of a novel rotating Gamma ray machine for SRS/SRT.
Materials/Methods: The new SRS/SRT system (CybeRay, OUR United RT Group, Xian, China) consists of a ring gantry and a focusing treatment head with 16 cobalt-60 sources. Each source has 7 collimators of 6, 9, 12, 16, 20, 25 and 35mm diameter. The treatment head can swing 35° superiorly, allowing a total of 43° non-coplanar beam incident. The treatment couch provides 6-degrees-of-freedom motion compensation and the kV cone-beam CT system has a spatial resolution of 0.4mm. Monte Carlo simulations were performed to compute plan dose distributions and to compare with previously treated CyberKnife plans.
Results: The CybeRay system had a 0.5mm isocenter accuracy. The low-dose acquisition mode of the CBCT system provided fluoroscopy and 3D imaging at a dose level of <1cGy. The maximum dose rate was >3Gy/min at the center of a 16cm diameter PMMA spherical phantom. The output factor varied from 1 to 0.739 for intracranial treatment using 20mm to 6mm collimators, and from 1 to 0.698 for extracranial SRS/SRT using all 7 collimators. The beam penumbra (20%/80%) was 3.3mm and 4.5mm for the 6mm and 35mm collimators. Superior treatment plans were obtained with CybeRay for intracranial SRS/SRT with much reduced near target brain doses. CybeRay also produced favorable dose distributions for peripheral lung tumors using a partial-arc technique to spare the opposite lung and critical structures.
Conclusion: The unique dosimetric properties of cobalt beams and the accurate stereotaxy/dose delivery make the new cobalt design an ideal system for advanced SRS/SRT of intra- and extracranial targets.

Contribution ID: 169
19. Radiation Oncology Physics and Systems
19.08. Stereotactic radiosurgery

Tracking accuracy of robotic radiosurgery for liver lesions

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Purpose: To estimate adequate PTV margins for liver treatments with CyberKnife and to characterize features which are correlated with increased tracking errors.
Methods and materials: Treatment log files are analyzed for 72 liver patients to assess tracking accuracy. The margins to compensate for the target translational motion encompassing different percentiles of the entire patient population are proposed. The rotational corrections are evaluated, and an additional margin is suggested to compensate for uncorrected rotations. Target deformations are also assessed for these patients. The relationships between treatment errors and

the motions of internally implanted fiducials and external infrared markers, as well as the linearity of the models are investigated. Variation of treatment errors across different liver segments in which the fiducials are located is also evaluated.
Results: Considering the 95th percentile of the patient population, margins of 3, 2 and 2 mm in SUP-INF, LT-RT and ANT-POST directions, respectively, are sufficient to account for the translational errors. If rotational corrections are not applied due to imperfect placement of fiducials or if rotational corrections are larger than the system limits, additional margins of 1 to 2 mm are required. Most patients exhibit linear relationships between the internal target and the positions of external makers. The radial treatment errors across eight liver segments have considerable variation. Analysis of target deformation indicates that expansion or contraction of targets on the order of 2 to 3 mm is typical for this population.
Conclusions: Non-isotropic PTV margins could be used for liver treatments by CyberKnife Synchrony tracking system. Larger PTV margins may be necessary if rotational corrections are not applied and to correct for target deformation. A linear correlation between internal target and external marker motions is observed for most patients which may have implications for other treatment and tracking modalities.

Contribution ID: 243
19. Radiation Oncology Physics and Systems
19.08. Stereotactic radiosurgery

Extracranial doses on Leksell Gamma Knife Perfexion – in vivo TLD study on 80 patients

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Main purpose of this study was to perform an assessment of extracranial patient doses received during treatment on Leksell Gamma Knife (LGK) Perfexion. Results were compared with published data from previous gamma knife systems (model B and C).Extracranial doses were measured for 80 patients treated on the LGK Perfexion. Thermoluminescent dosimeters (TLDs) were positioned on patients at seven different following locations: eyes, thyroid, chest, abdomen, pelvis, knee and ankle. Measured data were evaluated and analyzed in terms of parameters that may affect extracranial doses. Following parameters were considered for analyses: prescribed dose, total irradiation time, distance between isocentre and position of TLDs, volume of prescribed isodose, total integral dose in target volume and total integral dose in brain. Mean extracranial doses delivered to patients in this study were: eyes (151.2 mGy), thyroid (10.1 mGy), chest (4.1 mGy), abdomen (1.2 mGy), pelvis (0.73 mGy), knee (0.30 mGy) and ankle (0.11 mGy). Significant dependence of extracranial doses was observed on total irradiation time, distance between isocentre and position of TLDs, volume of prescribed isodose, total integral dose in target volume and total integral dose in brain. In comparison with previous LGK models (B and C), there was observed a significant decrease of the extracranial doses in LGK Perfexion in the range of two to twenty times lower (depending on measured anatomical location). Measured extracranial doses are generally very low and thus safe for treated patients. Observed measured doses are far below dose limits for deterministic effects. In comparison with previous LGK systems, Perfexion appears to be much safer with significantly lower extracranial doses.

Contribution ID: 250
19. Radiation Oncology Physics and Systems
19.08. Stereotactic radiosurgery

Monte Carlo validation of output factors measurements in stereotactic radiosurgery with cone

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Small photons field application in stereotactic radiosurgery cone irradiation requires the determination of output factors (OF) with high precision. The purpose of this work is to assess 8 detectors variation performance for OF determination in a clinical TrueBeam Novalis 6MV FFF (flattening-filter-free) mode for cone irradiation using the Monte Carlo (MC) simulation as reference. We used 10 cones with diameters between 30 to 4mm. MC simulations were done with PENELOPE, the detectors evaluated in a water tank were ionization chambers: Pinpoint and Pinpoint 3D (PTW), diodes: SRS, P and E (PTW), Edge (Sun Nuclear) and diamond: microdiamond (PTW). EBT3 radiochromic films (Ashland) were used with slab solid water. The OF were normalized with the 30mm cone diameter and compared to MC. The measurements were repeated 10 times for the film and 3 times for the other detectors.
For the 8 detectors, the OF measurements reproducibility was very high: $r=0.99$ and $p<0.0001$. The uncertainty of the MC calculation was lower than 0.8% (type A).
The results shows: pinpoints (radial position) underestimates OF until -2.3% for cone diameter ≥ 10mm and down to -12 % for smaller cones. Non-shielded diodes (SRS and E) and shielded diodes (P and Edge) overestimates OF respectively up to 3.3% and 5.2% for cone diameter ≥ 10 mm but in both case > 7% for smaller cones. Microdiamond slightly overestimates OF, 3.7% for all the cones and EBT3 film is closest to MC, maximum difference ±1% whatever the cone size.
In our study, film is the more accuracy detector for OF determination of stereotactic cones but it is restrictive to use. Pinpoints and diodes, respectively due to inappropriate size of sensitive volume and composition doesn't seem appropriate without corrective factors below 10mm diameter cone. MicroDiamond appear the best detector for all cones despite its sensitive volume size.

Contribution ID: 273
19. Radiation Oncology Physics and Systems
19.08. Stereotactic radiosurgery

Variation of small field dosimetry of Novalis Tx beam data: multi-institutional study

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Introduction: Accurate measurements of small field photon beams are challenging, but inappropriate data registration may lead to serious accident. In this study, we collected measured beam data of Novalis Tx linear accelerator (Brain Lab) from multiple institutions and evaluated the inter-variability of small field dosimetry.
Methods: The beam data of Novalis Tx measured for modeling of iPLAN treatment planning system were provided by the vendor under consent letters collected from 16 institutions. Percent depth dose (PDD) and output factor (OPF) were evaluated for field sizes of 0.5-22 cm2. Transversal profiles were also analyzed and the full width at half maximum (FWHM) and penumbrae width of profiles of the 1 cm slit part were evaluated.

Results: For small field measurements, fourteen institutions (87.5%) used diode detectors, and other two (12.5%) used ionization chambers with sensitive volume of 0.01-0.016 cm3. Although PDD of 10 x 10 cm2 field size showed small variation within ±0.5% at exponential region, 5 x 5 cm2 field showed large variation exceeding 2%. Standard deviations (SDs) of the OPFs were within 0.5% for field sizes ≥4 cm, but it was 6.21% at 0.5 x 0.5 cm2 field. The minimum and maximum difference of the OPF from mean values were -13.16% and 7.88%, respectively at 0.5 x 0.5 cm2 field. The 1 cm slit profiles of transversal profile showed small variation: the SD of FWHM were within 0.2 mm.
Conclusions: We evaluated the variation of small field dosimetry of Novalix Tx system collected from multiple institutions. The OPF of 5 x 5 mm2 field size showed large variations and the maximum range exceeded 20%. Such variations include not only machine-specific difference but also detector characteristics and the uncertainty of measurements. Special attention is needed for clinical application of such small fields.

Contribution ID: 352
19. Radiation Oncology Physics and Systems
19.08. Stereotactic radiosurgery

Stereotactic radiosurgery for multiple brain metastases: A dose-volume study

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A substantial number of cancer patients develop brain metastases, 50-60% of which present as multiple lesions. Stereotactic radiosurgery (SRS) can be used to treat brain metastases, with some incidental dose to the healthy brain. This study evaluated the effect of the number and combined volume of metastatic lesions on the dosimetric quality and the deliverability of a small sample of SRS test treatments.
Five simulated cases of cranial metastases were contoured using a CT scan of the CIRS 605 head phantom. The number of metastases per case ranged from 4 to 12, with total lesion volumes from 4.4 to 8.0 cc. Static conformal arc treatments were planned for delivery using a Varian iX linear accelerator with attached BrainLab m3 micro-multileaf collimator system. Treatment delivery was verified with Gafchromic EBT3 film measurements performed in a transverse plane.
The volume of healthy brain receiving 12 Gy was found to increase linearly with the total target volume. Several of the treatment plans were considered clinically acceptable when local dose prescriptions (14 to 18 Gy) were used, but when the prescription dose to all metastases was increased to match the RTOG 0320 recommended value of 24 Gy, no plans resulted in a V12 less than 10 cc. Gamma pass rates (using 3% / 1.5 mm criteria) were lowest for the treatments of 10- and 12-metastases, due to increased disagreement in out-of-field regions.
Using the static conformal arc method, it is possible to deliver treatments to relatively large numbers and total volumes of brain metastases without excessive radiation doses being delivered to the healthy brain, provided it is possible to compromise the prescription dose. If prescription doses above 18 Gy are required for such cases, the decision to use SRS and the particular SRS method selected for use may both need to be reconsidered.

Contribution ID: 378
19. Radiation Oncology Physics and Systems
19.08. Stereotactic radiosurgery

A study of single-isocenter for three intracranial lesions with VMAT-stereotactic radiosurgery: Treatment planning techniques and plan quality determination

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Objective: To compare modified single-isocenter technique between 1) 6-MV flat beams (6X) and 6-MV flattening filter free beams (6FFF) and 2) fixed collimator angles and optimized collimator angles for three intracranial lesions by using volumetric modulated arc therapy (VMAT)-stereotactic radiosurgery
Material and Methods: Twenty patterns of three intracranial lesions varying in size and location were generated. The VMAT plans using Eclipse version 13.6 were initially generated according to the University of Alabama, Birmingham (UAB)'s guideline. Planning parameters including 6X, 6FFF, and collimator angles were further modified. All plans were normalized to achieve 99% dose coverage with 20 and 24 Gy to 5 mm and 10 mm lesions, consecutively. Dosimetric parameters, including RTOG and Paddick conformal index (CI-RTOG and CI-Paddick), gradient index (GI), heterogeneity index (HI), mean dose to the normal brain, and volume of dose at 5 Gy (V5Gy) and 12 Gy (V12Gy) were analyzed using Wilcoxon or pair t-test.
Results: The plans with 6FFF beams offered superior plan quality than 6X beams for target coverage (CI-RTOG 1.106 vs 1.146, $p=0.005$ and CI-Paddick 0.890 vs 0.862, $p=0.002$), dose fall off (GI 4.914 vs 5.097, $p<0.001$) and normal brain sparing (V12Gy 3.802 vs 4.224, $p<0.001$ and V5Gy 22.092 vs 24.966, $p<0.001$). The optimized collimator angle plans provided less V5Gy (18.686 vs 23.043, $p=0.01$), V12Gy (3.255 vs 3.784, $p=0.01$) and GI (8.231 vs 9.795, $p<0.001$) compared to fix collimator angles of UAB protocol, while CI-RTOG and CI-Paddick index were similar.
Conclusion: A single-isocenter technique for three intracranial lesions by using VMAT with 6 FFF beams provided better plan quality than 6X beams. The optimization of collimator angles also showed an improvement of dose fall-off and normal brain sparing than fix collimator angles.

Contribution ID: 778
19. Radiation Oncology Physics and Systems
19.08. Stereotactic radiosurgery

Evaluation of a custom collimator designed for rodent irradiation with a Linac TrueBeam STx

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Rodent models are used for research in brain radiotherapy. Devices for rodent irradiation exist although they are expensive and not always available. One alternative is to use a clinical linear accelerator (Linac). To irradiate very small regions inside the brain of the rat using a clinical Linac, we designed, built and characterized a lead collimator plug to reduce the diameter of the photon beam from a commercial circular collimator (BrainLab). The plug was introduced inside the

collimator (20mm) commonly used for radiosurgical brain treatments with a Linac (TrueBeam Stx, Varian 6MV). The photon beam diameter was measured using the FWHM of the beam profile in irradiated radiochromic films at isocenter and digitized using a scanner (Epson Perfection V800). The mechanical precision of the system using the collimator plug was assessed and compared with the intrinsic mechanical precision of the Linac. Additionally, we used radiochromic film to measure the dosimetric parameters of the photon beam produced by the custom collimator plug. Finally, the reproducibility and spatial accuracy of a custom rat fixation system were evaluated, measuring the deviation of the interaural coordinate of the rat's skull from tomographic images of the same animal repositioned inside the device. We measured deviation from target coordinates after applying image fusion tools using IPlan v4.5.4 (Brainlab) software. The resulting value of the beam diameter at isocenter was 2.03 mm ± 0.05 mm. Mechanical beam total uncertainty was 0.71mm. A variation of 1.3 mm ± 0.8 mm was found in the fixation system. From the results obtained, we concluded that system could be used to irradiate small regions in rats (>2mm) although the murine fixation system could be improved to decrease the variation in the positioning.

Contribution ID: 1318
19. Radiation Oncology Physics and Systems
19.08. Stereotactic radiosurgery

Comprehensive Dosimetric Feasibility of Accelerated Partial Breast Irradiation (APBI) using CyberKnife

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Accelerated partial breast irradiation (APBI) is a new treatment modality aiming to reduce treatment time using fraction doses higher than conventional fractionation. In this study, a comprehensive study is performed to investigate the dosimetric feasibility of CyberKnife-based APBI for 10 patients with lest-sided breast cancer who had already finished conventional treatment at the Inha University Hospital. Dosimetric parameters during these 4 kinds of treatment plans (3D-CRT, IMRT, VMAT, CyberKnife) were analyzed and compared to constraints in the NSABP B39/RTOG 0413 protocol and published CyberKnife-based APBI study. For the 10 patients recruited in this study, all the dosimetric parameters, including coverage of the target, and doses to the normal structures, met the guidelines from the NSABP B39/RTOG 0413 protocol. Compared to other plan techiques, a more conformal dose to the target and better dose sparing of the critical structure were observed in CyberKnife planning. Accelerated partial breast irradiation via CyberKnife is a suitable platform for partial breast irradiation offering improvements over external beam APBI techniques.
Keywords: APBI, CyberKnife, Treatment planning

Contribution ID: 1397
19. Radiation Oncology Physics and Systems
19.08. Stereotactic radiosurgery

Pateint-specific 3-dimensional quality assurance using phosphor screen based dosimetry system for Leksell gamma knife Icon

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The purpose of this study is to perform the patient-specific 3D dose treatment plan verification for stereotactic radiosurgery using Leksell Gamma Knife IconTM (LGKI) (Elekta, Norcross, GA, USA) with the proposed QA device.
The device that consists of a moving head phantom, an embedded thin active layer and a CCD camera system was designed to be mounted to LGKI and a phosphor plate is inserted beneath the hemispheric head phantom for the dosimetric measurement. The device including the phosphor plate can be obtained a three-dimensional dose distribution by stacking the acquired images while moving ± 30 mm with 0.2 mm slice interval in the S-I direction. The patient-specific QA was verified in 5 patients by comparing the measured and calculated dose distributions. Calculated planning data were obtained from the GammaPlan treatment planning system version 11.
Geometric distortion of acquired images caused by the optic system and lens itself was corrected using a checkerboard image. The optical scatter component is also corrected by deconvolving the 2D spatial invariant scatter kernel.
The 2D corrected images taken by the CCD camera were compared with the dose distributions calculated by the GammaPlan under the same conditions. The differences in the full widths at half maximum (FWHM) of 2D profiles between the measured and calculated were less than 0.3-mm. The average 3%/3 mm gamma passing rate of 5 patients was 97.6% ± 1.1%. All cases passed at a >95% rate (range, 95.6%–99.7%).
The scanning task for all peak regions took less than three minutes under the new system.
It can be utilized as a patient-specific QA tool for the Gamma knife radiosurgery system instead of film dosimetry, the use of which requires much more time and many more resources.

Contribution ID: 1485
19. Radiation Oncology Physics and Systems
19.08. Stereotactic radiosurgery

The output factor measurements of CyberKnife system using various detectors

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Purpose: In Stereotactic Radiosurgery, the extremely high radiation dose is delivered to the target in a single or few fractions using narrow radiation fields. The radiation fields are collimated with 12 fixed circular collimators ranging from 5 to 60 mm in diameter in CyberKnife which is a robotic radiosurgery system. The output factor (OF) measurement of small fields is very problematic and the small field measurements are more sensitive to physical properties of detectors. The aim of the present study is to perform the relative OF measurements of 12 fixed collimators in CyberKnife system using different detectors.
Materials- Methods: In this study, the OF measurements of 12 fixed collimators were made with CyberKnife system at maximum dose depth in water equivalent RW3 slab phantom using PTW 60019 microDiamond, PTW 31014 0.015 cc PinPoint, PTW 31010 0.125 cc Semiflex, EBT3 Gafchromic film and GR-200A TLD. All detectors were positioned at the center of the radiation field with the point laser from treatment head. The measured data were compared with Monte Carlo (MC) factors.
Results: The OF values measured at 30 mm and greater collimator sizes were found similar for all detectors. The OF values decrease rapidly as the collimator size becomes smaller. The measured data with TLD and microDiamond detector at the smallest collimator sizes such as 7.5, 10, 12.5 and 15 mm were found very similar to MC factors.
Conclusion: 0.125 cc Semiflex ion chamber may lead to large uncertainties in the OF measurements for the smallest collimator sizes. TLD and microDiamond detector show similar results for all collimator sizes except 5 mm. TLD is a utilizable dosimetric tool in the small field OF measurements by means of its small active volume.

Contribution ID: 85
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Dosimetric comparison of tangent-based volumetric modulated arc therapy and tangent-based intensity modulated radiation therapy for deep inspiration breath-hold left-sided breast

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Purpose: Low dose area of volumetric modulated arc therapy (VMAT) represents a treatment planning challenge when the organs at risk (i.e., lung and heart) are very close to planning target volume (PTV) (i.e., left-sided breast). The tangent-based intensity modulated radiation therapy (TIMRT) is a common strategy for breast conserving therapy. This study was conducted to compare dosimetric characteristics of tangent-based volumetric modulated arc therapy (TVMAT) and TIMRT of left-sided breast cancer patient during deep inspiration breath-hold (DIBH) technique. Materials and Methods: Fourteen patients with left-sided breast cancer were included. TVMAT plans were generated using Mono-isocenter and four partial rotations for ipsilateral breast. First arc started at 340 degree, and stopped at 300 degree. Third arc started at 137 degree, and stopped at 90 degree. Second and Fourth arcs were reverse arcs of first and third arcs. TIMRT inversing plans were generated using opposing tangential fields. Two techniques were performed for each patient with similar PTV conformity and homogeneity. Dose of ipsilateral lung, contralateral breast, heart and contralateral lung were evaluated. Results: The average ipsilateral lung volume receiving 30Gy or more (V30Gy) was 5.7% for TVMAT plans compared to 8.5% for TIMRT plans (P = 0.031). For low dose area, the average ipsilateral lung, contralateral breast, heart and contralateral lung volume receiving 10Gy or more (V10Gy) was not significant difference (P = 0.645 for ipsilateral lung, P = 0.903 for contralateral breast, P = 0.252 for heart, P = 0.447 for contralateral lung). The monitor unites (MU) was 375.7 for TVMAT plans compared to 524.0 for TIMRT plans (P = 0.009). Conclusions: TVMAT for left-side breast cancer with DIBH technique retains similar target homogeneity and conformity without compromising the low dose level of ipsilateral lung, contralateral breast and right lung. For breath-hold patients, the efficient TVMAT is a better choice.

Contribution ID: 115
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Dose verification using in-room 4D-CT images for respiratory moving target in carbon-ion pencil beam scanning method

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In i-ROCK (ion-beam Radiation Oncology Center in Kanagawa), we have begun the respiratory gated irradiation with carbon-ion pencil beam scanning method to the respiratory moving target such as liver and lung. To overcome the interplay-caused inhomogeneous dose distribution that has been a weak point of previous pencil-beam scanning methods, our strategy is the combination of the carbon-ion pencil-beam fast re-scanning and the gating irradiation with respiratory sensor. Our clinical criteria for keeping the acceptable dose homogeneity are to keep the respiratory motion less than 5mm and to re-scan at six times on each layer during gate-on period. In treatment planning using 4D-CT images, medical doctor draws the GTV contours for all of respiration phases. Then we determine the period of respiration phase which the motion of GTV centroid is within 5 mm. Using these phases of CT set, a set of averaged CT images are reconstructed for the dose calculation. Furthermore, the gating level on the amplitude of respiration wave is decided. In treatment room, the patient is set using orthogonal x-ray FPD images based on the bone structures, then just before the irradiation, we confirm the range of the movement of implanted fiducial markers using oblique x-ray fluoroscopic images. After that irradiation is started. To verify our method for moving target and the reproducibility of dose distributions for each irradiation, we analyzed 4D-CT images that was taken at in-room CT scanner. From the results of 5 cases of liver cancer, target movement was controlled within approximately 5 mm, and the dose coverage of CTV was also enough. In this report, we show the treatment workflow for respiratory gated irradiation with scanning carbon-ion beam, and show the dose verification results for liver cancer.

Contribution ID: 164
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Treatment planning and dose prescription incorporating spatial uncertainty for lung SABR

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Current clinical practice is to prescribe to 95% of the planning target volume (PTV) in 4D stereotactic ablative body radiotherapy (SABR) for lung. However, frequently the PTV margin has a very low physical density, so that the internal target volume (ITV) receives an unnecessarily high dose. This study investigates the alternative of prescribing to the ITV, while including the effects of positional uncertainties.
Five patients were retrospectively studied with PTV margin of 5 mm and prescribed dose of 54 Gy in 3 fractions. Volumetric modulated arc therapy (VMAT) treatment plans were created using AutoBeam (v5.8) for the 6 MV flattening filter-free beam of an Elekta accelerator. Two thirds of the segments were conformally shaped to the PTV for robustness, while the remaining segments were modulated. Four plans were produced: a static plan prescribed to PTV D95% and three probabilistic plans prescribed to ITV D95%. For the three probabilistic plans, the scatter kernel in the dose calculation was convolved with a spatial uncertainty distribution, consisting of either a uniform distribution extending +/- 5 mm in the three orthogonal directions, a distribution consisting of delta functions at +/- 5 mm, or a Gaussian distribution with standard deviation 5 mm.
Median (+/- hemi-range) ITV D50% is 67.5 +/- 1.9 Gy for static planning, 58.8 +/- 0.9 Gy for uniform uncertainty, 58.6 +/- 2.0 Gy for delta-function uncertainty and 58.6 +/- 1.2 Gy for Gaussian uncertainty. Median monitor units are 3341 +/- 557 for static planning, 2957 +/- 538 for uniform uncertainty, 2926 +/- 479 for delta-function uncertainty and 2899 +/- 527 for Gaussian uncertainty.
This study shows that a robust probabilistic approach to planning SABR lung treatments results in the ITV receiving a dose closer to the intended prescription. The exact form of the uncertainty distribution is not found to be critical.

Contribution ID: 216
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Dosimetric and radiobiological impact with different dose calculation algorithm and grid size on plan for prostate VMAT

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Purpose: This study was to investigate the dosimetric and biological impact according to the dose calculation algorithm and grid size on plans of volumetric modulated arc therapy (VMAT) using endorectal balloon (ERB) for prostate cancer.
Methods: Prostate VMAT plans for twenty patients were generated with different dose calculation algorithms and grid sizes. Dose grid sizes to calculate dose were 1, 2, and 3 mm for Acuros XB (AXB) and 1, 3, and 5 mm for anisotropic analytical algorithm (AAA). Dosimetric parameters such as the D2%, V95%, homogeneity index (HI), conformity index (CI), and conformal number (CN) were analyzed. In addition, tumor control probability (TCP) to planning target volume (PTV) and normal tissue complication probability (NTCP) of organs at risk (OARs) such as bladder, rectum, and femoral head were compared to evaluate the radiobiological effect.
Results: For AAA plans, dosimetric parameters and TCP to PTV decreased with increasing dose grid size. Whereas, the dosimetric parameter and TCP of AXB plans increased with increasing dose grid size. Average HI, CI, and CN showed worst value in AAA plan with 5 mm grid size, and were 0.13, 0.93, and 0.89 respectively. NTCPs were under 0% for bladder and femoral head and ranged from 1.51% to 11.76% for rectum. These values showed relatively large in AAA than AXB plan. NTCP of rectum, similarly in TCP, reduced gradually with increasing grid size for AXB and decreasing grid size for AAA. AXB plan took generally long time to calculate the in compered to AAA. Difference of computation time between both algorithms was relatively increased, when small grid size was used.
Conclusion: Although observed the different dosimetric and biological impact, this study showed that accurate dose calculation was obtained with a smaller grid size and AXB algorithm, especially in prostate VMAT plan using ERB.

Contribution ID: 272
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Dosimetric comparison of intensity modulated radiation therapy with irregular surface compensator in whole breast radiotherapy

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This study aimed to compare the dosimetric aspects of whole breast radiotherapy (WBRT) between an inverse planning intensity modulated radiation therapy (IMRT) technique and a forward planning irregular surface compensator (ISC) technique. The ISC technique involves radiation beam modulation using multi-leaf collimators (MLCs) and increases the dose homogeneity to the target volume. The ISC technique for WBRT has already been applied at our institution; however, the technique requires more planning time and advanced planning skills. Therefore, the present study attempted to improve dose distribution using the IMRT technique. Treatment plans were

produced for 20 patients. The Eclipse treatment planning system (Varian Medical Systems) was used for the dose calculation: For the IMRT technique, two beam directions were inversely optimized to provide the best dose homogeneity; for the ISC technique, the fluence editor application was used to extend the optimal fluence. The two treatment plans used the same isocenter, tangential beam angles, and field sizes. These two treatment plans were compared in terms of doses in the planning target volume, the dose homogeneity index, the maximum dose, ipsilateral lung and heart doses for left breast irradiation, and the monitor unit counts required for treatment. The dose homogeneity and dose to organ at risk were similar for the IMRT and ISC treatment plans. No statistically significant differences were observed in the comparisons ($p > 0.05$). The IMRT optimized plans were generated to achieve the same objectives described for the ISC plan. In addition, the IMRT optimized plans reduce planning time and are user friendly. Therefore, the IMRT technique is useful for WBRT.

Contribution ID: 279

19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Estimation of normal tissue complication probability parameters for rectum and bladder after carbon ion therapy for uterus cancer

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Purpose: The aim of this study is to estimate normal tissue complication probability (NTCP) parameters on late rectum and bladder complications after carbon ion radiation therapy (C-ion RT) for uterus cancer.
Material and methods: A total of 85 patients were used to derive NTCP parameters. These patients included were treated with dose ranging from 52.8 Gy (RBE) up to 74.4 Gy (RBE) at the National Institute of Radiological Sciences (NIRS). The Lyman-Kutcher-Burman (LKB) model with DVH as a function of equivalent uniform dose (EUD) was used as a NTCP model. The end points for the analysis were Grade ≥1 and Grade ≥2 toxicity for the rectum and bladder.
Results: The resulting NTCP parameters for rectum were as follows. The volume effect parameter; $n = 0.076$ (95% confidence interval: 0.059-0.097), the steepness of NTCP curve; $m = 0.12$ (0.078-0.20), the tolerance dose associated with 50% probability of complication; TD50 = 50.9 Gy (RBE) (49.2-52.7 Gy (RBE)) for Grade ≥1. For Grade ≥2, the values were $n = 0.058$ (0.0045-0.075), $m = 0.078$ (0.056-0.11), TD50 = 58.4 Gy (RBE) (56.7-60.2 Gy (RBE)). The resulting NTCP parameters for bladder were as follows. For Grade ≥1, the values were $n = 0.58$ (0.13-1.0), $m = 0.38$ (0.31-0.89), TD50 = 57.1 Gy (RBE) (50.0-67.6 Gy (RBE)). For Grade ≥2, the values were $n = 0.12$ (0.051-0.36), $m = 0.29$ (0.22-0.41), TD50 = 75.0 Gy (RBE) (66.1-87.4 Gy (RBE)).
Conclusion: A set of NTCP parameters for rectum and bladder after C-ion RT was determined. The rather small n values suggest that the rectum was consistent with being strictly serial organ. The dose response for Grade ≥2 complications shifted to higher doses for rectum and bladder. The derived parameter values facilitate estimation of NTCP for rectum and bladder in C-ion RT.

Contribution ID: 299

19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Tangent-based volumetric modulated arc therapy (TVMAT) for Deep inspiration breast-hold left-sided breast

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Purpose: This study was conducted to quantify the dose reduction by TVMAT with deep inspiration breath-hold (DIBH) comparing to free-breathing (FB) TVMAT technique. Materials and Methods: Fourteen patients with left-sided breast cancer after breast-conserving surgery were included. Each patient underwent DIBH and FB computed tomography (CT) scans. Prescribed dose was 50 Gy in 25 fractions to left breast residual tissue. DIBH-TVMAT plans were generated using Mono-isocenter and four partial rotation arcs. First arc rotated from 340 degree to 300 degree. Second arc rotated from 300 degree to 340 degree in reverse direction. Third arc rotated from 137 degree to 90 degree, and fourth arc rotated from 90 degree to 137 degree in reverse direction. Gantry setting was the same for FB-TVMAT plans for each patient. Same planning target volume (PTV) coverage was required between two techniques for each patient. Dosimetric comparison between DIBH-TVMAT and FB-TVMAT was calculated for contralateral lung, contralateral breast tissue, heart and ipsilateral lung. Results: Compared with FB-TVMAT, the average mean heart dose of DIBH-TVMAT plans was reduced from 7.9Gy to 3.2Gy. The average ipsilateral lung volume receiving 20Gy or more (V20Gy) was reduced from 20.7% to 9.2%. V20Gy of all DIBH-TVMAT plans were lower than 17%. DIBH-TVAMT plans had lower mean contralateral breast and mean contralateral lung doses (2.0Gy, 0.7Gy) than FB-TVMAT plans (3.4Gy, 1.5Gy). The average volume receiving 5Gy or more (V5Gy) was reduced from 24.0% of FB-TVMAT plans to 9.1% of DIBH-TVMAT for contralateral breast and 6.7% to 1.0% for contralateral lung. The mean dose and V5Gy of all evaluated organs were reduced significantly. Conclusions: DIBH-TVMAT resulted in a significant reduction of mean dose without increasing V5Gy volume for contralateral lung, contralateral breast tissue, heart and ipsilateral lung compared with FB-TVMAT.

Contribution ID: 365
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Application of data mining to clinical protocol design: Are breath-hold techniques beneficial for prone breast radiotherapy patients?

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Breath hold techniques have been shown to benefit left breast radiotherapy patients, by reducing the dose delivered to the heart and potentially reduce cardiac morbidity. The use of breath holds during breast radiotherapy treatments of patients in the prone position has reportedly produced promising results. However, the adoption of a breath hold technique has associated costs (time, equipment and patient discomfort), so it is important to establish whether the adoption of breath hold techniques for prone patients is justified by clinical benefit.
Crowe et al’s TADA code [1] was used to complete a bulk retrospective evaluation of dose-volume metrics for 744 breast and chest wall radiotherapy treatments, planned across five treatment centres between 2013 and 2015. Of this cohort, 1.8% of treatments were identified as involving

patients in the prone position. All treatments were planned using the same clinical protocol, which did not utilise a breath hold technique.
Statistically significant differences were observed between the maximum heart doses from the prone left and right breast treatments (p = 0.01) and between the maximum heart doses from the prone left breast and supine right breast treatments (p = 0.02). However, of the prone left breast treatments investigated in this study, half included maximum heart doses that were lower than the mean maximum heart dose planned for the supine-positioned right breast treatments.
The results of this study suggest that there may be a benefit to using breath hold techniques during the treatment of selected prone-positioned left breast radiotherapy patients. However, many prone left breast radiotherapy patients (e.g. approximately 50% of the sample in this study) already receive very low heart doses, and may therefore experience no noticeable benefit from the use of a breath hold.
1. S. B. Crowe, T. Kairn, N. Middlebrook, et al. (2013) J. Med. Radiat. Sci. 60(4): 131-138.

Contribution ID: 372
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Automated VMAT treatment planning for complex cancer cases: a feasibility study

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Treatment plans for high-risk prostate and endometrial cancer are highly complex due to large irregular-shaped pelvic target volumes, multiple dose prescription levels and several organs at risk (OARs) close to the targets. The quality of these plans is highly inter-planner dependent. We aimed to assess the performance of the Auto-Planning module present in the Pinnacle treatment planning system (version 16.0), comparing automatically generated plans (AP) with the historically clinically accepted manually-generated ones (MP). Twenty-two consecutive patients (12 for high-risk prostate and 10 for endometrial cancer) were re-planned with the Auto-Planning engine. Planning and optimization workflow was developed to automatically generate “dual-arc” VMAT plans with simultaneously integrated boost. Primary target (PTV1) included the prostate and seminal vesicles or the upper two thirds of vagina; PTV2 included the lymph-nodal drainage. Target volumes were simultaneously irradiated over 25 daily fractions at 45 Gy for the PTV2 and 65 or 55 Gy to the prostate and endometrial PTV1s. For AP plans, a progressive optimization algorithm is used to continually adjust initial targets/OARs objectives. Tuning structures and objectives are automatically added during optimization to increase the dose fall-off outside targets and improve the dose conformity and homogeneity. Various dose and dose-volume metrics, as well as conformity indexes and healthy-tissue integral dose were evaluated. A Wilcoxon paired-test was performed for plan comparison (p<0.05 as statistical significance). Differences in all dose coverage metrics for both PTVs were not statistically significant. Similarly, differences in DVHs were no significant in overall dose range for rectum, bladder and small bowel. However, AP plans provided significant better conformity and an average decrease in Integral Dose of 8%. The mean number of MUs and estimated treatment time was similar between MP and AP. The Pinnacle Auto-

Planning module is capable of efficiently generating highly consistent treatment plans, meeting our institutional clinical constraints.

Contribution ID: 475
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Develop a fast non-coplanar IMRT treatment plan optimization system for a robotic radiosurgery system

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Introduction: Non-coplanar intensity modulated radiotherapy (IMRT) has shown a better normal organs dose sparing, which is favored by stereotactic body radiation therapy (SBRT). Recently the CyberKnife M6 system was equipped with a multi-leaf collimator (MLC) to shape the beam, which is ideal for delivering non-coplanar IMRT plans. The purpose of this paper is to develop a fast non-coplanar IMRT treatment plan optimization system.
Methods: The treatment nodes information was taken from clinical CyberKnife treatment plans. The column generation method was adopted, which iteratively generate apertures and optimize their corresponding weights. During optimization, the apertures were generated from any available nodes before reaching the maximum nodes number defined by users, and limited to those already selected nodes after reaching the maximum nodes number. The optimization was stopped either the algorithm was converged or the maximum apertures number was reached. To maximize the computation efficiency, the algorithm was implemented on GPU. Since the GPU memory is limited, to pre-calculate and store the very large dose deposition matrix from thousands of nodes is not possible, a fast pencil beam dose engine was therefore developed and to conduct real time dose calculation during optimization.
Results: An original clinic CyberKnife plan for lung patient was re-optimized with the proposed system, the maximum nodes number of 15 and the maximum apertures number of 70 were used for optimization. Compared with the original plan with circular collimators, the non-coplanar IMRT plans reduced the maximum dose from 7.4Gy to 2.6Gy for spinal cord, and from 12.2Gy to 7.1Gy for esophagus.
Conclusion: A non-coplanar IMRT treatment plan optimization system has been developed and evaluated by a lung case, which was proven to have better OAR dose sparing and higher delivery efficiency than original CyberKnife plan with circular collimators.

Contribution ID: 531
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Patient-specific prediction guided automatic multi-criteria optimization for intensity modulated radiotherapy

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Purpose: To propose a novel framework for automatic treatment planning by incorporating knowledge-based dosimetry prediction and tailored prediction guided multi-criteria optimization.
Method: The automation was achieved by incorporating a patient-specific dosimetric endpoint prediction and thereupon prediction-oriented multi-criteria optimization. An in-house developed geometric-dosimetric prediction model was firstly performed to afford a close-to-optimal DVH endpoint, as the initial goals to the following priority list. Afterwards, the automatic multi-criteria optimization was motivated by gradually tuning goals according to a priority list order. Elements within the list were planning goals for ROI endpoint, and they were classified and sequenced according to its clinical importance. Both a relaxing and a tightening round were carried to traverse and assure the optimality of every endpoint, by adjusting criteria gradually from low to high priority, and in reverse the other round. Ten GYN IMRT plans were collected to evaluate the feasibility and efficiency of our method. Evolved ROI's DVH and detailed dosimetric endpoint were compared for the original (clinical) plan and our automatic plan.
Results: DVH comparison show quality improvement for our proposed method, with comparable DVHs for the PTV but further dose sparing for most OARs, without any trade-offs. For the PTV, an average minimum dose was from 37.8Gy to 39.3Gy, and maximum dose from 50.2Gy to49.7Gy, for the original plan and automatic plan, respectively. Average dose was decreased from 42.61Gy to 40.74Gy, and 41.12Gy to 38.15Gy for the rectum and bladder, respectively. Among these, average V40Gy of the rectum and bladder is decreased from 76.04% to 71.04%, and 66.31% to 60.31%,for clinical plan and automatic plan, respectively.
Conclusion: We have successfully developed a patient-specific prediction guided automatic treatment planning framework for intensity modulated radiation therapy. This method can not only raise the routine working efficient, but also assure the plan quality.

Contribution ID: 561
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

A treatment planning comparison of scanning beam and passively scattered beam in carbon-ion radiotherapy for head and neck cancer

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Introduction
We started passively scattered carbon-ion radiotherapy (C-ion RT) in 2013, and more than 2000 patients have been treated. Currently, we are preparing for a new treatment room with the scanning beam method (SBM). For understanding treatment planning for the SBM, a treatment planning comparison study was performed between the conventional passively scattered beam method (PBM) and the SBM for patients with the nasal cavity and paranasal sinus cancers.
Methods and Materials
10 patients who had already received C-ion RT with the PBM for the nasal cavity and paranasal sinus cancers were selected for this study. Using their CT data and region of interest used in actual treatment planning (XiO-N, Mitsubishi Electric Corporation), we made treatment plans by using the SBM (Monaco, Elekta). We compared the results of two treatment plans, based on the dose–volume histograms (DVHs) with respect to the 95% doses to the planning target volume (PTV) and maximum and mean doses to organs at risks (OARs, e.g., brain, eyes and optic nerves).
Results
Both methods showed comparable PTV dose coverage. On the other hand, the maximum dose and mean dose to the OARs with the SBM were reduced by 10.0% and 41.0%, respectively, compared with the PBM. The SBM significantly decreased the maximum dose of optic nerves and the average doses of optic nerves, eyes and brain ($p<0.05$).
Conclusions

The present results showed that there were some potential to improve DVHs by using the SBM in the treatment for the nasal cavity and paranasal sinus cancer. The SBM is useful to create the more sophisticated treatment plan taking into account the complicated anatomical structures and locations adjacent to the PTV.

Contribution ID: 585
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Improved plan with volume-based algorithm for lung dose optimization in novel dynamic arc radiotherapy

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Purpose/Objective
Volumetric-modulated arc therapy (VMAT) has become the majority treatment technique for esophageal cancer. The optimal RTP requires time-consuming trial-and-error adjustments by each operator. We develope a volume-based algorithm (VBA) that provides optimal arc angles before the inverse planning and rapidly reduces the lung dose. This study aims to compare with lung dose distribution between retrospective plans and re-planning with VBA for esophageal cancer in VMAT.
Material/methods
The VBA could provide the arc angle and related restricted angle preceding automated inverse treatment planning. The isocenter of arc angle was defined as gantry rotation center. The restricted angle in lung could further form a restricted volume to spare the primary beam and assess the lung V5. Seven patients treated with VMAT were included. The prescribed dose was normalized to 50 Gy. First, all plans were re-planned without constraints by 20 iterations to analyze lung V5 distribution. Second, VBA plans were compared to retrospective plans with same constraints. The organs at risk (OAR) including lung, heart, spinal cord, dose distribution, and dose-volume histogram from retrospective plans and VBA plans were analyzed.
Results
Retrospective plans and VBA plans were computed without constraints using 20 iterations during inverse planning in 5 mins. The lung V5<55% could be achieved in 28% retrospective plans and 85% VBA plans. Retrospective plans were compared to VBA plans in the mean lung dose (11.07±2.86 versus 11.59±2.99), lung V20 (20.57±5.92 versus 24.31±2.88), lung V5(47.19±12.49 versus 45.36±10.83), mean heart dose (24.16±7.4 versus 23.97±7.48), and cord maximum dose (44.85±4.1 versus 46.23±5.67), there was no significant difference in all OAR (p>0.05).
Conclusion
The VBA could provide the optimal arc angle and reduce lung dose preceding automated inverse planning. The lung V5<55% can successfully be achieved rapidly. Even the less experienced operators only need 20 iterations to get the optimal lung V5 in 5mins.

Contribution ID: 586
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Development of the MATLAB-based proton pencil beam scanning treatment planning system PSPLAN for research and education

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Proton therapy can deliver highly conformal dose to the target while sparing surrounding healthy tissue from radiation damage. Many radiotherapy centers worldwide have growing interest in acquiring or developing proton therapy systems for cancer treatment, making research and education in the area of proton therapy increasingly important for medical physicists. In this work, PSPLAN, the MATLAB-based proton pencil beam scanning treatment planning system, was developed for research and educational purposes. The aims of this development were to provide insight into physics models and algorithms used for proton therapy treatment planning, and to provide a computational tool for pre-clinical study of patient-specific proton dose distributions. PSPLAN is divided into modules (subprograms), each of which has specific functions and works independently, including (i) reading of CT-DICOM files and information of target and organ delineation, (ii) pencil beam dose calculation, (iii) field optimization, and (iv) calculation of dose-volume histogram (DVH). Users can provide CT data of a patient and manually input pencil beam parameters such as beam spot size, initial proton energy distribution, depth increment of pencil beam scanning and source-to-isocenter distance, or use the default parameters compiled from literature. At present, PSPLAN is able to calculate single field uniform dose (SFUD) plans, for which each optimized field delivers homogeneous dose to the target volume. The overview of PSPLAN development including the program structure, the verification of physics models used for pencil beam dose calculation, and examples of investigated cases will be presented. The modular structure and the accessibility to modify pencil beam parameters will facilitate medical physicists and researchers to perform dosimetric investigation of proton therapy at different scenarios despite limited or unavailable access to proton therapy systems.

Contribution ID: 596
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Improved plan with volume-based algorithm for lung dose optimization in novel dynamic arc radiotherapy

Kuan-Heng Lin[1,2], Chen-Xiong Hsu[1,2], Chiu-Han Chang[2], Chih-Wei Yu[1,2], Hui-Ju Tien[1,2], Pei-Wei Shueng[2,3], Tung-Hsin Wu[1]
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Conclusion
The VBA could provide the optimal arc angle and reduce lung dose preceding automated inverse planning. The lung V5<55% can successfully be achieved rapidly. Even the less experienced operators only need 20 iterations to get the optimal lung V5 in 5mins.

Contribution ID: 606
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

The CT extended Hounsfield unit range for higher precision in radiotherapy treatment planning for patients with active implantable medical devices

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The conventional Hounsfield units (CHU) range is suited for tissue but is inappropriate for metallic materials. The extended Hounsfield units (EHU) range allows a more proper representation of dense materials. Precise HU values on computed tomography (CT) images are required for accurate dose calculations in radiotherapy, thus for the safety of patient carrying implants. We present a quantification of HU values for typical materials used in active medical implants.
HU values of metallic objects (titanium, chromium, aluminium, silicon and copper) and non-metallic materials (carbon, epoxy, ceramic and plastic) were determined in the CHU and EHU range. All objects were placed in a water phantom and CT images reconstructed in both ranges. A SIEMENS Somatom Force dual energy CT (100 kVp and 150 kVp) was used. Image quality was evaluated by a QA phantom (Catphan® 604) scan. The HU values were quantified by the Varian Eclipse™ software.
Materials with a physical mass density below 3.8 g/cm3 are properly represented in the CHU range. The metallic objects silicon and aluminium show HU values of (1962 +-19) HU and (2148 +-

172) HU in both HU ranges. This agreement is also seen for all non-metallic materials. Materials with mass densities above 3.8 g/cm3 are represented as a constant value of HUmax=3017 HU at the CHU range due to saturation. This applies for Titanium, Chromium and Copper. However, in the EHU range Titanium has a HU value of (6543 +-713) HU, chromium (8722 +-127) HU and copper (11552 +-127) HU. The EHU range has been used to prepare radiotherapy plans and compared to conventional plans.
Image quality is not affected by the use of EHU range compared to the CHU range. The EHU range better reproduces HU values of high-density materials for the purpose of dose calculations in radiotherapy treatments for patients with medical implants.

Contribution ID: 608
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Design and production of customized bolus using 3D rapid manufacturing techniques for external beam radiotherapy

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Objectives:
When treating superficial lesions, radiotherapy is described to have a skin-sparing property; boluses are often used to overcome this effect. The most commonly used commercial boluses are presented as flat flexible polymer plates and cannot establish perfect contact with the irregular surface of skin, resulting in air gaps that cannot be accounted for, leading to a discrepancy between planned and delivered doses. The aim was to develop a customized bolus using 3D rapid manufacturing (3D-RM) techniques and evaluate if it could overcome the disadvantages of commercial boluses.
Material&Methods:
The customized 3D-RM bolus was designed for a RANDO phantom breast area. 3D-CRT treatment plans were performed on CT scans of the phantom with the customized (A) and commercial (B) bolus. The obtained plans were compared to the standard plan (C) calculated with a virtual bolus assigned by the TPS. Visual inspection and assessment of dosimetric parameters such as dose volume histogram of the target volume were performed.
Results&Discussion:
The customized bolus presented a better fitting to the surface of the phantom than to the commercial one. The resulting dosimetric parameters indicated that the customized bolus could be clinically effective, helping to overcome the problem of air gaps and improving reproducibility of daily setup on irregular surfaces. Results also showed a dose distributions difference between plans B and C.
Plan Dmax Dmin Dmean V95%
A 108.2% 65.3% 99.4% 95.4%
B 107.8% 65.0% 99.4% 95.9%
C 109.0% 0.0% 99.1% 92.3%
Conclusions:
This study has shown the feasibility of 3D-RM techniques to produce customized bolus, improving radiotherapy effectiveness. The results indicated that with the use of customized bolus, air gaps were reduced when compared to a commercial bolus. The work made a prove of concept of the

approach, indicating that these techniques can be used to produce an efficient customized bolus for patients.

Contribution ID: 621
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

A novel metal artifact reduction algorithm for patients with pedicle screws in radiotherapy

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The aim is to develop a novel metal artifact reduction (MAR) algorithm for patients with pedicle screws, in order to improve dose calculation accuracy of treatment plan.
Convolution neural networks (CNN) combined with generative adversarial networks (GAN) were trained to generate pseudo CT images (without metal artifacts) from CT simulation images (with metal artifacts), by using voxel-wise optimization. An adversarial discriminator was also trained to identify the generated images, and its performance was in terms of the adversarial loss.
An entire lumbar spine specimen was used for an end-to-end verification of the algorithm. The vertebrae were implanted with pedicle screws according to rational clinical method. Then, the vertebrae were immobilized and placed in the water tank for CT simulation. After that, the algorithm was performed to reduce the metal artifacts. Three treatment plans (3D conformal, 5-fields IMRT and VMAT) were designed with pseudo and simulation images respectively, by using Monaco treatment planning system (with Monte Carlo algorithm). A semi-conductor in-vivo dose detector was put into the vertebral spinal cord, at the same position as the interest point (before measuring, kV-CBCT was used to assure the consistency of position between the interest point and the measuring point). After delivering the treatment plans, the measured doses were obtained from the in-vivo dose measuring system, and were compared with the planned doses.
The relative errors between measured doses and planned doses were 1.43%, 1.18% and 0.76% of the pseudo images and 10.6%, 7.21% and 3.89% of the simulation images, for three treatment plans respectively. Results show that the dose calculation accuracy can be improved by using this MAR algorithm.
A novel metal artifact reduction algorithm was developed to reduce metal artifacts of patient with pedicle screws, and its feasibility was demonstrated by an end-to-end cadaveric lumbar spine experiment.

Contribution ID: 760
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

The enhancement of radiotherapy planning quality for cancer patients with cardiac devices

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Nowadays an increasing number of patients undergoing radiotherapy have cardiac implantable electronic devices (CIEDs). Ionizing radiation has the potential to alter device functions and can cause damage to CIEDs during radiotherapy. Thus, in such cases, it is essential to make irradiation plan properly minimizing the dose received by devices. However, there is a problem that the cardiac devices can cause severe artifacts in the computed tomography images. The artifacts contribute uncertainty to a calculation of the dose received by implantable devices. Analyzing the issue, we have tested Metal Deletion Technique (MDT) in Masaryk Memorial Cancer Institute on cancer patients with different tumor localization. In this research, we have examined the influence of MDT method application on the plan parameters. Planning was conducted in the VARIAN Planning System Eclipse 11.0 with application 3D-CRT, IMRT, VMAT and SBRT irradiation techniques. The biggest malfunction in determining the maximum dose received by CIEDs was observed in 3D-CRT plan of breast and lymph node cancer and constituted approximately 3.2 %. In most plans without application of MDT method, we have noticed a tendency to reduction of maximum dose. The data obtained in the experiment confirm the necessity of MDT application to improve the planning treatment quality for cancer patients with cardiac implantable electronic devices.

Contribution ID: 935
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Dosimetric comparison of non-coplanar VMAT plans on CT and MRCT for SRS patients: a retrospective study

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Aim
To compare the dosimetric effect of direct dose calculation versus optimized dose calculation on a density assigned MR image set.
Materials and methods:
15 patients diagnosed with schwanoma treated with Stereotactic radio surgery (3 non-coplanar arcs) were selected retrospectively. These entire patients underwent contrast-enhanced 3-dimensional fast spoiled gradient-echo image (3D FSPGR) as routine protocol to assist tumor delineation. The FSPGR image is assigned Hounsfield values (termed as MRCT) of 0, +1000 and -1000 to body, bone and air respectively. The CT and MR images are registered and subsequently bone and air structures are copied from CT to make the process less cumbersome. Original delivered plan is pasted on the MRCT data. Dose calculation is done in two ways. 1. with preset MU values 2. With optimization (same dose constraints). Data including D100% and D2% of PTV, conformity index of the plans, and Dmax and D0.5cc of Brainstem were collected and analyzed.
Results:
Deviation of Brainstem doses for Dmax and D0.5cc using Direct Dose Calculation (DDC) on MRCT ranged 0.5% to 7.76% (average of 3.05%) and -0.6% to 2.56% (average of 0.85%) respectively. whereas, deviation of brainstem dose for Dmax and D0.5cc with optimization followed by dose calculation (OPT_DC) on MRCT ranged from -6% to 1.65% (average of -1.7%) and -5.76% to 0.51% (average of -2.48%) respectively. Deviation of Conformity index with DDC is slightly higher but acceptable (2.02%) but deviation of OPT_DC is only 0.65% and closely matches the actual plan done on CT data.
Conclusion:
Results show that there is no difference between plans generated with actual CT data and MRCT data. Thus MR scans may directly be employed for radiation planning without requiring CT data. This gives us further room for reducing PTV margins as errors owing to image registrations are completely avoided.

Contribution ID: 939
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Comparison of Axxent electronic brachytherapy with Mammosite system in breast treatments for skin, lung and heart dose

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Purpose
We have treated 250 patients at our center from May 2015 to September 2017 for breast cancer with Axxent (Xoft Inc.) intraoperative radiotherapy (IORT), in this work we compare the doses in the skin, lung and heart of the first 150 patients treated with the 50 kVp source with the doses they would have received using the Mammosite system using an Ir192 source.
Material and Methods
To the 250 patients treated in our center after removing the tumor, the appropriate balloon size is chosen to cover the tumor area with a dose of 20 Gy on the balloon surface.
Results
The differences in maximum skin dose for both types of treatment are 8.1 ± 1.2 Gy for the case of Mammosite and 5.7 ± 1.5 Gy for patients treated with electronic brachytherapy source. This explains the very few cases of acute dermatitis at 6 months (8 cases of grade 2 and 2 cases of grade 3) with no recurrence to date.We also show the mean and maximum doses (expressed as percentage of prescribed dose) for the left lung (Axxent 1% and 20.4% vs Mammosite 3.9% and 29.9%) and heart (Axxent 0.8% and 4.1% vs Mammosite 3.3% and 10.4%) in cases of left breast tumor for the volumes of 30 and 35 cm3, which are the most common in our hospital (70% of cases):
Conclusion
It is concluded that the IORT treatments performed with the Axxent equipment with electronic source are a good alternative to those performed with Ir192 and our 250 patients treated to date to the good results presented by other centers are joined.In addition to the low skin toxicity, there is no recurrence in patients treated so far, which makes us very optimistic about the results

Contribution ID: 1048
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Dosimetric comparison of air-filled and water-filled rectal balloon in line scanned proton radiotherapy

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Objective: The rectal balloon is the most widely used to reduce rectal wall dose and prostate motion in prostate radiotherapy. The purpose of this study is to investigate the dosimetric effects of different rectal ballooning materials with scanned proton radiotherapy.

Methods and Materials: A retrospective treatment planning study was performed to compare an air-filled rectal balloon (AFRB) and a water-filled rectal balloon (WFRB) for 9 prostate patients. Bilateral pencil beam scanning fields were optimized to ensure appropriate target coverage and rectal wall/bladder sparing, using a RayStation planning system with single filed optimization. To evaluate the setup uncertainties, each plan was simulated by shifting the treatment isocenter. The prescription was established as 70 GyRBE to cover > 95% of target. Plans were evaluated based on the ability to meet dose homogeneity index (HI), conformity index (CI), mean dose and maximum dose for the target volume, and volume receiving at least 45 and 70 GyRBE for rectal wall/bladder volumes.
Results: All plans achieved fulfilled objectives. CI(98%) for PTV was 1.8 (AFRB) and 1.76(WFRB). HI (D2%-D98%) for PTV was same between AFRB and WFRB. There was no significant difference in CI and HI for PTV between two materials (p=0.866). However, plans using WFRB are considerably less sensitive to setup uncertainties. For the rectal wall, the mean dose and V45 using WFRB were decreased 10% compared to AFRB.
Conclusion: Compared with AFRB, WFRB reduced the dose to normal tissues in the prostate cancer patient while maintaining satisfactory dose distribution in the target. In addition, it is well known that accuracy of dose calculation algorithms in heterogeneous media has a limitation in proton planning system.

Contribution ID: 1116
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Dosimetric impact of the uncertainties in the determination of the Output Factors for small fields on VMAT plans

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Purpose: Aim of this study is to evaluate the impact of the uncertainties in the determination of output factors (OF) for small fields on VMAT plans elaborated with Pinnacle3 Treatment Planning System (TPS).
Methods and materials: Our TPS Pinnacle3 was originally commissioned (2008) for Elekta Synergy BM for field sizes (FS) from 1.6cm. In this work, a new TPS machine, commissioned on the basis of OFs recently measured with scintillator and films, has been used for recalculating, at 2mm resolution, OFs and 12 VMAT plans, to evaluate possible differences. Moreover, dose at isocenter in QA phantom has been calculated with both versions of the machine and compared to dose measured with ionization chamber, to verify a possible improvement of the agreement.
Results: For FS <4cm, new measured OFs were higher than original OFs (up to 3% for 1.6cm). Calculated OFs agree with measurements within 1.8%. For 6 plans with PTV >3cm, no difference was observed in dose distribution calculated both in patient and QA phantom CT (dose at isocenter unaltered within 0.4%). Nevertheless, for 1.5cm<PTV<3cm, the mean increase in calculated dose (patient and QA phantom) was 1.4% and for PTV<1.5cm 2.4%. For PTV<3cm, the agreement between calculated and measured dose increased with the new TPS machine: mean absolute deviation reduced from 1.5% to 0.6% (maximum absolute deviation 2.8% to 1.3%).
Conclusion: The 3% difference in 1.6cm FS OF didn’t show any influence on dose distributions of VMAT plans for PTV >3cm. An increase in calculated dose within 3% and an improvement in dosimetric agreement was observed for 6 stereotactic plans. Further investigation is necessary to confirm the obtained results in case of more complex plans (PTV shapes and modulation degree)

and different OF variations and to establish which is the tolerance for the inaccuracy in measurements of small fields OFs.

Contribution ID: 1294
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Status of radiotherapy treatment in Lebanon

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Lebanon is located in the heart of the Middle East Region with a population of 4.5 million and is considered one of the best places of Medical Hot Spot destination that attracts many of the neighboring Arab countries to seek medical treatment. This is due to the fact of the highly skilled medical professionals and advanced health infrastructure in the country. Radiotherapy started in the early 70's with Cobalt Machines and has developed tremendously thought the years to include the highly technological and advanced Linac Systems.
Now, there are 10 Hospitals that offer Radiotherapy Treatment with 14 Linacs equipped with the state of the art technology using 3-D Conformal, IMRT, Stereotactic Radiosurgery, IGRT and other modalities.
In this presentation, an overview of the current cancer treatment in these 10 hospitals will be revealed. Detailed information will be unwrapped for two Centers: Rafik Hariri University Hospital (RHUH) and the newly opened Radiotherapy Center at Nabih Berry Governmental University Hospital (NBGUH) in South Lebanon, which covers one third of the Lebanese population in that region.

Contribution ID: 1298
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

How to design a setup error insensitive, unformed dose junction for large volume radiation treatment plan

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Purpose: Radiation therapy often needs multiple radiation fields having different isocentres. Uniformed dose across field junctions and sensitivity to setup error must be addressed. In 3DCRT, a feathered junction is often employed, where the junction between the two isocentres is moved after a certain number of fractions. However, associated planning and treatment documentation is labor intensive as multiple plans for each junction are required. Recently, Jagged-Junction-IMRT that make uniformed dose junction and insensitive to setup error associated with multiple radiation fields have been published. But, some other published papers presume that using IMRT techniques alone will ensure treatment insensitive to setup error. We use Jagged-Junction-IMRT (JJ-IMRT), Non-Jagged-Junction-IMRT (NJJ-IMRT) and VMAT to demonstrate how these different techniques more or less sensitive to setup error.
Methods: JJ-IMRT, NJJ-IMRT and VMAT plans were developed with a same patient for PTV about 50cm in length with three isocentres for craniospinal irradiation. Verification of the dose delivered to the craniospinal junction for all plans were done through ion chamber and film measurements on a human-shaped wax phantom. For film measurements, each verification plan was delivered with and without 3cm setup error in the longitudinal direction.

Results: The dose difference between measured with ion chamber and planned from the verification plans was 1.59% for JJ-IMRT, 1.35% for NJJ-IMRT and 1.68% for VMAT. The The maximum difference in dose profiles between film measurements with and without setup error was less than 4% for JJ-IMRT, less than 6% for VMAT and about 10% for NJJ-IMRT.
Conclusions: IMRT and VMAT techniques alone will not make treatment plans insensitive to setup error. Ensuring that beam field edges are not all placed on the same line is the reason the plans are insensitive to setup error. Attention must be given to how the multiple beams are overlapping at the junction edges.

Contribution ID: 1309
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Rapid prototyping for a novel carbon fibre breast support to reduce skin folds during radiotherapy

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Here we describe the development of a novel device for breast positioning in supine radiotherapy that reduces breast sag and skin folds for patients with large or pendulous breasts. The overall aim of this work is to provide a practical and robust means of reducing high grade skin toxicity (moist desquamation) which tends to occur in skin folds. Participants with breast cup size D or greater were recruited to this ethics board approved prototype design study. Brassiere size, cup size, breast diameter, body mass index, height, weight, skin folds and torso dimensions were measured. Participants were positioned in treatment position on a breast board, with arms above the head and skin folds were identified and measured. 3D optical surface imaging provided initial design ideas and a rapid prototyping process using 3D printing was employed to arrive at a suitable design. The final clinical device consists of a curved carbon fibre breast support scoop suspended from a rigid frame that is compatible with commercially available breast boards. In addition to reducing skin folds, the device better positions the breast on the chest wall to help minimize the volume of normal tissue being irradiated and facilitates rapid setup. We present results of preliminary testing of the device, including dose buildup incurred by the carbon fibre scoop, skin fold reduction data and treatment planning data from CT simulations with and without the device. Surface dose with the device in place remains less than 80% of the prescription dose to the breast. Greater than 90% reduction in skin fold area was achieved and reductions in heart and lung dose were achieved compared with free breathing plans without the device. The device shows great potential to address a long-standing problem for a significant population of patients undergoing radiotherapy for breast cancer.

Contribution ID: 1651
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Simplifying palliative VMAT cases using a final gantry beam spacing of 4°

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Objectives: Treat palliative patients using a VMAT technique while reducing the calculation treatment time, reducing the workload on the treatment planning servers and accelerate the treatment planning process.
Methods and Materials: Treatment plans of 21 palliative patients treated with a VMAT technique to a dose of 30Gy were used. The original plans had a dose grid of 3mm, a final gantry beam spacing of 2° with no limit in the number of optimization or objectives used. The plans were replanified using a 3mm dose grid but the final gantry beam spacing was changed from 2 to 4°. The objectives used for these plans were pre-determined using the 1st iteration with a fluence optimization requiring no full dose calculation. The optimization number was kept to a maximum of 3. The quality of the plans was evaluated using dose volume histograms (DVHs) and a correlation index between the modulation of the plans and their quality assurance results.
Results: 18 out of 21 cases gave similar results as the original plan. No correlation was found between the modulation index and the quality assurance results for the plans done using a 4° gantry beam spacing. Predetermined objectives for future palliative patient plans as well as beam angulations based on the PTV positions (centered or ipsilateral) were established. A treatment planning time reduction of 50% was also obtained.
Conclusion: A beam spacing of 4° for palliative patient allows to accelerate and simplify the treatment planning and to reduce the workload on the treatment planning servers. With this study we were able to demonstrate that palliative treatment cases using VMAT can be done using predetermined objectives, a beam spacing equal to 4° and a maximum number of optimizations equal to 3 without degrading the quality of the final plans.

Contribution ID: 1658
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Comparison of MLD obtained with MCO (RayStation), PRO (Eclipse) and predicted by homemade software for patients with stage III NSCLC

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Purpose The aim of this study was to propose a method of mean lung dose (MLD) prediction for III non-small cell lung cancer patients, based on their individual anatomy. The method was validated by comparison with results for volumetric modulated arc therapy (VMAT) plans, obtained with MCO (RayStation, v 5.1) and PRO (Eclispe, v13).
Methods Dose distributions calculated for each patient in Eclispe for a set of single fields and the method based on linear equations were implemented in a standalone, homemade software (DosePredictor). The software predicts MLD. Prediction results were validated for a group of 21 patients with NSCLC treated in our clinic. Coplanar dynamic two full arcs VMAT plans were prepared with MCO and PRO for each patient. Prescribed dose (PD) of 58,80 Gy was delivered in 21 fractions. For all techniques, the same objectives were used: 95% of PD covering at least 98% of planning target volume, minimization of MLD. The Wilcoxon signed pairs rank test was used to compare predicted MLDs and the ones obtained by MCO and PRO. Correlation between DosePredictor and VMAT plans was examined using Pearson correlation coefficient.
Results The average MLD was 13,7 Gy [8,5 Gy–20,8 Gy], 14,0 Gy [8,5 Gy–2,6 Gy], 14,8 Gy [8,7 Gy–24,3 Gy] for DosePredictor, PRO and MCO respectively. There was no significant difference between predicted MLD and the one calculated with PRO. For MCO the difference was significant

(α = 0,01), but small (1,1 Gy±1,2 Gy). The Pearson correlation coefficient was 0,918 and 0,925 for MCO and PRO respectively.
Conclusions The method allows to predict MLD for individual patient without necessity of plan preparation. The method can be used to define starting constraints for VMAT optimization or as a guidance for less skilled treatment planners.

Contribution ID: 1663
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Evaluation Of The Effectiveness Of Lead Used In Irregular Surface Compensators In Achieving Dose Optimization Of 3D Conformal Breast Radiotherapy

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The escalating incidence of breast cancer among women in Trinidad and Tobago is of national concern. Approximately 45% of clients at the National Radiotherapy Centre (NRC), are breast cancer diagnosed, with 3D- Conformal Radiation Therapy (3D-CRT) - the current gold standard , playing a vital role in their overall management. The goal of radiation therapy is to provide adequate coverage of the tumour volume while attempting to spare the dose to adjacent organs. The NRC is equipped with a Elite-80, Cobalt-60 teletherapy unit (1.25MeV photon energy) which on its own possess a challenge of gross dose inhomogeneity in certain breast cases such as those with larger tissue separations. Without the ability to utilize higher energy photon energies as found in a Linear Accelerator (LINAC), the NRC developed a client- specific technique of designing by hand irregular surface two-dimensional (2) compensators (IS2d-C) in order to achieve greater dose homogeneity in breast 3D-CRT. IS2D-C are made with sheets of lead of thickness 0.762mm which attenuate the photon beam and thus the shape and amount of lead required are determined from the isodose distribution obtained from the mid-sagittal slice of the patient's breast CT Simulation. Various validation and verification experiments were conducted to determine the attenuation of the photon beam with compensation. Results showed a reduction in beam intensity by 4.8% with each sheet of lead placed at 26.5cm away from the surface of the skin. As a result of the use of IS2D-C we achieve both dose homogeneity and optimal treatment of the tumour volume for all breast radiotherapy cases at NRC.

Contribution ID: 1743
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

Influence of different breathing maneuvers on deep inspiration breath hold for left-sided breast radiation therapy

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The aim of this study is to compare anatomic and dosimetric characteristics between abdominal breathing (AB) and thoracic breathing (TB) in deep inspiration breath hold (DIBH) for left-sided breast radiation therapy. Nine patients with left-sided breast cancer underwent AB_DIBH, TB_DIBH and free breathing (FB) planning computed tomography scans, and virtual simulation was performed for conventional tangential fields. To investigate anatomic characteristics between

AB_DIBH and TB_DIBH, left lung volume, intrathoracic anterior-posterior (AP) and left-right (LR) distance, and craniocaudal (CC) distance from lung apex to heart apex were measured. In addition, dose-volume histograms were analyzed for heart, left anterior descending coronary artery (LAD), and left lung among each breathing maneuver. The left lung volumes of AB_DIBH and TB_DIBH were significantly larger than FB. AP distance of TB_DIBH was significantly longer than AB_DIBH, and CC distance of AB_DIBH was significantly longer than TB_DIBH. Dose to heart and LAD was significantly lower in AB_DIBH and TB_DIBH than in FB by all metrics. The comparison of AB_DIBH and TB_DIBH on dose metrics showed no significant difference. However, the degree of dose reduction for heart and LAD in each breathing maneuver varied for patients. Among them, the maximum difference of LAD mean dose was 6.1 Gy. It was confirmed that AB_DIBH and TB_DIBH affect the displacement of the thorax and heart, and some patients could reduce the dose of heart and LAD depending on AB_DIBH or TB_DIBH. Therefore, patients must receive good breath training throughout the treatment course.

Contribution ID: 1821
19. Radiation Oncology Physics and Systems
19.09. Treatment planning

The influence of mean lung dose minimization on planning target volume coverage for lung patients base on multi-criteria optimization results

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Purpose The main goal during radiotherapy of patients with lung cancer is not only adequate coverage of planning target volume (PTV) but also sparing a lung healthy tissue. The influence of mean lung dose (MLD) minimization on PTV coverage was tested with the multi-criteria optimization (MCO, RayStation v 5.1).
Methods For group of 25 patients with stage III non-small cell lung cancer (NSCLC) two plans were prepared. Both plans consisted with full double arcs volumetric modulated arc therapy. The target prescription dose was 58,80 Gy delivered in 21 fractions and was equal to mean PTV dose. First plan was optimized to fulfill the department plan acceptance criteria for PTV (D98% > 95%, VMAT). The minimization of MLD was the main goal in second plan (MCOmin). Changes in MLD, PTV coverage (D98%, D95%) and Conformity Index (CI) were analyzed. CI was defined as a ratio between the PTV volume covered by the 95% isodose of prescribed dose and the total isodose volume. The Wilcoxon signed pairs rank test was used to test the statistical difference between the analyzed parameters.
Results It was possible to reduce MLD on average by 1,51 Gy (range -3,5 Gy – 4,6 Gy). At the same time D98% was worsen on average from 96,2% to 88,5% and D95% from 97,1% to 91,3%. CI was 0,77 and 0,94 for VMAT and MCOmin plans, respectively. All differences were statistically significant at alfa = 0,01. For 5 patients MLD and PTV coverage obtained in VMAT plans were better than in MCOmin.
Conclusions It was possible to minimize MLD, however with compromising PTV coverage. MCO offers the opportunity to explore this compromise. It appears that still the user knowledge and experience play an important role in planning. It seems, that for 5 patients the potential of MCO was not fully utilized.

Contribution ID: 48
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Assessment of radiation induced pneumonitis in breast cancer patients using a radiobiological model

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Abstract
Purpose: to develop a multiple logistic regression model as normal tissue complication probability model by LASSO technique for breast cancer patients treated with 3D-CRT with focused on the changes of PFTs to achieve the optimal predictive parameters for the occurrence of symptomatic radiation pneumonitis.
Materials and methods: Dosimetric and spirometry data of 60 breast cancer patients were analyzed. All of patients pulmonary function tests were done before RT, after completion of RT, 3 , and 6 months after RT. Multiple logistic regression model was used to fit the effective predictive parameters. Forward selection method was applied in NTCP model to determine the effective risk factors from obtained different parameters.
Results: SRP was observed in five patients. Significant changes in pulmonary parameters has been observed at three and six months after RT in breast cancer patients. The bridge separation, central lung distance and mean irradiated lung volume in tangential field have obtained as 23.4 cm, 2.43 cm and 10.06 % in patients without pulmonary complication, respectively.
Conclusion: The results showed that if BS, CLD, and ILV are more than 23cm, 2cm, and 10%, respectively; so incidence of SRP is significantly probable. Our multiple NTCP LASSO model for breast cancer patients treated with 3D-CRT showed that in order to have minimum probability of SRP occurrence, the BS, IV20, ILV and especially MLD parameters and considering dose-volume histograms the mean lung dose factor is most important parameter which minimizing it in treatment planning, consequently improves the quality of life in breast cancer patients.

Contribution ID: 79
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Helical tomotherapy in esophagus cancer: A comparision plan of imrt ,3DCRT to see conformal target coverage & homogeneous dose distribution

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We compare different radiotherapy techniques—helical tomotherapy (tomotherapy), step-and-shoot IMRT (IMRT), and 3-dimensional conformal radiotherapy (3DCRT)—for patients with mid-chest esophageal carcinoma on the basis of dosimetric analysis. Six patients with locally advanced mid-chest esophageal carcinoma were treated with neoadjuvant chemoradiation followed by surgery. Radiotherapy included 39.6 Gy to gross planning target volume (PTV) and 23.4 Gy to elective PTV in 35 fractions Total 63 Gy in 35 fractions. Tomotherapy, IMRT, and 3DCRT plans were generated. Dose-volume histograms (DVHs), homogeneity index (HI), volumes of lung receiving more than 10, 15, or 20 Gy (V10, V15, V20), and volumes of heart receiving more than 30 or 45 Gy (V30, V45) were determined. Statistical analysis was performed by paired t-tests. By isodose distributions and DVHs, tomotherapy plans showed sharper dose gradients, more conformal coverage, and better HI for both gross and elective PTVs
compared with IMRT or 3DCRT plans. Mean V20 of lung was significantly reduced in tomotherapy plans.

However, tomotherapy and IMRT plans resulted in larger V10 of lung compared to 3DCRT plans. The heart was significantly spared in tomotherapy and IMRT plans compared to 3DCRT plans in terms of V30 and V45. We conclude that tomotherapy plans are superior in terms of target conformity, dose homogeneity, and V20 of lung.

Contribution ID: 92
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Charged particle minibeam radiation therapy

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The dose of tolerance of normal tissues continues to be the main limitation in radiotherapy. To overcome it, we propose to ally the inherent physical advantages of charged particle therapy with the normal tissue preservation observed when irradiated with submillimetric spatially fractionated beams (minibeam radiation therapy, MBRT) [1, 2]. This would allow the use of higher and potentially curative doses in the treatment of radioresistant tumors. A dosimetry evaluation was performed by means of Monte Carlo simulations (GATE/Geant4). Relevant dosimetric parameters such the peak-to-valley dose ratios (PVDR) were assessed. Special attention was given to the contribution of nuclear fragmentation to the valley doses, considered the main responsible of tissue sparing. The optimum irradiation configuration in heavy ion spatially fractionated radiotherapy in terms of ion species, beam width, center-to-center distances (ctc), and linear energy transfer (LET) was assessed. Our results show that beam widths larger than 400 µm are needed to keep a ratio between the dose in the entrance and the dose in the target of the same order as in conventional irradiations. A large ctc distance (3500 µm) would favor tissue sparing since it provides higher PVDR, it leads to a reduced contribution of the heavier nuclear fragments and a LET value in the valleys a factor lower than ctc leading to homogenous distributions in the target. Among the different ions species evaluated, Ne stands as the one leading to the best balance between high peak-to-valley dose ratio and peak-to-valley-LET ratio in normal tissues and high LET values (close to 100 keV/µm) in the target region. Although biological experiments are warranted to confirm these conclusions, the results of this work may be used to guide the future biological studies.

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Contribution ID: 149
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Edema and source displacement in prostate cancer brachytherapy can result to dose variations using MCNP simulation

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In prostate cancer brachytherapy, edema and source displacement are not accounted for in treatment planning. Edema or swelling of the prostate, results from trauma due to source implantation. The increase in prostate volume results to source displacement. The preplan positions of the implanted sources can result to deviations in the prescribed dosage to be delivered in the prostate. Deviation from the prescribed dosage might not only affect the target volume but

also the surrounding healthy tissues and organs. The actual dose delivered and the deviations are difficult to measure in prostate brachytherapy. Thus, MCNP is a useful tool in quantifying these variations. The increase in prostate volume and source displacement were based on actual clinical data. The maximum volume due to edema and mean source displacement were used in the simulation. This paper aims to determine the dose variation due to edema and source displacement in prostate brachytherapy via MCNP simulation.

Contribution ID: 182
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Least squares based curve fitting – A method to estimate the equivalent square concept in linear accelerator

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Least squares based curve fitting – A method to estimate the equivalent square concept in linear accelerator
Arun Chougule , Athiaman A
Aim:
Determination of equivalent square fields for rectangular and shielded fields is of great importance in radiotherapy centres and in treatment planning software. This is accomplished using standard published tables and empirical formulae. Semi-Empirical methods with different approaches such as BJR tables & Sterling methods are published. The purpose of the present presentation is to estimate the accuracy of the standard published tables of equivalent squares through measurements performed.
Materials and Methods:
The measurements are performed on linear accelerator using farmer type ion chamber at 5cm, 10cm & 15cm depths in radiation field analyzer. The photon beam of 6MV X-Rays are used for this study. The output factors are obtained from the ratio of doses for given field size to that of reference field size. A graph is plotted between square field output factors against their respective field sizes. The data points in the graphs are subjected to obtain a curve along with the polynomial. This is accomplished by the method of curve fitting based on least squares method. We obtained a third-degree polynomial, y= ax3+bx2+cx+d, for the measured output factor plot against the field size; where y is the output factor, x is the equivalent square and a, b, c& d are the constants obtained from the curve fitting.
Results and Discussion:
It was observed that the estimated equivalent square values are much higher than the published values of BJR & Sterling et al. The measurements revealed that the measured value is differing in less significant level at the smaller field sizes as compared to larger field sizes. The details are presented in this work

Contribution ID: 254
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Assessment of organ at risk dose in breast cancer intraoperative electron beam radiation therapy using Monte Carlo simulation

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Background: One of the treatment choices in breast cancer is Intraoperative electron beam radiation therapy(IOERT). Due to high dose delivery in this procedure, shielding disk is used to protect organs at risk (OARs). In this study, we evaluate the OARs dose in the breast IOERT using Monte Carlo simulation with and without shielding disk in RANDO phantom.
Material and Method: Simulation of dedicated IOERT linear accelerator (LIAC) head with 5cm diameter applicator was performed using BEAMnrc Monte Carlo simulation code. Three phase-space files for each nominal electron beam energies (6, 8, 10, 12 MeV) produced in the end of the applicator, after 2cm tissue in end of the applicator and the last phase-space was created after disk. These phase-space files were used as an input source in DOSXYZnrc for irradiation of RANDO phantom. Both lungs and heart were considered as OARs in the IOERT of the left breast irradiation. For each energy, the 3ddose files, as an output of DOSXYZnrc and contoured organs in the RANDO phantom imported to CERR software. 12Gy was considered as a normalized value in the target. Then dose-volume-histogram(DVH) data were extracted for analysis.
Results: The mean and maximum dose for each OAR in all energies with and without disk and with consideration of 2cm tissue as a target were extracted from DVH data. For all nominal energies, the right lung dose was zero. The maximum and mean dose range in the left lung without disk were 11.5- 13.9 and 0.15- 0.5 Gy, respectively. These values for heart were 0- 2.9 and 0- 0.16 Gy. The mean dose of heart and the left lung were un-remarkable with applying 2cm tissue and disk.
Conclusion: With the increase of the electron beam energy in the IOERT, an increase of OARs dose was seen with and without shielding disk application. On the other hand, application of shielding disk in breast IOERT reduces OARs dose significantly.
Keyword: Monte Carlo simulation, IOERT, Organ at risk, Breast cancer

Contribution ID: 266
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Measuring midline dose without build-up cap for patients with brain tumor undergoing 15MV external radiotherapy by using EBT3 Gafchromic film

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Purpose: Measuring midline dose for the patients undergoing brain radiotherapy without any need to build-up cap.
Methods: The study was performed on 28 patients with brain tumor undergoing 15 MV radiotherapy by a Siemens LINAC. To estimate the midline dose, the entrance and exit doses were calculated by a conversion ratio. The conversion ratio was determined as the ratio of the measured dose by EBT3 Gafchromic film at the phantom surface to that measured by an ionization chamber at the depth of 3 and 12 cm. Then, the midline and exit transmission curves were obtained in a solid water phantom for various irradiation conditions with and without a 30 degree wedge for various field sizes of 5×5, 10×10 and 15×15 cm2 and at various SSDs including 80, 90 and 100 cm at various depths ranged from 6 to 22 cm by a 0.6 CC ionization chamber. Eventually, to measure the midline dose, we used both of the midline transmission and arithmetic mean algorithms.
Results: The mean and standard deviation of the whole sample for midline transmission algorithm were -3% and 4.52% and for that of arithmetic mean algorithm -2.97% and 4.3%, respectively. However, for 9 patients, more than 5% error was noted in estimated midline doses.

Conclusions: A new method was developed for measuring the midline dose without any need to use the build-up cap. The main advantage of the developed method is that there is no disruption in the dose reached to the treatment volume.
Keywords: 6 MV radiotherapy, in vivo dosimetry, midline dose, build- up cap, EBT3 Gafchromic film

Contribution ID: 577
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Evaluation of deformable image registration between high dose rate brachytherapy and Intensity modulated radiation therapy for prostate cancer

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abstract
【Purpose】High risk prostate cancer is treated with a combination of intensity-modulated radiation therapy (IMRT) and 192Ir high dose rate brachytherapy (HDR-BT). Deformable Image Registration (DIR) techniques can be used for the calculation of accumulated total dose. The accuracy of DIR gets worse when density of an organ differs greatly between two images. However, needles and contrast medium are used in HDR-BT. In this study, the effect of needles and contrast medium for DIR accuracy was evaluated.【Methods】The radiotherapy plans of six prostate cancer patients who completed radiotherapy with HDR-BT and IMRT for the locally prostate or the whole pelvis were collected. The treatment planning system used for IMRT was Monaco (Elekta AB, Sweden) and Oncentra Brachy (Elekta AB, Sweden) for HDR-BT. In the HDR-BT plan, the needles were filled by the surrounding tissue density, the bladder wall was replaced to 30 HU and the contrast medium inside the bladder was replaced to 10 HU to create needleless image (NI) and needleless and no contrast medium image (NCI). DIR and Rigid Registration (RR) was performed on the original image (OI), NI and NCI by using MIM Maestro ver. 6.7.6 (MIM software Inc, the USA) and after that the dose distribution of HDR-BT (used as the reference image) and IMRT were accumulated. The Dice Similarity coefficient (DSC) between DIR and RR were analyzed and compared each other.【Results and Discussion】The mean DSC values of the prostate with DIR on OI, NI and NCI were 0.51, 0.57, 0.73, respectively, and all of these with RR was 0.75. The DSC with DIR on NCI was higher than DSC with DIR on OI and NI. The DSC values improved by removing the contrast medium.

Contribution ID: 625
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

The effect of energy variations for 6 and 15 MV photon beams on tissue inhomogeneity correction factors

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Purpose
The purpose of the study was to investigate the dependence of tissue inhomogeneity correction factors (CFs) for a range of photon beam energy spectrum.
Materials and Methods
Heterogeneous lung (0.26g/cm3), adipose tissue (0.92g/cm3) and bone (1.85g/cm3) phantoms were constructed in Eclipse treatment planning system for calculating inhomogeneity CFs. The calculations were performed with Anisotropic Analytical Algorithm (AAA) for a range of energy spectrum for 6 MV (TPR20,10 = 0.670±k * 0.01) and 15 MV (TPR20,10 = 0.670±k * 0.01), k = -3, -2, -1, 0, 1, 2, 3. This range of energy spectrum was obtained based on the data collected for 42 accelerators installed in Poland. CFs were calculated for several beam sizes and for points lying at several depths inside and below of different thicknesses of heterogeneous slab phantoms.
Results
Our experiments showed that CFs increase for lung and fat tissues with increasing the beam quality (TPR20,10 values), while decrease for bone. Calculations with AAA predict that the 6% variations in energy (TPR20,10) lead to changes of CFs of maximum 11.12% (6MV) and 7.2% (15MV) for points inside of lung. For points below lung, CFs differ of less than 2.6% if CPE exists. In case of fat, the differences of CFs of less than 1% were obtained for both 6 MV & 15 MV, when calculated inside and below of fat tissues. For bone, 2% (6 MV) & 5.2% (15 MV) variations of CFs were observed for points inside of bone tissues, while 1.9% (6 MV) & 1.6% (15 MV) differences were found for points lying below of bone tissues. These differences of CFs decreased with increased radiation fields.
Conclusions
Variations of energy lead to significant changes of inhomogeneity correction factors for points inside of the inhomogeneity. Much smaller differences were obtained for points lying below inhomogeneous tissues.

Contribution ID: 828
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Validation by Monte Carlo model of Varian 2300 C / D accelerator to peripheral dose calculation

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Peripheral doses are referred to doses outside geometric limits of the treatment field.These doses are important when evaluating the occurrence of radio-induced secondary cancer.Determination of these doses requires measurement time and high precision detectors that are sometimes not available in the clinic. A Monte Carlo model can be useful by virtue of its precision and flexibility.In this work, the code EGSnrc (BEAMnrc / DOSXYZnrc) was used to validate the model of the 6MV (Megavolt) photon beam of a Varian 2300 CD accelerator, to estimate peripheral doses.The PDD (Percent Dose Depth) curves were intercompared at different energies around 6.0 MV (Megavolt), as well as the dose profiles varying the FWHM (Full width at half maximum), in order to obtain the best combination (energy/ FWHM) of the beam. The criterion established by Venseelar as a criterion of acceptability of the model was taken into account.The best energy / FWHM combination of 6.25 MV / 1.5 mm was obtained for which the percentage differences point to point between the simulated values and the experimental values were always below 2% for the case of energy and 1% for the FWHM. It was obtained that peripheral doses increase with increasing field size and decrease as we move away from the central axis of the beam. It was also observed that they suffer a little variation with the increase of the depth in the phantom. The contribution to the peripheral doses by the scattering in the phantom and in the collimator does not change as we move along the transversal axis of the beam. This contribution by scattering in the phantom in the points to 5cm, 10cm, 15cm and 20cm from the edge of the field was around 87%, in the same way for the case of the dispersions in the collimator these were around 0.5%.

Contribution ID: 835
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Dose calculation and verification of an intra-operative radiotherapy system IntraBeam

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The intra-operative radiotherapy system IntraBeam utilizes 50 kV low energy X-rays to provide high dose irradiation to the tumor bed in one single fraction, and has been applied for the treatment of superficial cancer, as breast/brain/skin/rectum cancer, etc. The accuracy of surface dose calculation is crucial to the prescription; well the three-dimensional dose distribution is necessary for evaluation. However, direct measurement of surface dose is technically not possible, and the system does not provide planning system. This abstract reports the dose curve fitting and Monte Carlo simulation method for the dose calculation, and phantom and film experiments for dose verification.
A series of depth-dose measurement was carried out based on a plate soft x-ray ion chamber PTW-23342 in water tank for the probe source and sphere/flat/surface applicators with different diameters. By analysis of physical processes and studies on fitting methods for the depth-dose-curve (DDC), different fitting methods are tested and compared with the measurement data. A combination of function of quadratic distance law and three functions of Lambert-Beer absorption law has good fitting accuracy for DDC of probe source, and composite functions with exponential and power function could be qualified for fitting the applicator’s transfer function.
In order to get the dose distribution, the probe source (x-ray tube) and typical applicators were modeled and simulated by Monte Carlo platform GATE, and film experiments with dedicated solid water phantoms were carried out. Simulation result has good agreement with the measured 1D depth-dose data and 2D film experiments, and the system modeling is validated.
We have studied and provided fitting method for DDC of IntraBeam system, which could give accurate surface dose for prescription. The MC simulation and dedicated phantom-film experiments we have implemented could provide dose distribution for evaluation.

Contribution ID: 962
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Design and expected performance of GPU-based full Monte Carlo dose calculation system for proton therapy

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The PTSim is Geant4-based full Monte Carlo simulation software package for particle therapy developed in Japan, has more than a decade of history and has been used in several particle therapy facilities including Nagoya Proton Therapy Center (NPTC). The NPTC which has both scanning and broad beam irradiation systems started the operation in 2013. Up to now, we have carried out MC dose calculation for approximately 300 patients treated in NPTC including for all cases in scanning irradiation and some cases in broad beam irradiation. MC has been used for independent dose calculation in patient-specific QA and has played a crucial role. It takes a half day to complete MC dose calculation for one patient by using PC Linux cluster.
Recently the MPEX which is an extremely fast GPU-based full Monte Carlo simulation system of electromagnetic processes in Geant4 using CUDA framework has been reported. In NPTC, we have a plan to speed-up MC dose calculation by introducing MPEXS-proton which is an upgraded version of the MPEXS system capable of full Monte Carlo simulation of the hadronic process of the proton in Geant4. We will substitute MPEXS-proton dose calculation engine for current CPU-based system to boost calculation speed in the patient CT geometry.
Current software framework including an interface between treatment planning system and PTSim will be utilized in the new system. The MPEXS-proton dose calculation engine will be invoked by PTSim system. It takes less than a few minutes until completing the dose calculation for one patient. The MPEXS-proton system will be promising device for dose calculation in proton therapy.

Contribution ID: 1097
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Design and dosimetry consideration for the fabrication of manual multileaf collimator for a cirus cobalt 60 teletherapy machine

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A manual eight multi-leaf collimator (MLC) has been designed and fabricated for the Cirus cobalt-60 machine at the Oncology Directorate of the Komfo Anokye Teaching Hospital. The fabricated MLC is made up of a high carbon steel leaves. The leaf in each bank has a standard width of 7.5 cm projected at the isocentre at a thickness of 4.6 cm. The leaf transmission factor was determined to be 4.8%, which is within the acceptable standard of ≤ 5%. The cobalt-60 beam characteristics such as beam profiles, output factors, MLC effect were determined. Inter-leaf leakage was determined with the 2D dose profile showing a linear increase between field size and leakage at the ends of the leaves. Output factors measurements were done for open and closed fields using ion chamber and a 30 x 30 cm2 water phantom. The MLC output factor was measured for square fields from 4 x 4 to 32 x 32 cm2 and varying the depths from 0.5 to 15 cm in steps of 0.5cm. Output factors for open MLC fields ranged from 0.952 to 1.250. The MLC effects were measured for square and rectangular fields and depth dependent within the phantom. MLC effect measurement for 7.5 and 15 cm square fields had output factor ranges of 0.979 to 1.218 and 1.143 to 1.218 respectively. The fabricated MLC needs further refinement in terms of the number of leaves, designed of the ends of the leaves and limiting the interleaf leakage radiation.
Keywords:Multileaf collimator, interleaf leakage, leaf transmission factor, dose profile

Contribution ID: 1260
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Evaluation of a systemic change of Superficial X-ray tube characteristics

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Very low, Low and Medium X-ray machines are used extensively for superficial Radiation Therapy concentrated on Basal Cell Carcinoma, Squamous cell Carcinoma, and Melanoma skin cancers. In most of cases, Superficial X-ray Therapy (SXRT) is preferred to Electron beams generated using a linear accelerator. SXRT tube characteristics may vary with the use of the machine for a long time. This study investigates the machine output used for treatment planning system and calculation of the radiation dose delivered to patients supposed to be treated.
At the first stage, beam quality index, half Value Layer (HVL), radiation beam profiles in different depths for a range of applicator for all available applicators were collected. At the end, machine output was also compared with baseline established during the machine commissioning.
Result shows that there is a systemic variation of the beam quality index up to 4.3%. Although results are within tolerance proposed, but a systemic change of the date shows that machine characteristics are modified. So, based on data achieved, re-commissioning of the machine for more accurate treatment is recommended.

Contribution ID: 1466
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Investigating the accuracy of Monte Carlo based treatment planning of head and neck patients

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The global electron cutoff energy (ECUT) equal to 700 keV is often used for the Monte Carlo (MC) treatment planning dose calculations. Previous studies [1], performed in heterogeneous phantoms, reported that DVHs for targets including large low-density regions may be significantly affected by the use of the high value of ECUT. In the present work, we investigate the effect of ECUT on the calculation accuracy of MC Treatment Planning for head and neck patients.
Clinical cases including large low-density cavities in the target were selected for this study. Dose calculations (6MV-IMRT-two beams) were performed on the CT based phantoms using MCSIM code, different number of histories and ECUT equal to 700 keV. MCSIM was modified to score independently the dose deposited on air voxels of the target. And consequently determine the contribution of the air dose uncertainty to the total uncertainty of the target dose.
Calculations with different number of histories (RUN1 and RUN2) generated average dose value on the target with uncertainty lower than 2%. The value of Dmax occurred in the air voxel, and the uncertainty on Dmax varies from 2% (RUN1) to 8% (RUN2). Comparing the target DVH-RUN1 and target DVH-RUN2 we observed maximum differences of about 10%. While the differences between DMH-RUN1 and DMH-RUN2 are less than 2%.
DVHs for targets including large (about 45 %) low-density regions may be significantly affected by the ECUT value used for the MC dose calculations. In contrast, DMH was not affected by high ECUT in the treatment plan evaluation, and thus we can use high ECUT and DMH to improve the efficiency and accuracy of MC based Treatment Planning for head and neck patients.
1- G Mora, A Eldib, J Li, C M Ma. AAPM 2017. Influence of Electron Transport Parameters on MC Treatment Planning.

Contribution ID: 1472
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

INVESTIGATION OF IN-VIVO DOSIMETRY FOR DEEP INSPIRATION BREATH-HOLD TECHNIQUE IN BREAST CANCER RADIOTHERAPY

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PURPOSE: In this study, the availability of in-vivo dosimetry was investigated for high accuracy applicability of the deep inspiration breathhold (DIBH) RT technique.
MATERIAL/METHODS: Early stage 10 left breast cancer patients underwent CT scans with breath control system and RT plans were created by using FinF technique.It was aimed to investigate the compliance of the doses received during the treatment with the intended doses of the patients by IVD. The skin depth was assumed to be 0.07 mm, the depth recommended in the ICRU 39 report. Doses calculated in TPS were compared by measured doses which were obtained by placing the TLDs and OSLs at 3,5.5,8 and 15 cm (contralateral breast) distances from the center of the beam on the patient's skin and around the thyroid organ in every single fraction.
RESULTS: In the study, the skin dose measurements were taken with TLD and OSL at all points. The average differences between the measured and calculated doses were found to be -15.88% and -15.65% for TLD and OSL, respectively. The average median dose differences were obtained for TLD and OSL, respectively; 2.99% (min:-83.59; max: 46.87) and -9.65% (min:-90.25; max:57.56) for contralateral breast, 16.75% (min:-26.12; max: 91.35); -17.63% (min:-43.73; max:84.79) for thyroid.
CONCLUSION: Measured and calculated contralateral breast dose differences change from patient to patient.Although the dose differences found for the thyroid are more or less different from each other, the values obtained by TLD were lower than the values calculated by TPS, whereas the values measured by OSL were found higher than the values calculated by TPS.Surface dose measurements by using OSL and TLD have been found to be approximately 15% greater than TPS and no superiority has been seen in the systems used in skin dosimetry. Besides, out of field doses found by OSL were higher than TPS.

Contribution ID: 1478
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

A comparison of different dosimetry systems for surface and buildup region dose measurements

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PURPOSE:In this study, the surface doses obtained by optically stimulated luminescence (OSL), thermoluminescence (TLD) and markus parallel plane ion chamber were compared with TPS results and the availability of the systems in surface dosimetry was investigated.
MATERIAL/METHODS:The percentage depth dose (PDD) measurements of buildup region were made by TLD, OSL and markus pp ion chamber, at the surface, 1, 2, 5, 10 and 15 mm water equivalent depth at 100 cm source-detector distance for 5x5, 10x10, and 20x20 cm2 field sizes.DD values were measured at the depth of 0.07 mm, which was suggested for surface dose measurements by ICRU Report 39.The effective measurement depth of each dosimeter was taken into account. The water equivalent thickness (WET) was considered to make an accurate comparison. Interpolations and extrapolations were performed for all systems to obtain the doses at the same depths.Under the same conditions, surface doses were calculated by TPS for different

field sizes and were recorded.The buildup region doses measured by different dosimetry systems and calculated by TPS were compared for different field sizes.
RESULT:The overdoses occured in the buildup region were corrected for Markus chamber according to Gerbi’s method. The surface doses using 6 MV photon beams for 5x5, 10x10, and 20x20 cm2 field sizes at 0.07 mm were found to be 14%, 24.75%, 13.17%, 7.74%; 19.69%, 31.78%, 21.63%, 11.04%; 30.87%, 43.80%, 28.71%, 13.61% for Markus chamber, TLD, OSL and TPS, respectively.
CONCLUSION:The lowest build-up region PDD values in all field sizes were obtained with the TPS. At 0.07 mm water equivalent depth, while the OSL and Markus pp. ion chamber results are close to each other, TLD results are higher in all field sizes. However, it is seen that the TLD gives closer results to Markus pp. ion chamber than OSL after 3 mm depth in all field sizes.

Contribution ID: 1611
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Absorbed dose calculation and risk estimation of radiation-induced thyroid cancer following whole brain radiotherapy

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Introduction: Radiation therapy is the main part of brain tumor treatment procedure. Effect of radiation on normal tissues which may result in radiation-induced malignancy is a major concern in radiation therapy. Thyroid cancer is the second most malignancy following radiation therapy of head and neck tumors. The aim of this study was to calculate the absorbed dose and estimate the risk of radiation-induced cancer of thyroid for whole-brain radiation therapy patients.
Methods: Our study included 50 patients undergoing radiation therapy to whole brain, with an average age under 30 years old using the ONCOR accelerator machine and 6MV photon. Thermo-luminescence dosimeter (TLD) was used to determine the dose received by the thyroid. To estimate the risk of radiation-induced thyroid cancer, we used BEIR VII report methods and Excessive relative risk (ERR) quantity suggested by ICRP.
Findings: The calculated average absorbed dose was 1.976 cGy±0.611 in women and 2.213 cGy±1.041 in men. The average risk of radiation-induced cancer of the thyroid in women for 3, 5, 10, 15 and 20 years after whole-brain radiation therapy was respectively 4.601±1.614، 1.559±0.595، 0.176±0.063، 0.050±0.018، 0.022±0.009. This risk was respectively 3.253±1.721، 1.150±0.516 ، 0.125±0.066، 0.035±0.019 ، 0.016±0.008 in men.
Conclusion: The absorbed dose of thyroid correlated nor with age neither with sex, although the risk of radiation-induced cancer of the thyroid has a significant relationship with sex and is 1.4 times higher in women compared to men. In addition, by increasing the age after radiation the average risk of induced cancer was decreased.
Keywords: Radiation- induced Cancer Risk, Brian Radiotherapy, Brain Tumors, Thyroid cancer

Contribution ID: 1669
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Quality assurance of intensity modulated radiotherapy treatment planning: A comparison study

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The Purpose of this study was to analysis the comparison of intensity-modulated radiation therapy quality assurance (IMRT QA) using GAFCHROMIC® EBT3 film, Electronic Portal Imaging Device (EPID) and MapCHECK®2. Pretreatment authentication is main apprehension in advanced radiation therapy treatment plans like IMRT. Twenty patients were planned on Eclipse treatment planning system (TPS) using 6 MV and 15 MV separately. Gamma index of EBT3 film results show the average passing rates was 97% for 6MV and 96.6% for 15 MV using criterion of ±5% of 3mm, ±3% of 3mm and ±3% of 2mm for brain. Whereas by using ±5% of 3mm and ±3% of 3mm criterions, the average passing rates were 95.4% on 6MV, and 95.2% on 15 MV for prostate. For EPID, the results show the average passing rates were 97.8% for 6 MV, and 97.2% for 15 MV in brain case. Where ±5% of 3mm and ±3% of 3mm were used, the analysis gives average passing rates as 96.6% for 6 MV, while 96.1% for 15 MV in prostate case. MapCHECK®2 results show average passing rates of 96.4% for 6MV and 96.2% for 15 MV respectively for brain using criterions of ±5% of 3mm, ±3% of 3mm and ±3% of 2mm. Whereas for ±5% of 3mm and ±3% of 3mm, the average rates are 95.2% for 6MV, and for 15 MV 94.7% in prostate. The EPID results are better than other and hence EPID can be used effectively for IMRT pre-treatment verifications.

Contribution ID: 1740
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

The Influence of Magnetic Fields on the Spatial Response of Ionization Chambers

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The introduction of MR-guided radiotherapy in clinical practice still poses several problems for dosimetry. Because the trajectories of secondary electrons are influenced by the strong magnetic field, the response of the ionization chambers changes. While it has been shown that the total influence of the magnetic field can be described by a correction factor kB, the field's influence on the spatial response function may be more complex.
Spatial response functions for an NE2571 ionization chamber in magnetic fields that had flux densities between 0T and 2.25T were calculated using the EGSnrc code. A thin slit beam that had dimensions of 10^{-3}mm x 10^{2}mm was used as a radiation source in the simulation. By passing the slit beam over the chamber in steps of 0.1mm, lateral response functions were obtained. For this, the energy deposition in the sensitive volume of the chamber was evaluated in dependence on the slit beam position. The beam direction, the chamber axis and the magnetic field direction were each perpendicular to the other components. After normalization to the highest dose value at 0T, the response functions were transformed into Fourier space. Previous publications have shown that, in Fourier space, only low frequencies are relevant for spatial response functions; therefore, the frequencies were cut off at 0.1mm^{-1}.
A Fourier-transformed gaussian was fitted to the results for each magnetic field strength (R^2>0.99). While the amplitude varied between 6.05 and 8.90, σ was influenced less and had values that ranged from 2.45mm to 2.87mm. The most noticeable change in the amplitude was found between 0 T and 1.5T, where it changed by 2.85.
The spatial response of ionization chambers that are influenced by a magnetic field can be described by a scaled Gaussian function. An experimental validation of the Monte Carlo simulated response functions is currently under preparation.

Contribution ID: 1756
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Evaluation of RBE-weighted dose calculation for the open source treatment planning toolkit matRad

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Introduction
Carbon ion therapy planning requires the computation of physically absorbed dose weighted by its relative biological effectiveness (RBE). Among others, RBE calculation depends on radiation type, linear energy transfer, dose and tissue radio-sensitivity. The aim of this study is to benchmark the RBE-weighted dose calculation for carbon ions as implemented in the Matlab-based open source treatment planning system (TPS) matRad against the clinical TPS Syngo used at the Heidelberg Ion-Beam Therapy Center (HIT).
Methods
RBE-weighted dose was calculated based on the local effect model (LEM) I. We consider the following planning scenarios for comparison between matRad and Syngo: i) mono-energetic pencil beams with initial carbon ion energy 155, 283 and 382 MeV/u, ii) modulated spread-out Bragg peaks at depths of 5, 12,5 cm and 20 cm in water , iii) optimized fields in heterogeneous medium, iv) glioma plans with doses of 2 to 20 Gy(RBE), v) prostate plans with assigned alpha beta ratios (α/β) of 2 and 4Gy. Dose profiles and gamma analysis (2mm/2%) were used to evaluate the agreement between dose calculations.
Results
Gamma analysis pass rates greater than 98% were observed in all cases. Local dose differences in the entrance and plateau region increased with case complexity but remained lower than 1.8% in all cases. In the fragmentation tail region, local dose differences also increased with case complexity staying under 3.8% for the most complex cases considered. The distance-to-agreement in the distal falloff systematically increased with the complexity of cases, ranging from 0.1 mm for a pencil beam in water to 0.6 mm for biologically optimized multi-field plans.
Conclusion
For the investigated cases, matRad RBE-weighted dose calculation results are in excellent agreement with a clinical TPS for varying doses, beam energies and α/β-values. matRad's carbon ion module may be used for research and educational purposes.

Contribution ID: 1805
19. Radiation Oncology Physics and Systems
19.10. Dose calculations

Deformable dose accumulation under conditions of tumor volume regression

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Deformable image registration (DIR) using intensity-based (e.g. B-spline) algorithms under conditions where the tumor undergoes volume regression during the course of fractionated radiotherapy (RT) is a challenging problem. Intensity-based algorithms tend to align anatomical structures, geometrically, such that source and target images can be accurately registered, in situations where the tumor undergoes regression. However, these same deformation maps cannot be used for accurate deformable dose accumulation (DDA), under circumstances where mass changes are significant, because the conservation of energy would be violated. To mitigate this concern, we propose a method to better approximate DDA, by applying a volume-conserving constraint (Jacobian=1) to the tumor during DDA between source and target image datasets. We have applied this method by performing DDA between CBCT and planning CT datasets for patients undergoing fractionated RT for lung and head/neck cancers, using an optimized B-spline-based algorithm (Elastix, ITK/VTK). Volume reduction for the head/neck and lung cancer cases was 15% and 60%, respectively. Dose volume histogram (DVH) differences between the b-spline-based DDA with the volume-preserving constraint relative to that without volume-preserving were as follows: lung (percentage dose difference): PTV (min. dose=21.1%; mean dose=8.8%); GTV (min. dose=11.9%; mean dose=2.2%); and head/neck: PTV (min. dose=11.5%; mean dose=1.2%); GTV (min. dose=1.5%; mean dose=0.2%). In all cases, doses for DDA without volume conservation were lower, implying underestimation of the actual dose delivered to the regressed tumor volume. Results suggest that significant differences can occur in dose accumulation when B-spline algorithms are applied for DDA without consideration of volume or mass conservation, in cases where tumor regression is significant. The application of a volume-preserving constraint will ensure that energy is approximately conserved in the dose mapping process between regressed and initial tumor volumes, and will consequently provide a better estimate of dose during deformable dose accumulation.

Contribution ID: 45
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Radiotherapy quality assurance using statistical process control

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Radiotherapy quality assurance using statistical process control
Statistical process control (SPC) is an analytical decision making tool that employs statistics to measure and monitor a system process. The fundamental concept of SPC is to compare current statistics in a process with its previous corresponding statistic for a given period. Using SPC,a control chart is obtained to identify random and systematic variations based on the mean of the process and trends are observed to see how data can vary in each evaluated period. An upper and lower control limit in an SPC derived control chart indicate the range of the process calculated based on the standard deviations from the mean, thereby points that are outside these limits indicate the process to be out of control. Metrics such as: process capability and acceptability ratios were employed to assess whether an applied tolerance is applicable to the existing process. SPC has been applied in this study to assess and recommend quality assurance tolerances in the radiotherapy practice for helical tomotherapy. Various machine parameters such as beam output, energy, couch travel as well as treatment planning parameters such as minimum percentage of open multileaf collimators (MLC)during treatment, planned pitch (couch travel per gantry rotation) and modulation factor (beam intensity) were verified against their delivery quality assurance tolerances to produce SPC based tolerances. Results obtained were an indication of the current processes and mechanical capabilities in the department rather than a vendor recommended or a

prescriptive approach based on machine technicalities. In this study, we have provided a simple yet effective method and analysis results to recommend tolerances for a radiotherapy practice. This can help improve treatment efficiency and reduce inaccuracies in dose delivery using an assessment tool that can identify systematic and random variations in a process and hence avoid potential hazardous outcomes.

Contribution ID: 106
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

3D volumetric scintillation dosimetry for proton scanning beam therapy applications.

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We have been developing novel 3D detector systems using organic plastic and liquid scintillators to measure or image the dose distribution from proton therapy beams in near real-time. Proof of concept and initial feasibility studies using only one charge-coupled device (CCD) were investigated by Beddar et al in 2009 (1). The recent studies focused on the characterization of scanning proton beams used for patient treatments using a 3D system with 3 scientific-complementary metal-oxide semiconductors (sCMOS).
The basic concept consists of using a 3D volume of a solid or a liquid scintillator material to measure or image the dose distributions from proton beams in three dimensions (2). A larger liquid scintillator (LS) detector system was recently developed and consists of a transparent acrylic tank (20x20x20cm3) filled with a water equivalent, commercially available liquid scintillator that when irradiated with protons generates scintillation light. To track rapid spatial and dose variations in spot scanning proton beams we selected to use 3 high-speed sCMOS imagers (2560x2160pixels) to image the scintillation light signals from three orthogonal projections in cine mode. The system has been fully developed and characterized at the Proton Therapy Center at MD Anderson Cancer Center.
We will show that such systems can provide fast and accurate measurements of the range, lateral profile, and lateral position for scanning proton beams with higher spatial resolution (~ 2.5 mm). We will also show the ability of such detectors to rapidly measure or image proton beam characteristics and intensities at multiple energies, which make them an ideal tool for scanned proton, beam quality assurance as well as the verification of patient treatment delivery.
(1) Beddar S, et al, Med Phys 36(5):1736-1743, 5/2009.
(2) Hui C, Robertson D and Beddar S, Phys Med Biol 59(16):4477-4492, 8/2014.

Contribution ID: 113
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Delivered dose verification for lung cancer stereotactic body radiotherapy using cone-beam CT

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Purpose: To verify the delivered fractional dose distribution of lung cancer stereotactic body radiotherapy (SBRT) using the cone-beam CT imaging.

Methods: Five lung cancer patients underwent SBRT with 25 CBCT images were enrolled in this study. Targets and organ at risks (OARs) were mapped to CBCT in two different methods: deformed or without deformed, with Pinnacle dynamic planning module. Delivered fractional dose distributions were reconstructed on CBCT images with deformed and undeformed contours, respectively. Dose differences between original plans and reconstructed plans were compared. Results: There were total of 5 original plans on CT (Pct) , 25 reconstructed plans with deformed contours (Pdcbct) and 25 plans without deformed on CBCT (Pcbct), respectively. The average planning target volume changes for Pdcbct vs. Pct and Pcbct vs. Pct were 0.11%±0.01% and 0.37%±0.11%, respectively. The target coverage (V100%) (p<0.01) and homogeneity index (HI) (p=0.01) were found have a significance difference in the patient 1 with a V100% of 95.46 vs. 93.52 for Pcbct vs. Pct and 95.46 vs. 92.53 for Pdcbct vs. Pct, respectively. The conformity index (CI) and gradient index (GI) showed a good agreement between the planned and delivered dose distribution for patients without changes in anatomy. There were no other significant difference observed on target coverage and OAR sparing for other patients.
Conclusions: CBCT images were usefully tool for setup and dose deliver verification for lung cancer patients underwent SBRT.

Contribution ID: 135
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

2D electron beam control of linear accelerator using electromagnet

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Introduction
Dose reduction is important for acquiring images during radiation therapy. When considering controlling the electron beam output from the linear accelerator accurately, it is necessary to analyze the distribution of x-rays that is generated from the accelerated electrons. In this research, a magnetic field was generated by electromagnet, and the deflected directions of the electron beams generated by the linear accelerator were observed. By deflecting the electron beam irradiated from the linear accelerator using an electromagnet, the electron beam can be locally irradiated.
Materials and Methods
The two 90 V electromagnets were placed opposite to each other to generate a perpendicular magnetic field, which were attached on the shadow tray of the linear accelerator. The off-axis dose distribution of the electron beam output from the linear accelerator was measured with and without a magnetic field using a micro chamber.
The four 90 V electromagnets were placed X and Y opposite to each other to generate a perpendicular magnetic field. The 2D dose distribution of the electron beam output from the linear accelerator was measured with magnetic field using EPID.
Results and Discussion
In experiments using two electromagnets, it was confirmed that the electron beam was deflected. In the beam's eye view, when the magnetic field was generated in the rightward direction, the electron beam in the central part of the irradiation field was deflected to the couch side when the magnetic field was generated to the left, and to the linear accelerator’s head side when it was generated to the left. In experiments using four electromagnets, arbitrary high dose area could be generated in the irradiation field by controlling the electron beam by using electromagnet.

Contribution ID: 154
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

The Influence of gimbal motion on the dosimetric parameters in VERO tracking system

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The aim of this study was to assess the changes of dosimetric parameters of the system when a gimbaled linac of VERO was rotating away from the central axis. Beam profiles and percent depth doses (PDD) were measured when a gimbal was tilted from 0.6 to 2.4 degrees (from 10 to 40 mm at isocenter). These data sets were acquired with varying square field sizes (SFS) of 50 to 150 mm and varying depths of 15 to 300 mm on the surface of the water. All measurements were carried out using BLUE PHANTOM2 (IBA, Germany) and cc13 ionization chamber (IBA, Germany). The dosimetric parameters such as symmetry, flatness, penumbra, and beam quality (TPR20,10) were compared with those in the reference condition. The reference condition was defined at tilted angle 0º. The symmetry deviations increased with tilted angle for all SFSs and depths. For tilted angle 2.4º, the maximal average deviation was 0.30 ± 0.06%, 0.83 ± 0.11%, and 1.33 ± 0.06% with SFS 50 mm, 100 mm, and 150 mm, respectively. Below SFS 100 mm and tilted angle 1.2º, the average deviations were <1% for all measurement conditions. The parameters such as flatness and penumbra exhibited deviations of <0.5% for all tilted angles, depths, and SFSs. The differences of beam quality were not observed with increasing tilted angle for each SFS. The results of this study suggests that dose corrections may not be needed for tracking a moving target on the order of 0 to ±20 mm or with square field sizes below 100 mm when using a gimbaled linac of VERO SBRT system. For gimbal rotations beyond ±20 mm with square field sizes above 100 mm, corrections of dose symmetry would be advantageous to improve the accuracy of dose delivery.
Key words: VERO, tumor tracking, gimbal motion, dosimetric parameters

Contribution ID: 276
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Sensitivity of electronic portal imaging device (EPID) based transit dosimetry to detect inter-fraction patient variations

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Introduction
Sensitivity of EPID based transit dosimetry to detect variations between treatment fractions are examined using a gamma analysis and a structural similarity index (SSIM).
Method
An a-Si-500 EPID with a Varian linear accelerator was used. EPID images were acquired for 3-dimensional conformal (3DCRT) and dynamic intensity modulated (dIMRT) radiation therapy fields in multiple fractions. Transit images were converted to dose based on a modification the method by Sabet, 2014. The dose in the first fraction was considered as the reference dose. Variations in

position or weight of the patient were introduced in the subsequent fractions. For positional variations, lung (CIRS) and head and neck (Alderson RANDO) phantoms were examined. Variations were introduced by moving the phantom of 2, 3, 4 or 5 mm on the right side. For anatomical variations, slab phantom was examined on three scenarios using solid water simulating tissue, medium-density fibreboard simulating fat and styrofoam simulating lung. Variations were introduced by removing slabs of 1,2,3 or 4 cm in each scenario. The dose difference between first and subsequent fractions computed using various gamma criteria and SSIM index.

Result

With a criterion of 3%/3mm, the sensitivity of EPID was slightly higher for lung compared to H&N treatment site. The EPID can detect tissue and fat variations≥ 1 cm whereas it cannot detect lung variations up to 5 cm. EPID shows higher sensitivity for 3DCRT compared to dIMRT. With using criterion of 3%/1mm, EPID can detect most variations. With SSIM index EPID can detect a 2 mm positional variation and 1 cm of lung variation.

Conclusion

Sensitivity of EPID depends on treatment site, delivered technique, and tissue heterogeneities. The factor optimized the sensitivity is reducing a distance to agreement criteria. Our study introduces the SSIM which is an alternative analysis that has higher sensitivity for a minimal variation.

Contribution ID: 296

19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Monte Carlo simulation on water based microfluidic calorimeter

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A microfluidic calorimeter to measure the absolute value of the absorbed dose in a small photon field is under development. In this study, water equivalence and direction dependence of the microfluidic calorimeter were investigated using Geant4 10.01 based Monte Carlo simulations. The sensitive volume was a 0.5×0.5×0.1 mm3 water block and attached on a thin thermistor board. The detecting parts were located in an evacuated PMMA tube of diameter 1.2 cm. The structure of the detector was imported to the Geant4 code using an open source code, CADMesh. The water equivalence of the detector was assessed by comparing the absorbed dose in the detector and that of the same water block surrounded by water instead of the detector. Two types of beams, a 10 x 10 cm2 single directional 60Co beam and a multi-directional 60Co beam from the 16 mm collimator of a Gamma Knife® Perfexion (GKP) were used. Variations of the absorbed doses were assessed by rotating the detector around the beam axis and the z-axis of GKP, respectively. The range cut value was 0.1 mm for photons and electrons. In GKP simulations, photons were generated within 0.35 radians around the collimator axis. The detector size was also varied to get the best results. Simulation results of five runs of two billion events were averaged at each configuration. As the best result, the detector showed 1.5% and 0.6% smaller absorbed doses than the water-only cases for the single directional and GKP beams, respectively. When the detector was rotated from 0 to 180 degrees with 30 degree step, the variations in the absorbed dose was less than 1.0% for both types of beams. A microfluidic calorimeter could be designed to show water equivalence of 1% range but the design should be carefully contrived.

Contribution ID: 350
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Characterization and calibration of Gafchromic EBT-XD film, with comparison to EBT3 film for 6MV photon beams

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Film dosimetry is an effective dosimetry tool for the quality assurance of complex dose delivery treatments, such as Stereotactic Radiosurgery (SRS) and Stereotactic Body Radiation Therapy (SBRT). Gafchromic EBT-XD, was recently made available for high-dose treatment verification. The calibration curves and the dosimetric performance for EBT-XD films were evaluated using single red channel dosimetry, against the existing EBT3 model of films. The optical density of EBT-XD was found to be lower than that of EBT3 for the same dose value. Doses from 0 – 40 Gy were delivered to EBT-XD and EBT3 films for calibration. Two calibration curves were obtained from 15 mins and 15 hours after exposure for both sets of films. In the verification of a 28 Gy SRS treatment, less than 1% absolute dose agreement was seen with EBT-XD using red-channel dosimetry, with 99.84% gamma pass rate using 2%, 2mm gamma. Generally, EBT-XD gave higher gamma pass rates for the SRS-plan and had greater sensitivity in calibration for high doses as compared to EBT3. However, the improvement in gamma pass rates was found to be small and was only significant in high dose SRS treatments. In conclusion, the use of EBT-XD was validated for routine quality assurance for SRS and SBRT dosimetry, and only a slight superiority was found against EBT3 films. EBT-XD will be particularly suitable for high-dose, small-field radiotherapy such as high dose SRS treatments.

Contribution ID: 491
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Monte Carlo dosimetry of organ doses from a cobalt-60 sweeping-beam total body irradiation technique: a retrospective study

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Introduction: Total body irradiation (TBI) is a radiation treatment often purposed to suppress the immune system prior to a bone marrow transplant. Several toxicities can arise in TBI, and high-quality dose volume data for organs at risk are required if one is considering any change from a well-established technique. We present preliminary results from a retrospective study using a new Monte Carlo dosimetry technique to produce accurate organ-specific dose data for sweeping beam delivery incorporating a plastic flattening filter and patient-specific lung compensators. This technique has been successfully used for >22 years at our institution but a change in technique to improve patient experience is being considered.
Methods: For each of 11 previously treated patients, we produced two composite virtual phantoms using in-house Python, Matlab, and C++ scripts. Supine and prone phantoms including the planning CT, lung compensators, and a polystyrene flattening filter were produced. Dose simulations were performed using source 21 of DOSXYZnrc with three billion particle histories per phantom. Finally, a deformable registration with MIM Maestro was used to sum the dose from the

two treatment positions. Dose volume statistics for lungs, liver, thyroid, kidneys, and body were obtained.
Results: For a total body prescription dose of 12 Gy ± 10%, the mean body dose ranged from 11.19 to 12.15 Gy with smaller patients receiving lower mean body doses than larger patients. The mean dose delivered to the thyroid was the highest of the contoured organs receiving up to 12.84 Gy, and the lung doses were the most heterogeneous, with standard deviations up to 0.73 Gy in individual patients.
Conclusion: Monte Carlo dosimetry of a clinical sweeping beam TBI technique has been achieved. The resulting high-quality dose data shows promise for use in both routine quality assurance, and to provide baseline data for development of a new technique.

Contribution ID: 503
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Ten year's results of the postal dose audit for external radiation therapy in Japan

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In 2007, a postal dose audit of an external radiation therapy unit was initiated in Japan using radiophotoluminescent glass dosimeter (RGD). Audit began with a reference condition and expanded its application to beams of different field size and wedged beams in 2010. In addition, in 2016, the modern type treatment units such as a flattening filter free linear accelerator, Tomotherapy unit, and Cyberknife unit could also be applied to audit. By the end of the Oct. 2017, 2326 beams were checked as a reference condition. Mean and standard deviation of the ratio of the measured dose to the intended dose (deviation) were +0.3% and +1.1%, respectively. This result indicates that the audit system was maintained well, and the dose was successfully evaluated. Regarding the variation in audit results, 99.9% of the beams was within tolerance level (Deviation should be within the ±5%). However, 5 beams exceeded the tolerance level of ±5%. In most cases, there was a clear mistake in the contents of the entry sheet of the audit. Hearing was done to the hospitals to clarify the cause, and in almost every case the cause was identified. This activity has certainly improved the quality of the radiation therapy in Japan. More efforts are underway, such as application to electron beams or intensity modulated radiation therapy.

Contribution ID: 559
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

A Risk Based Review of Medical Physics Quality Assurance Activities in a Large Radiotherapy Department

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Background: Peter MacCallum Cancer Centre is a large radiotherapy provider operating 16 linear accelerators over five campuses offering a wide range of specialized services such as TBI, stereotactic treatments and pediatric oncology. In 2017 we conducted a ten month review of all

medical physics quality assurance activities in radiation oncology with the objective to streamline procedures and prioritize activities using a risk management based approach.
Methods: Machine based ("technologies") and patient specific ("techniques") activities were considered in a 'patient centered' approach. A Failure Mode and Effects Analysis (FMEA) was performed for three demonstration cases: Computed Tomography (CT) for planning, kV therapy machine QA and in vivo dosimetry. The topics were selected to highlight complementary activities performed by physicists. Risks were identified through an incident reporting system, QA and engineering records as well as opinion of physicists in the department. These also ranked the risks in terms of likelihood and severity.
Results: Features of the planning CT scanner that were not part of diagnostic systems (lasers, flat couch top) were most likely to fail and warrant specific attention. The lack of reported incidents pertaining to kV treatments (3 physics related reports over 6 years) highlights the need for FMEA as a prospective risk analysis tool. Patient geometry and lack of a fully independent monitor unit calculation system were identified as highest risks and helped to develop a business case for a commercial MU check tool. We also identified a large variation of in vivo dosimetry utilization in the different campuses which did not reflect complexity as much as culture.
Conclusion: The review of our QA program has raised awareness of staff about the need to critically appraise quality activities. The use of demonstration projects made the review manageable and yielded outcomes that can be translated into clinical practice.

Contribution ID: 598
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Comparison of 2D array detectors for carbon ion therapy quality assurance

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Purpose
To investigate dosimetric characteristics and performance of four commercial ion chamber array detectors for carbon ion therapy QA.
Materials and Method
The four 2D ion chamber array detectors used in this comparison were as follows: IMRT MatriXX Evolution (IBA Dosimetry) with 1020 of ion chambers (4.5mmφ x 5mm) and 7.62 mm chamber distance. MatriXX PT (IBA Dosimetry) with 1020 of ion chambers (4.2mmφx 2mm) and 7.619 mm chamber distance. Octavius 729XDR (PTW-Freiburg) with 729 of 5x5x5mm3 ion chambers and 10 mm detector spacing. Octavius 1500 (PTW-Freiburg) with 1405 of 4.4 x 4.4 x 3 mm3 ion chambers and 7.1 mm detector spacing. Octavius 1500 has a unique detector layout where the ion chambers are arranged in a checkerboard pattern. 400MeV/u and 290MeV/u carbon-ion beam with 10x10 cm2 field are irradiate to those detectors. First, we observed dose linearity. Secondly the dose distributions in lateral and beam depth direction represented by each 2D array detector were evaluated.
Result
The dose linearity with prescribed the dose monitor count was observed for all detectors. There was no significant difference in 2D dose distribution caused by each ion-chamber size among all 2D ion chamber array detectors. On the other hand, in the beam depth direction, there was difference in measured dose around Bragg peak area. The distal fall-off was observed in 1 mm shallower than other three detectors. This difference was observed especially in very sharp dose distribution area e.g. mono energy carbon beam. However it was hardly seen a wide spread-out Bragg peak area.
Conclusion

The result expressed that the 2D ion chamber array detectors affect the dose distribution especially in beam direction depending on each ion chamber size. However these detector specific difference are acceptable for patient-specific QA in carbon ion beam therapy.

Contribution ID: 660
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Combining EPID-based transit in-vivo dosimetry and kV-CBCT information for a posteriori 3D dose calculation and delivered dose reporting

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Purpose: The aim of this study is to assess a robust dose reporting by sharing information using 2 major footprints of each fraction of the treatment: simultaneous 2D EPID-based transit dosimetry and a posteriori 3D dose calculation with anatomical information provided by the kV-CBCT to trigger relevant differences between planned and delivered dose.
Material and methods: kV-CBCT were acquired before each fraction and EPID images during dose delivery in transit condition for five prostate plans and 2 breast plans (Varian Eclipse TPS, 6MV, VMAT, TruebeamTM). Dose from the 2D-EPID images were back projected in the planning CT (pCT) and a posteriori 3D dose calculation was computed using Eclipse on the pCT corrected with kV-CBCT body information. DVH and gamma index evaluation were compared with the planned dose to conduct the report of the delivered dose.
Results: On patient study errors such as wrong positioning or anatomical and morphological modifications were well detected by transit dosimetry and a posteriori DVH calculation identified dose discrepancies. Transit dosimetry alerts on dose or volume deviation with a threshold of 5% tolerance criterion. The a posteriori 3D dose calculation using the “patient of the day” allows re-computing dose in the actual condition given by the kV-CBCT and EPID images.
Conclusion: This approach of fraction dose reconstruction demonstrates that using 2D dose EPID image and a back-projection algorithm in the pCT can be used to flag unexpected discrepancies about dose and volume prescription. The a posteriori 3D dose calculation refines dose evaluation according to the TPS accuracy. Combining 2D and 3D information as major treatment footprints reduces uncertainties on reconstructed delivered dose values and may contribute to robust actual dose reporting needed for patient specific quality assurance and allows adaptive radiotherapy.

Contribution ID: 864
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Comparison of setup error and exposure in 3D couch with obi and 6D couch with exactrac for radiation therapy

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In image guided radiation therapy (IGRT), a patient is positioned primarily using his/her skin marker and the set-up of position is revised secondarily by moving the couch after identifying his/her anatomical locations by comparing images obtained from OBI (On Board Imager) and Exactrac imaging with images obtained through treatment planning after computed tomography for simulation. This study was intended to measure additional dose which the patient may be exposed in OBI, Exactrac, CBCT imaging other than treatment, as well as analyzing possible error between the set-up and the revision.
In planning a radiation therapy, DRR (digital reconstructed radiography) images, digital reconstructed images at the front side (0°) and the lateral side (270°), and images from OBI and Exactrac were compared with 2D-2D matching. Then, for treatment of main organs, the patient was investigated with OBI imaging in every treatment. In 3 dimensional conformal radiotherapy (3DCRT), the treatment regions such as head and neck, thoracic, chest, abdomen, and pelvic region, bones and vertebrae were investigated 2~3 times a week and in intensity modulated radiation therapy (IMRT), all the treatment regions were investigated in every treatment.
It was identified that in the set up of patient using OBI, the errors were within treatment permissible error range as less than 3 mm of mean error in both 3DCRT and IMRT therapy. It was considered that although the error in set up of patient with Exactrac was over 2mm at maximum

Contribution ID: 1061
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Cherenkov imaging for real-time verification and monitoring of external beam radiotherapy

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Cherenkov radiation, resulting from megavoltage radiation beam delivery during external beam radiotherapy, has been shown to be detectable from patient’s skin and from water phantoms. 1) Real-time videos of visible Cherenkov light emission from patient’s skin can provide information of the beam shape and local 2D surface dose. An overlay of detected Cherenkov emission on patient’s 3D surface mesh can be used to monitor intra- and interfraction stability and conformity of radiation beams. 2) Cherenkov emission from water phantoms may be used as a surrogate to the deposited dose. By imaging a side of a water phantom, a projected 2D view of the beam can be captured at video frame rates, providing information of projected depth-dose distribution and cross-beam profiles. By combining projected Cherenkov imaging with cine portal dosimetry, 3D dose distribution volumes can be calculated in real time and used for routine patient-specific quality assurance of highly conformal treatment plans in VMAT or SRS/SBRT modalities.

Contribution ID: 1074
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

3D absorbed dose reconstructed in the patient from EPID images for IMRT and VMAT treatments

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Purpose
The EPID panel (electronic portal imaging device) is increasingly used for dosimetric purposes in external radiotherapy. Two methods are currently available to verify the absorbed dose in the patient and the indirect one which redistribute the absorbed dose into the patient. This latter, also referred as a back-projection method, is used in our study to reconstruct the 3D absorbed dose matrix in the patient from EPID images for IMRT and VMAT fields.
Materials and Methods
Images are acquired with the clinac 23iX aS-1000 imager (Varian) and a 6MV beam.
After pre-treating the portal images, a calibration step is performed to transform the gray levels of the pixels into absorbed dose in water via a response function. Correction kernels are also used in this step to redistribute the absorbed dose according to the field size and to take into account the penumbra.
Then the dose is back_projected into the patient for all EPID parallel plans with a 1 mm resolution, for each gantry angle.
The total dose is obtained by summing the 3D dose associated for each gantry angulation.
The estimated dose from the EPID was compared to the one calculated by the TPS (Treatment Planning System) with a local and global gamma index of 3% and 3mm. Our algorithm has been tested for 20 IMRT and VMAT prostate and head and neck treatments in a homogeneous cylindrical phantom.
Results
The global gamma index obtained is greater than 99% for all IMRT treatments and over 97% for VMAT treatments.
The local gamma index is greater than 95% both for IMRT and VMAT treatments.
Conclusion
We have developed and validated a reconstruction algorithm that can be used to verify the 3D dose distribution in a homogeneous phantom for the IMRT and VMAT fields from in vivo EPID images.

Contribution ID: 1115
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Quantifying the performance of two different types of 3D patient dose reconstruction: machine log-file vs. machine log-file with EPID image

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Purpose: The aim of this study was to clarify the reconstructed 3D dose difference between two reconstructed algorithms for prostate cancer patients.
Methods and Materials: Fiifteen prostate cancer patients treated with IMRT (74Gy/37fr) were studied. Log-file and cine EPID images were acquired for each fraction. Two commercial software programs were used: Mobius3D version.2.1.1 (Mobius Medical Systems) and PerFRACTION version.1.7.1.1 (Sun Nuclear Corp.). Mobius3D can reconstruct 3D patient dose using log-file, whereas PerFRACTION can reconstruct patient dose using log-file with EPID image. First, we re-calculated the treatment planning dose on cylindrical phantom and then we acquired log-file and

cine EPID images with various acquisition rates (3, 4, 8 and 10 frames/image). We measured the dose at three points using ion chamber and compared the measured point dose with reconstructed point dose in the phantom.
Next, we compared dosimetric metrics (mean dose for PTV, rectum and bladder) calculated by Mobius3D and PerFRACTION for all fractions from fifteen patients.
Results: For phantom, there was no significant difference in point dose between measurement and reconstructed dose for both software (<2%). For PerFRACTION, reconstructed dose was not changed by frame acquisition rate of EPID (<1%).
For patients, differences in dosimetric metrics were within 1% for almost all fractions. PerFRACTION had wider range of dose difference between first fraction and the other fractions than Mobius3D (e.g., maximum difference: -0.70% for Mobius3D vs. -2.44% for PerFRACTION), possibly because EPID can detect subtle a structural failure leading to MLC positioning errors, or that EPID data might include image acquisition failure.
Conclusions: There were small differences in dosimetric metrics between two software, although there were no significant differences between measurement and reconstructed dose for both software in phantom. Although EPID can detect subtle a structural failure leading to MLC positioning errors, EPID data might include image acquisition failure.

Contribution ID: 1122
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Absolute dosimetry with EBT3 films

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Introduction
In treatments with small or modulated fields such as intensity modulated radiotherapy (IMRT), stereotactic body radiation therapy (SBRT) and stereotactic radiosurgery (SRS), a high resolution dose measurement technique would be advantageous, and radiochromic film dosimetry is suitable for this purpose. In this work, two different multichannel film dosimetry algorithms using the triple channel approximation and a hybrid version have been compared.
Materials and Methods
EBT3 film was used for QA of IMRT and SBRT cases for a range of anatomical sites. Dose distributions were generated from the film using:
1. Red channel only
2. Méndez multichannel algorithm using the truncated normal distribution (TN) [1]
3. Pérez-Azorín multichannel algorithm [2]
4. A hybrid of the Méndez and Pérez-Azorín algorithms developed in his study.
All images were analysed at the same resolution. An adaptive median filter was used to minimise noise dependencies and the calibration curve was fitted to a rational parametric form. To perform absolute dosimetry, net optical density was used rather than pixel value.
OmniPro I'mRT software was used to perform absolute gamma analysis using 3%/3mm and 2%2mm criteria on a 20% threshold comparing the various generated distributions from film to the calculated distribution from the treatment planning system (TPS) (Monaco v5, Elekta).
Results
The mean gamma value for the red channel, 56.2±35.0 (3%, 3 mm) and 40.8±31.3 (2%, 2 mm) was the lowest of all procedures analyzed ($p<0.05$). The highest value for 3%, 3 mm criteria was found in the hybrid model (98.8±0.9) and was very close to the result given by Pérez Azorín model (98.7±1.1).
Conclusions

The red channel based dosimetry is inadequate. The three-channel algorithms give good results, however the Pérez-Azorín's algorithm seems to be more robust, and is capable of obtaining a very close dose map when compared to the TPS.

Contribution ID: 1257
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Short and Automated Linear accelerator Quality Assurance tests using Electronic Portal Imaging Device

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Short and automated Quality Assurance is becoming one of the challenging tasks in Radiotherapy. This research, investigates the accuracy of treatment couch motion with four degrees of freedom (4DoF) with by fast and accurate method based on an image acquired using an electronic portal imaging device (EPID).
An accurate PTW phantom and a proper algorithm were used. A Siemens machine equipped with OPTVUE 1000 EPID was used to capture portal images for the exposures. A rectangular field (26 cm ×26 cm) was irradiated for the tests. At first, mechanical performance of the EPID positioning, including its movement, levelling, off-axis positioning was investigated. At second section, EPID sensitivity and accuracy of the code recognition for image processing were investigated. For this purpose, three deliberately deviations in the phantom were created. The translational and rotational motions of the treatment couch were then evaluated along the X, Y and Z axis and rotation around the Z axis. Finally, loading effect on treatment couch was also investigated.
The results of the prerequisite tests on mechanical performance of the EPID, EPID sensitivity and the accuracy of the code recognition for image processing were found to be within tolerance expected. The mean errors of the tests between requested and performed shifts by (4DoF) treatment couch were found to be 0.27°, 0.15 mm, 0.11 mm and 1.04 mm for the rotational, longitudinal, lateral and vertical shifts, respectively.
The results showed that the proposed method to acquire the aSi-EPID images and application of an in-house algorithm is very reliable and fast to find the errors occurs for treatment couch position verification.

Contribution ID: 1261
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

HDR Brachytherapy dosimetry: clinical use of micro-silica bead TLD & Gafchromic EBT3 film

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Conclusion: A novel, high spatial resolution experimental method was developed for validating brachytherapy dosimetry using micro silica bead TLDs on high precision templates. The measured radial dose distributions around both of the 60Co and 192Ir sources were comparable within the experimental uncertainty to the relevant TG-43 data and superior to that of EBT3 Gafchromic film

measurement in terms of the dynamic dose range evaluated. The experimental method presented is suitable to address the challenge of HDR brachytherapy dosimetry.
The novel experimental method suitably addressed the dosimetry challenges. Dose response was linear in the investigated range, 0.5–40Gy, (correlation coefficient of R2 > 0.999). The ability of detector to assess the high gradient dose distribution with variable dose rate within the range of 10–4000cGy/min around the sources was compared to the TG-43 data to that of EBT3 film within experimental uncertainty.
A novel high resolution experimental method is developed for validating Monte Carlo-derived TG-43 brachytherapy source data of 60Co and 192Ir using micro silica bead TLDs recently developed at University of Surrey. Its dosimetric characteristics (independency from dose rate and angle of radiation incidence) accompanied by small size (1.2 mm diameter and 0.9 mm thickness), chemically inert nature, ease of use and reusability were considered as a very promising for this application.
Dosimeter positioning templates were produced using AutoCAD software. TLDs were threaded using cotton yarns and stitched onto the template to accurately position the dosimeters within ±0.1mm, in a full-scatter water tank.
The dose rates were from 10-4000cGy/min and dose ranged from 0.5-40Gy. The results of dose distribution measurements around the sources were compared to TG-43 tabulated data and simultaneously irradiated EBT3 film. A TOLADO TL system was employed for read out of the TLDs. Triple-channel dosimetry using FilmQAPro with uncertainty reduction technique was used for film dosimetry.

Contribution ID: 1306
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Proton imaging for accurate treatment planning and pre-treatment verification: from the physics laboratory to clinical use

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Proton radiography (pRad) and proton CT (pCT), using a technique that tracks individual protons traversing the patient to measure the water-equivalent path length they cross, has been developed in the physics laboratory and is now undergoing testing in a clinical environment. With this contribution, we describe our engineering solution to make this technology available for the first human pilot studies in order to demonstrate the potential reduction of proton treatment margins with this low-dose, potentially artifact-free imaging modality. The suggested approach for planning and pre-treatment verification for proton therapy patients with brain tumors and head and neck cancer as the first application is as follows: We will install a motorized rotating patient chair on a clinical horizontal beam line, synchronized with the pencil beam scanning system and the proton imaging system. The use of the chair avoids the complication of delivering beam with a rotating gantry. We will deliver a patient-specific scanning pattern and record proton data with a pair of tracking detectors and a residual energy detector. The next step is to develop pRad and pCT software programs that will interface to existing clinical systems. This will allow for pCT images from up to one billion protons to be acquired in under 3 minutes and reconstructed in under 30 minutes for treatment planning with reduced RSP uncertainty and pRad images from three million protons to be acquired and reconstructed in 1 minute or less for pre-treatment verification. Range errors larger than the allowed distal PTV margins will trigger rescanning and replanning with proton CT. The workflow using pCT for planning and pRad for pre-treatment verification appears safe and efficient and we expect to reduce daily imaging dose by at least a factor of 10 and treatment planning margins to less than 1% of the proton range in water.

Contribution ID: 1388
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Intensity modulated radiotherapy (IMRT) phantom fabrication using fused deposition modeling (FDM) 3D printing technique

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Radiotherapy phantom is an important tool in the verification of the delivered dose against the planned treatment. An in-phantom dosimetry prior to treatment is a part of clinical quality assurance to check for possible dose delivery errors. With the popularity of 3D printing technology, a cost-effective fabrication of a customized phantom becomes possible for quality assurance and clinical research. This study validates the use of 3D printed patient-specific phantom in quality assurance of Intensity Modulated Radiotherapy (IMRT). Using an IMRT Thorax anthropomorphic phantom (CIRS) as a substitute for an actual patient, a 3D printed radiotherapy phantom was designed based on a patient computed tomography (CT) scan during treatment planning. Before printing the phantom, the tissue equivalence of Acrylonitrile Butadiene Styrene (ABS) and Polylactic Acid (PLA) polymers used in 3D printing was characterized by quantifying its CT number and relative electron density to water. A total of 10 cubes (5 ABS and 5 PLA) with varying infill percentages (20% to 100%) were fabricated to analyze its tissue equivalence using the fused deposition modeling technique. It was found that ABS and PLA could be used as tissue equivalent material: ABS 100% for adipose, ABS 20% & 40% for lung, PLA 100% for soft tissue, and PLA 20% & 40% for lung. Then, a 3D stereolithography (STL) model was created using a marching cube algorithm and Laplacian filter. A five field IMRT plan was then generated to treat the mediastinum part of the thorax phantom using Analytical Anisotropic Algorithm (AAA) of EclipseTM treatment planning system (TPS) where the prescribed dose to the tumor volume is 200cGy per fraction. The TPS calculated and measured dose in CIRS and 3D printed phantom were in agreement within +/-3% relative to the measured prescribed dose.

Contribution ID: 1399
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Pilot Clinical Study of MRI-Only Radiotherapy Verification in Prostate IMRT Using Transit EPID-Based Dosimetry

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A benefit of magnetic resonance imaging (MRI)-only radiotherapy is to eliminate the systematic co-registration errors between MR and computed tomography (CT) images. The main method of MRI-only radiotherapy is to generate the substitute CT (sCT) from MR data set that may lose the precision of electron density for dose calculation. The purpose of this study is to verify the delivered dose using a simulation of transit dose calculated from sCT images to measured EPID image from first delivery. The outcome of this study is to ensure the accuracy of MRI-only radiotherapy in clinical use.
For our pilot clinical study, the measured EPID images from 6 patients were acquired at the first fraction and used to verify the accuracy of dose delivery and sCT generation. The sCT scans were calculated from standard T2-weighted (T2w) MR pelvic scans using hybrid method (combination of atlas and voxel-based conversion). To simulate transit images from sCT, a comprehensive physics-based model to calculate the predicted transit EPID image were used. The agreement between the transit images generated from sCT and the measured transit images are quantified using gamma evaluation with three level gamma criteria (2%2mm, 3%3mm, and 4%4mm) and percentage of absolute mean dose difference.
The gamma pass-rate between the predicted transit of sCT vs measured EPID was 78.0% (±5.4), 92.0% (±4.0%), and 97.6%(± 2.0%) for 2%2mm, 3%3mm, and 4%4mm gamma criteria respectively. The absolute mean dose difference was 2.1% (±1.6%). In our pilot study, the transit dose from sCT and measured transit dose showed high agreement. Therefore, by validating the transit dose at first fraction of MRI-only treatment planning radiotherapy of prostate IMRT, this provides confidence in the output of sCT generation to continue further treatment delivery fractions.

Contribution ID: 1491
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Introduction of independent calculation of dose at a point in our Regional Hospital Liberec

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One part of quality assurance for IMRT techniques is to verify the dose distribution and for other 3D techniques check dose at least at one point. Different phantoms are available for the measurement. The planning system used at our clinic fixes the monitor units and then recalculates the dose distribution into the phantom model in which the measurement is performed. With the new TPS we also began to use the independent dose verification at a point directly in the patient's anatomy. Using the patient´s contours and different densities, calculating software Diamond allows us to create a model of the patient. Then it estimates the dose which each field delivered to certain point. At the beginning, the dosimetric model had to be tuned to correspond well with reality. Then we set the maximum possible deviations: 8% for open fields and 10 % for wedge fields. Thanks to this system, we have detected a phantom model had been done.

Contribution ID: 1495
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Stereotactic pretreatment verification using a bidimensional pixelated diamond detector

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Purpose: This study aims at investigating the use of DIAPIX (DIAmond PIXel), a pixelated matrix of polycrystalline Chemical Vapour Deposition diamond detectors, for pre-treatment dose verifications of small size high intensity modulated treatments.
Materials and Methods: DIAPIX consists of two diamond detectors (Diamond Detector, UK) of area 2.5×2.5cm^2 and 300µm thick. In house Cr/Au electric contacts segmented detector in a 12×12matrix of pixels of area 1.8×1.8mm^2 and 2mm pitch. The two pCVD matrices were sandwiched inside slabs of PMMA. We have previously shown that this device is suitable to be used as a radiation-hard, tissue-equivalent dosimeter and was therefore used in the pre-treatment verifications of two clinical lung plans delivered by Cyberknife(CK) and a linear accelerator Elekta-Synergy-BM(EBM) respectively.
To cover the full irradiated area of EBM treatment, the detector was first positioned at the isocenter and then shifted in the latero-lateral and in gun-target direction. The dose distributions measured with DIAPIX were compared with the corresponding ones calculated by the TPS by evaluating the γ-index. The passing rate(γ < 1) was evaluated for the passing criteria3%/3mm.
Results: CK passing rate over the whole matrix was around 72% while for the EBM was 77%. However, due to problems in electrical contacts, several pixels, mostly concentrated in one of the two matrices, were not working properly and considering only an area without DIAPIX bad contacts the passing rate increases considerably. For example, γ <1 corresponding to the best performing matrix reaches 94% for CK and 98% for EBM, respectively.
Conclusion: DIAPIX, a bidimensional pCVD diamond detector with 2-mm pitch pixels covering an active area of 5.0x2.5cm^2, manufactured within projects funded by INFN Italy, was tested for pre-treatment verifications of CK and EBM plans showing on average very good results. Improved pixel contact quality will ensure a higher uniformity of the device response-

Contribution ID: 1498
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Synergists use of two in vivo monitoring devices in the external beams breast irradiation

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PURPOSE/OBJECTIVE

To evaluate the sensitivity of two systems for in vivo dosimetry, the IQM detector (iRT Systems GmbH, Koblenz, Germany) and the SoftDiso software (Best Medical Italy Srl), in detecting delivery and setup errors which can occur in standard 3DCRT external breast irradiation.
MATERIAL AND METHODS
IQM is a transmission detector mounted below the MLC, the signal acquired during treatment irradiation is dependent of radiation fluency. SoftDiso reconstructs the dose distribution at the isocenter plan from treatment EPID images and calculates the R-value, defined as the ratio between measured dose and planned dose at the isocenter. To simulate the female anatomy the ALDERSON-RANDO phantom was modified adding two silicon breast prosthesis. A 3DCRT plan of left breast was created and modified to mimic output errors (adding 2-3-5-10MU) and a calibration jaw bank error (opening and closing one jaw of 2-3-5-7mm). Moreover several setup errors were simulated rotating the phantom (1°-2.8°) respect to the longitudinal axis and translating it along the anterior-posterior direction (2-3-5-7-10mm). The deviations of IQM signal and R-value from the original values were evaluated.
RESULTS
To evaluate the short-term reproducibility of R-value, the original plan using the phantom was delivered 20 times. The standard deviation/R mean value was resulted 0.6%. IQM signal and the R-values linearly increase with the increment of MU (R^2=0.99 and 0.97 respectively). IQM signal is linearly correlated with the position of jaws (R^2=0.97 and 0.93 open and close jaw), while R-value is less sensitive to jaws positioning variations.
CONCLUSIONS
Both devices are able to detect small delivery variation of output. SoftDiso software is less sensitive to jaws positioning deviations than IQM. Instead SoftDiso has the potential of detecting set-up errors, which cannot be detected with IQM. The synergistic use of both the devices could be a great improvement in the QA process.

Contribution ID: 1668
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Presage® as a solid 3-D anthropomorphic radiation dosimeter

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Radiation oncology has been rapidly improved by the application of new equipment and techniques. With the advent of new complex and precise radiotherapy techniques such as intensity modulated radiotherapy, stereotactic radiosurgery, and volumetric modulated arc therapy, the demand for an accurate and feasible three-dimensional (3-D) dosimetry system has increased. In this study anthropomorphic PRESAGE® was used for evaluation of radiation dose delivery. The most important features of 3-D PRESAGE® dosimeter, apart from being precise, accurate and reproducible, it can be shaped into anthropomorphic shape. Many studies have been performed on the PRESAGE® dosimeters that show acceptable agreement between measured and reference doses. It also demonstrated that the PRESAGE®/optical CT system has excellent precision, accuracy, reproducibility, and robustness for 3D dosimetry. Previous work has focused on the basic dosimetric characteristics of PRESAGE® and investigation of the feasibility of the PRESAGE®/optical CT system for 3D dosimetry. The latter investigations involved delivering simple dose distributions or IMRT distributions to dosimeters fabricated in regular cylindrical shapes. The present study evaluates the feasibility of a breast shaped anthropomorphic PRESAGE® dosimeter, and builds on this earlier work by applying the PRESAGE®/optical CT system for the verification of IMRT, 3D and HDR brachytherapy dose delivery. This work demonstrates the feasibility of fashioning PRESAGE® into an anthropomorphic shape for verification of radiation doses, and it provides groundwork for future investigations into more complex anthropomorphic phantoms.

Contribution ID: 1721
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

The iterative angular matching algorithm for image guided radiation therapy

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Modern information and telecommunication systems are characterized by the fact that the objects of their processing are different types of 3D images that structure is quite complex. New radiation therapy methods for cancer treatment are good example.
The emergence of new techniques is associated with the desire to improve the accuracy of dose administration to the target and maximally reduce the radiation dose on the surrounding healthy tissue. Precise positioning of patients is necessary to ensure the desired accuracy for treatment. Variations in patient positioning and anatomical structures per fraction have always been a problem in fractionated radiotherapy. These changes can lead to significant deviations from the original plan.
Image guided radiation therapy (IGRT) is widely used for negative effects correction of interfractional variations. Even though modern technologies provide opportunities for more complex adjustments than simple shifts, in practice, rotational displacements and deformations of organs are not considered. This paper is devoted to the rotation error correction.
Some images are more conveniently represented by the isolated points form. To extract more information from such images it is proceed expediently to image processing of the group points objects (GPO).
In this paper, we propose to use the angular matching method of 3D images in conditions of priori uncertainty of the angular parameters. The iterative angular matching process of the GPO is based on the complete quaternion properties to simultaneously determine the measure signal similarity and the angle value between them and ensures the implementation of the correct and incorrect angular matching of GPO in contrast to matrix methods and methods based on solving the rotation inverse problem.
Automation of angular matching correction is the high importance for the online re-planning process because manual processes are not only slow, but also the risk of errors increases under time pressure.

Contribution ID: 1753
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Position sensing detector development for applications in radiation therapy

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The application of position sensing radiation detectors in real time and in phantom 3D dose profile measurements in radiotherapy is being developed in collaboration between Helsinki Institute of Physics and Radiation and Nuclear Safety Authority of Finland. Small beam radiotherapy has led

to difficulties with traditional approaches to dosimetry. A new type of detector with good spatial resolution would make transition from reference to clinical field size according to IAEA TRS 483 more practical. The aim is to build a detection system with linear dose response, flat energy response to absorbed dose to water and spatial resolution better than 0.5 mm. Tests have been done at the SSDL laboratory of STUK with detectors developed by HIP. The detectors under evaluation were semiconductor pixel detectors (Si and CdTe) and scintillator detectors (GAGG and CWO).
The pixel size of the semiconductor detectors was 100x150 µm2. A read out chip (ROC) developed for the Compact Muon Solenoid (CMS) experiment at CERN was used to collect the data from the chips. The ROC measures the spectrum on every pixel, but only the average over the whole detector was saved due to the large amount of data. The detectors were tested with a Cs-137 source. One CdTe detector showed an even spatial response and provided spectra with 13.2 keV FWHM at 662 keV.
The spatial resolution and dose response of a linear x-ray/gamma scanner was evaluated with a GBX200 Co-60 irradiator. Dose rates ranged from 5 to 43 Gy/h. Both scintillation materials showed a linear dose response in the measurement range. The beam profile could be reproduced with the scanner and the results can be used as a prove-of-concept for applicability of linear scanner approach for medical beam characterization. Further development of both detector types will be done on the basis of these tests.

Contribution ID: 1818
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Verification of entrance dose measurements with TLDs in conventional radiotherapy procedures delivered with Co-60 teletherapy machine

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Aim: The objective of this study was to determine the role of in vivo dosimetry with thermoluminescent dosimeters (TLDs) as part of quality control and audit in conventional radiotherapy procedures delivered with Co-60 teletherapy machine.
Subjects and Methods: Fifty-seven patients with cancers of the breast, pelvis, head and neck were admitted for this study. TLD system at the Radiation Monitoring and Protection Centre, Lagos State University, Ojo, Lagos-Nigeria was used for the in vivo entrance dose readings. All patients were treated with Co-60 (T780c) teletherapy machine at 80 cm SSD located at Eko Hospitals, Lagos. Two TLDs were placed on the patient surface within 1 cm from the center of the field of treatment. Build-up material made of paraffin wax with a density of 0.939 g/cm3 and a thickness 0.5 cm was placed on top of the TLDs. A RADOS RE 200 TLD reader was used to read out the TLDs over 12 s and at a temperature of 300°C.
Results: The results showed that there was no significant difference between the expected dose and measured dose of breast (P = 0.11), H and N (P = 0.52), and pelvis (P = 0.31) patients. Furthermore, percentage difference between expected dose and measured dose of the three treatment sites were not significantly different (P = 0.11). In general, 89.3% (50/56) patients admitted for this study had their percentage deviation difference below 5% recommended standard limit.
Conclusion: The values obtained establish that there are no major differences from similar studies reported in literature. This study was also part of quality control and audit of the radiotherapy procedures in the center as expected by national and international regulatory bodies.

Keywords: Co-60 machine in vivo dosimetry, Conventional radiotherapy, Entrance dose, Thermoluminescent dosimeters

Contribution ID: 1824
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

Results from 15 years of independent peer review of beam output at more than 2000 institutions

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Purpose: Independent peer review is an important tool for improving quality of the clinical physics program. While there have been many reports of results of such programs, they have largely focused on institutions that participate in clinical trials. The purpose of this study was to report independent peer review results from a spectrum of institutions, including both academic and non-academic centers.
Methods: We analyzed results from independent peer review of beam output for different types of radiation therapy beams, i.e. Photons (2 – 25 MV), electrons (2 – 20 MeV), and orthovoltage (1.9 mm AL – 3 mm Cu). We calculated summary statistics for the ratio between dose measured by independent peer review and dose reported by the institution. Analysis included data from over 2000 institutions in the United States and more than 150 from other countries. All beams monitored over the past 15 years (2001 – 2016) were included in the analysis. Data for 308,893 results from individual beam output checks were analyzed.
Results: The mean ratio between measured and stated doses for all beams, photon, electron, and orthovoltage beams were 0.999±0.018, 1.000±0.016, 0.999±0.019, and 0.995±0.033, respectively. While the mean values for each beam type were very close to one, > 5% of the beams monitored were more than more than ± 3% from a 1.000. Often discrepancies were found to indicative of incorrectly calibrated beams, misinterpreting the irradiation instructions, or errors in completing the irradiation form. In many instances communication with individual institutions led to identifying and correcting specific issues.
Conclusion: For a large sample of academic and non-academic institutions located throughout the world, the majority of beams monitored were found to be well within ± 3 of the stated dose. However, there were many instances where we identified serious calibration related issues that were subsequently corrected.

Contribution ID: 1827
19. Radiation Oncology Physics and Systems
19.11. Dose delivery verification

How can Dynalog files help in interpretation of Portal Dosimetry results?

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Varian Portal Dosimetry (PD) is widely used as a pretreatment Quality Assurance (QA) tool. The aim of PD is to test the linac's ability to deliver treatment plan. 40 clinical IMRT plans (Original Plans) for 4 cancer sites were explored. For each Original Plan the Portal Dose Image Prediction (Original PDIP) was calculated. Dynalog files including real MLC positions were recorded during measurement and used to prepare Dynalog RTPlan. We calculated dose distribution using

Dynalog RTPlan and PDIP (Dynalog PDIP) for that plan. Artificial portal measurements were generated on the basis of Dynalog PDIP. We compared:
1. Original PDIP vs measurement (comparison done in clinical practice),
2. Dynalog PDIP vs measurement (comparison excluding MLC performance error),
3. Original PDIP vs artificial measurement (comparison including only MLC performance error).
The 1%/1mm, 2%/2mm, 3%/3mm parameters for local and global gamma evaluation were used. Dose threshold was set to 5%.
Results for the 1st and 2nd comparisons were similar (max 2% difference for 3mm/3% global gamma analysis for single patient was recorded). Due to the fact that the 2nd comparison excluded MLC performance error we examined why percentage of passing points (gamma ≤ 1) was lower than 100%. After profile comparison we concluded that dose differences were observed mainly between the MLC leaves. Probably the sources of these effects are transmission between leaves and tongue & groove effect which are not properly modelled in TPS. The 3rd comparison showed at least 97.9% agreement for 2%/2mm local gamma analysis for Head&Neck, 98.6% for Gynecology and 100% for Brain and Prostate. We concluded that MLC performance error was infrequent and insignificant on the gamma results for clinical (1st) comparison. MLC machine performance is hard to detect by PD used alone, Dynalog files analysis is recommended.

Contribution ID: 912
20. Dosimetry and Radiation Protection
20.13. Keynote lecture

KEYNOTE LECTURE: International radiation safety system - Advancements and challenges with its application in regulatory frameworks

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The presentation will introduce IAEA standards of safety for protection of health and minimization of danger to life and property so called International Basic Safety Standards on Radiation Protection and Safety of Radiation Sources (BSS), and advancements with their application in the radiations radiation safety systems. The first BSS were published in 1962 and have been revised and updated since then. The latest version which was approved in September 2011 and published in 2014, is jointly sponsored by seven other international organizations. It applies to all situations involving exposure due to radiation, whether of natural or artificial origin. As such, they are universally applicable to the protection of people in all exposure situations. In order o ensure consistency in the radiation protection system and in regulatory frameworks worldwide, BSS follow ICRP recommendations, in particularly designation of situations of exposure in accordance with ICRP Publication 103 - ‘planned exposure situations’, ‘emergency exposure situations’ and ‘existing exposure situations’, as well as introduce recommended revised reduced dose limits to the lens of the eyes. The presentation will also address three existing or foreseen challenges namely (1) need to address dose coefficients per unit exposure to radon and radon progeny which are being prepared by ICRP and UNSCEAR, (2) application of the concepts of exclusion, exemption, and clearance, and (3) food drinking water safety related to the presence of natural and artificial radionuclides. In the last part, the presentation will discuss specific challenges that were highlighter in the aftermath of the TEPCO Dai-ichi NPP accident in Japan, particularly radiation protection of workers in elevated exposure situations and communication of radiation protection measures with non-expert parties.

Contribution ID: 57
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

A study on cable leakage of ionization chamber in megavoltage photon beam

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Purpose: Ionization chambers are widely used for dosimetry in megavoltage photon beams. Few report related to cable leakage have been published, however its mechanism has not yet been reported. The aim of this study is to estimate the charge of cable leakage and clarify the mechanism of cable leakage.
Materials and Methods: In order to separate the cable leakage from the readings, new method of cable leakage measurement was proposed. Measurement was performed using several cylindrical ionization chambers with different cable design. Measurement was also performed to identify the difference of grounded and floated connection type. The charge of cable leakage per absorbed dose to water per cable length was evaluated. Based on the measurement results, the mechanism of cable leakage was discussed.
Results: Cable leakage had a linear function of irradiated cable length regardless of manufacturer, detector type and sensitive volume. For the PTW ionization chambers, the leakage was about 0.4 pC / (Gy・cm). Cable leakage was positive charge and it was independent of connection type and the polarity of the applied voltage. It could be assumed that the positive charge apparently increases because electrons are recoiled from the core wire by interaction with photon. The leakage charge was calculated by photon fluence using cable design. The calculated leakage charge was compared with that by the measurement.
Conclusion: The cable leakage was quantitatively estimated using several chambers and discussed the mechanism of leakage by semi-theoretical analysis. The mechanism of cable leakage could be assumed as the electron outflow from the core wire. The leakage significantly influences the readings of mini- or micro-chamber.

Contribution ID: 99
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

The ionmetric measurement for the absorbed-dose to water of 400MeV/u 12C ion beam

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Radiotherapy with heavy ion is playing an important role in clinical therapy due to its physical characteristic. The absorbed-dose to water of the heavy ion beam is traced back to the 60Co γ radiation standard based on the relevant technical protocol. The uncertainty of correction for the beam factor kQ between 60Co γ and heavy ion beams is quite larger than that in other radiotherapy cases, such as high energy photons. This is mainly owing to the lack of experimental values of the factor kQ, therefore, only the theoretical data is used. Furthermore, the complexity of the interactions between heavy ions and matters causes the difficulties to precisely obtain the stopping-power and perturbation factors of the heavy ion beams. To date, the relevant factors are either assumed to be constant or unity. Both primary standard study and ionometric measurements for heavy ion beams are necessary to be conducted so that the dissemination can be improved.
Up to date, the primary standard study based on absolute measurement for absorbed-dose to water of heavy ion beams has not been performed widely in the world. In National Institute of Metrology of China, a water calorimeter is being developed to perform the primary standard study for heavy ion beams. The absorbed-dose to water of the 12C6+ beam with energy 400 MeV/u was separately measured by 4 ionization chambers. The correction factors including polarity, recombinations were evaluated based on the online measurement. The consistency of the normalized results from the chambers is roughly 0.7%, which is far smaller than the current estimated uncertainty(3.5%) for the absorbed-dose to water of the heavy ion beam. More intensive studies such as the absolute measurement and Monte Carlo simulations are needed to be done in order to give a more specific result of the uncertainty budget.

Contribution ID: 137
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Feasibility of a combination of 90Y/177Lu-Radiopeptide Therapy (PRRT) and External Beam Radiation Therapy in neuroendocrine tumors (NETs)

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BACKGROUND: PRRT with 90Y-DOTATOC and 177Lu-DOTATATE showed up to 35% objective responses in NETs and acceptable toxicity. Given NET indolent behavior, multiple treatments are sequentially applied; RT is proposed frequently as oligometastatic/palliative setting. The aim was to assess whether the combination of PRRT and RT (PRRT+RT) arise concerns about tolerability.
METHODS: Over our 807 pts receiving PRRT (1997-2014), 17% underwent also EBRT (14% after PRRT, 3% before PRRT). Among these, 25 pts had dosimetry and clinical data of PRRT+RT. The primary NETs were pancreas(12), lung(7), others(6), with multiple metastases in liver(13), bone(10), others(11). RT was adjuvant in 18 sites, palliative in 22. Bone metastases were treated with 3D conformal RT. Oligometastases were treated with image-guided IMRT or stereotactic RT, accounting for absorbed doses(AD) from PRRT. AD to OARs and tumour were assessed and toxicity investigated (CTCAE v4). For PRRT, OARs were kidneys and red-marrow ; AD to the liver was also evaluated. OARs for RT depended on the tumour site.
RESULTS: Individual metabolism leaded to large AD variability in PRRT (tumour: 1-42 Gy/GBq, 90Y-DOTATOC; 1-56 Gy/GBq, 177Lu-DOTATATE). Considering the injected activities of both 90Y-DOTATOC and 177Lu-DOTATATE, median(range) ADs follow. Kidneys: 19(2-32) Gy; red-marrow: 1.0(0.2-1.6) Gy; liver: 1.7(0.2-13.5) Gy. For RT, median(range) prescription dose was 28(20-45) Gy, with median(range) dose per fraction of 4.6(3-15) Gy. No severe red-marrow toxicity

was observed (14pts grade I-II; 3 none); no kidney toxicity was shown but in 1 pt (grade I). Median(range) follow-up was 3.5 (0.2-12.3) yrs. 7pts died.
CONCLUSION: PRRT and RT have different OARs, with the great potential to increase AD to tumours without increasing toxicity, especially in red-marrow and liver. This opens the way to future prospective studies. However, RT irradiating liver mets may (rarely) deliver non negligible AD to kidneys once summed to AD from PRRT. PRRT+RT imposes multidisciplinary dosimetry discussion.

Contribution ID: 197
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Establishment of a mailed audit dosimetry system for Canada using alanine

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The National Research Council (NRC) of Canada is currently developing a mailed dosimetry audit system to offer an independent check on the dose measurements performed in Canadian cancer centers. The audit employs the use of alanine, an amino acid which, upon irradiation, free radicals are produced; the concentration of which can be accurately determined non-destructively using electron paramagnetic resonance. The long lifetime of these free radicals, and effective atomic number close to that of water, makes alanine an ideal choice as an audit dosimeter compared to other possible dosimeters (e.g., OSL or TLD).
Alanine is known to be susceptible to environmental conditions, both at irradiation and read-out, and this was investigated using reference irradiations in the NRC Co-60 beam. A careful sample control and irradiation protocol combined with a stable reference sample, permanently fixed within the spectrometer (for signal normalization), led to a reduction in the standard deviation on a dose measurement from 0.5% to 0.25%.
Alanine dose response curves can show a small non-linearity, even at low doses below 30 Gy and therefore interpolation accuracy suffers if poor calibration sets are chosen. The literature suggests that a 0.5% - 1.0% fit uncertainty is reasonable in this dose range. An algorithm, which assesses all possible configurations of a calibration set, was developed to minimize fit error. Looking at doses from 10 - 500 Gy, the algorithm was able to reduce fit related error from over 1% to less than 0.2%.
A series of trial audits have been conducted in several clinical linac photon beams to practically test the audit system, on the clinically applicable dose range of 10 - 100 Gy. Referenced to the NRC Co-60 irradiations, these trials have shown that alanine is a suitable audit dosimeter, with an overall uncertainty below 0.8% at 10 Gy.

Contribution ID: 318
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Radiotherapy dose measurements using a fluorescing quinine solution

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Tonic water containing quinine fluoresces when exposed to ionising radiation. This study evaluated the feasibility of using tonic water as a radiotherapy dosimeter.

Samples of tonic water were poured into two transparent containers: a drinking glass (approximately 200 mL) and a cylindrical PET jar (approximately 1 L). The tonic water samples were irradiated with static beams for a variety of energies and dose rates: 6 and 10 MV photons at 600 MU/min; 6 MV flattening-filter-free photons at 1400 MU/min; 6, 9, 12, 15 and 18 MeV electrons at 400 MU/min and 6 MeV electrons at approximately 2000 MU/min (used for total skin electron irradiation). An acceptance-test sliding window field was delivered using a 6 MV photon beam at 600 MU/min, to assess dynamic response.
Fluorescence was successfully recorded using a monochrome low light CCD camera placed on the treatment couch and the Varian treatment room monitor system in the linear accelerator control area. Detection of this signal required minimisation of light within the linear accelerator bunker. Two consumer-grade digital point-and-shoot cameras were unable to detect the fluorescent signal.
Dose rate response was approximately linear for the 6 MeV electron beam. Energy dependence was observed for both photon and electron beams. While limitations in the bit-depth and focal length of the camera prevented precise quantitative analysis of depth dose profiles for conventional dose rates (≤600 MU/min), performance for higher dose rates (in terms of signal-to-noise in depth dose profiles) was comparable to radiochromic film. The movement of the sliding window field could be observed, though temporal resolution was limited.
Potential use includes measurement of dose in the build-up region, efficient checks of beam energy and tomographic reconstruction of 4D dose delivery, though further optimisation of fluorescent signal acquisition is required.

Contribution ID: 319
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Measurement of percentage depth-dose profiles in very small fields

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Radiotherapy treatment planning systems need accurately measured beam configuration data to produce accurate calculations of patient dose. This data is especially difficult to measure when using very small radiation beams. This study aimed explore some of the capabilities of a contemporary water-tank-based dosimetry system, for the purpose of accurate small field percentage depth-dose (PDD) profile measurement.
This study used a SNC 3D Scanner cylindrical water tank (Sun Nuclear Corp, Melbourne, USA) in combination with an unshielded PTW diode 60017 (PTW Freiburg GmbH, Freiburg, Germany). Two PDD measurement methods were investigated; (a) a “ray-tracing” technique, where a complex automated process was used to continuously drive the diode into the centre of the field while varying the measurement depth, and (b) a “manual” technique, where the centre of each field was identified using orthogonal profile scanning at two different depths and then the tank platform was iteratively shifted to place the diode at the centre of the field before measuring each PDD.
For both methods, the small size of the diode’s active volume, combined with the small size of the radiation fields (less than 1.5cm across) led to increased noise that was mitigated by scanning very slowly (2s integration times). When using the manual technique, the field centre was found to be reproducible within 0.1mm even after collimator and carousel repositioning. Differences of up to 5% were identified between the PDDs measured using the manual and ray tracing methods. Comparison of these small field PDDs with larger field (2x2 and 3x3cm^2) PDDs suggested that the ray-tracing method was over-measuring the dose (or under-measuring depth) in the very small fields.

Although time consuming, the use of a PDD measurement technique where the centre of the field is identified manually is advisable, unless the reliability more sophisticated ray-tracing techniques can be convincingly established.

Contribution ID: 320
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Novel Solid Dosimeters for Stereotactic Radiosurgery Techniques

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A polyurethane based dosimeter is composed of a polyurethane resin containing a component capable of reacting with radiation and a carbon radical initiator. Solid dosimeters can minimize the effect of oxygen on the sensitivity of the dosimeter compared to gel dosimeters. Therefore, the solid dosimeter is easy to fabrication, manufactured in any shape according to the container. Currently, although many studies have shown that various optimizations according to the composition and ratio of polyurethane dosimeters, there is no known type and composition ratio. However, for other dosimetric applications, the composition of the polyurethane based dosimeter are valuable studies. Therefore, in this study, we developed a dosimeter with various composition and ratios based on polyurethane, and compared it with the PRESAGE® dosimeter and evaluated the possibility as a dosimeter. The polyurethane dosimeter fabricated in this study was using 69.9% of Part A , 12.6% of Part B, 1.4% of LMG dye, 1.4% of Chloroform and 14.7% of solvent. A cuvette was inserted into a special phantom and a 1.5 cm thickness solid phantom was placed. The gantry angle was fixed at 0 degree, SSD 100 cm. All cuvettes delivered a dose rate of 600 MU/min using a 6 MV photon beam. The irradiated cuvettes were scanned at various wavelength ranges from 1 to 300 nm using a spectrometer, and the scanned data were analyzed using a personal computer. In this study, 5 and 10 Gy were irradiated to a polyurethane based dosimeter synthesized in this study. The maximum wavelength peak was 630 nm and the maximum wavelength peak of PRESAGE® dosimeter was 640 nm. Directly synthesized polyurethane based dosimeter showed 0.949, 0.923 and 0.824, respectively, from 620 to 640 nm. The linear coefficient of the PRESAGE® dosimeter was 0.99.

Contribution ID: 325
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Improvement of the sensitivity of the radiochromic gel dosimeter based on polyvinyl alcohol-iodide complex

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With rapid advances being made in radiotherapy treatment, three-dimensional (3D) dose measurement techniques of great precision are required more than ever before. It is expected that 3D gel dosimeters will satisfy clinical needs for an effective detector that can measure the complex 3D dose distributions. They are devices that utilize the radiation-induced chemical reactions of the radiosensitive reagent in the gel to store information about radiation dose. The 3D absorbed dose distribution can be deduced from the resulting distribution of products using several imaging modalities, such as MRI, X-ray, and optical CTs. In this study, we investigate about the improvement of the sensitivity of a novel radiochromic gel dosimeter (PVA-I gel dosimeter) based

on the coloring from colorless to red due to the formation of the polyvinyl alcohol (PVA) -iodide complex in a gel.
PVA-I gel dosimeter consists of partially saponified PVA, potassium iodide, fructose as a reductant, gellan gum as a gelling agent, and water (about 95 wt%) as a solvent. A very small amount of certain halogenated organic compound is added to the PVA-I gel dosimeter as a sensitizer. The prepared gel solution is divided into optical cells and is set. The samples are measured the absorbance by a UV-vis spectrometer after irradiation by 6 MV X-ray. (This gel dosimeter is expected to read out three-dimensionally by optical CT techniques in the future.)
In the results, the dose response is found to be linear between 0 and 25 Gy (or more) and its sensitivity was much higher than those of radiochromic gel dosimeters reported previously. The excellent characteristics of an original PVA-I gel dosimeter containing no sensitizer, such as dose rate independence, thermal, spatial and temporal stabilities etc. are retained, implying its favorable potential.

Contribution ID: 356
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

The peripheral dose outside the applicator in electron beams of Elekta linear accelerator

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Peripheral doses out of field could have short-term and long-term biological effects on the patients treated by electron beams. In this study the peripheral dose outside the applicator was measured using electron beams of Elekta Synergy Plateform linear accelerator. The peripheral dose profiles were measured and compared in a solid water phantom by using EBT3 film dosimetry system at energy levels of 6, 10 and 18 MeV. The measurements were done in 6 × 6, 10 × 10, 14 × 14 and 20 × 20 cm2 applicators and at different gantry angles of 0, 10 and 20 degree at the depths of 0, 0.5, 1cm and at the depth of Dmax (maximum dose) for each energy level. The peripheral dose Profiles were normalized to the CAX (central axis) of the field. The largest Peak of the peripheral dose was observed in the electron energy of 18 MeV at 3cm far from the outer edge of the applicator. Peak dose was increased with increasing the electron beam energy. .Peak dose at 18 MeV electron beam was 1.5% at the surface of phantom and at the distance of 2 cm from the outer edge of the applicator when the applicator of 20 × 20 cm2 was used. The Peak dose at 6MeV energy was 1.15% at the same distance in the same applicator size. It was found that the Peak dose decreases with increasing depth and increases with increasing field size. Also the Peak dose moved toward CAX with increasing gantry angle. In general, the tissues outside of the field could be prevented by using appropriate shields if we have a knowledge about location of peak dose, , dimension of applicator, depthof tissue , angle of gantry and the energy of electron beam.

Contribution ID: 564
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Development of optical computed tomography for evaluation of absorbed dose of the dyed gel dosimeter

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Abstract
【Purpose】Optical computed tomography (CT) is a reading device of the dyed gel dosimeters. We are developing the optical CT for the evaluation of 3D radiation absorbed dose distribution of the dyed gel dosimeters.
【Methods】We made the dyed gel dosimeters by using leuco crystal violet as a dye and the dyed gel will be contained in vials. The dyed gel dosimeters were irradiated with 10 MV X-ray beam at 100 to 2000 MU by a Linac Synergy (ELEKTA AB, Sweden). The irradiation field was set at 15×15 cm2, and the dyed gel dosimeters were placed at the center of the irradiation field at 5 cm depth in water. The optical CT we developed was consists of a liquid crystal monitor VL-176SE (FUJITSU, Japan) as a light source and a USB camera uEye XS (iDS, Germany). The dyed gel dosimeter was fixed to a rotate shaft and be rotated in a water tank at intervals of 0.9 degrees by a stepping motor (ST-42BYH 1004-5013, MERCURY MOTOR) to take 400 projections per rotation. Volume data were reconstructed from the projection images by the image processing software Plastimath. The correlation between the absorbed dose and signal value of the dyed gel dosimeter in the reconstructed image was analyzed.
【Results】We obtained the reconstructed images of the dyed gel dosimeters by the developing optical CT. This study showed that the signal value of the reconstructed image has linear relation in the dose range up to 20 Gy.
【Conclusions】The signal value of the dyed gel dosimeter in the reconstructed image has linear relation with the absorbed dose. Since similar dose response have been reported in other papers, our optical CT could evaluate the doses to the dyed gel dosimeters.

Contribution ID: 644
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Determination of the equivalent square field size for small beams made with IRIS collimator

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Accurate small field dosimetry is one of the challenges in stereotactic radiotherapy. Determination of the equivalent square field size for small beams is necessary in terms of applying small field output (OF) correction factor, which depends on field size or equivalent square field size (s) and type of the treatment machine. Calculation of the equivalent square field size is well-described in the ICRU91 (2017) protocol and Cranmer-Sargison et al., (2012) for rectangular and circular fields. Other than that in the special radiosurgery system CyberKnife® IRIS collimator is used, which is not rectangular or circular. It is made with two hexagon diaphragms, so we have unregularly dodecagon clinical filed size.

In this work correction factors for output factor measurements presented by Seuntenjens (2016), are used on the CyberKnife VSI machine for IRIS collimators measured with PTW 60017. A method to determine s is proposed for dodecagon filed, which is based on geometrical equivalent of the field area. To measure s we have to measure in-plane and cross-plane profiles as a maximum possible profile, and repeat this measurements turning our axes on 15° to measure the minimum one. So s can be calculated as:
$s=1.7623\cdot\sqrt[4]{D\_in1\cdot D\_in2\cdot D\_cr1\cdot D\_cr2}/2$,
where D_in1,D_in2,D_cr1,D_cr2 are measured FWHM of in-plane and cross-plane for 0° and 15° respectively. This formula is really close to the circular one:
$s=\sqrt{\pi}\cdot D/2=1.7725\cdot D/2$,
where D – is a mean FWHM of the circular filed, or beam diameter.
In aim to determine uncertainty of this approach corrected output factors calculated with two different s. The maximum difference in these factors is near 0.05% for the smallest 10mm field, which is in use in clinic. So it seems that using this approach from circular fields for the IRIS collimator is accurate, but anyway it’s necessary to measure all possible profiles to accurate s calculation.

Contribution ID: 659
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Comparing the dose measurements for Acuros dose-to-water and dose-to-medium calculation algorithm using CIRS IMRT Thorax phantom

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In the thoracic region there are many types of tissues (skin, adipose, muscle, bone and lung), therefore significant differences can appear here between different calculation algorithms. The main goal of this study was to compare the calculation results of Varian Eclipse Acuros XB (AXB) (Varian Medical Systems, Palo Alto, CA, USA) algorithm using dose-to-water (DtW) and dose-to-medium (DtM) settings with ionchamber measurements in anthropomorphic chest phantom.
Esophageal and lung treatment plans were created with Conformal Arc and RapidArc techniques on 6 MV and 10 MV energies. The calculation results of dose-to-water (DtW) and dose-to-medium (DtM) were compared to semiflexible ionchamber measurements. The relative differences were evaluated in all 10 available measurement points of the IMRT CIRS thorax phantom.
For 6 MV plans, the relative differences between calculations and measurements were below 5 % in most cases. The measured relative differences in low dose region for the soft tissue were up to 13.7 %, therefore for the lung and for the bone were 9.0 % and 11.7 %, respectively.
For 10 MV energies close to the build-up region there was also a slight difference between the measured and calculated values, the maximum deviation was 11.7 %. The differences in the lung and the bone reached 9.7 % and 11.3 %, respectively.
The dose difference between the dose-to-water and the dose-to-medium calculations depends on the density of the analyzed tissues. For the soft and the lung tissues the maximum deviation was 1.5 % and for bone it reached 12.5 %.
From the outcome of our investigation it is possible to conclude that the previous results of slab phantom based studies are also valid in case of clinical plans.

Contribution ID: 716
20. Dosimetry and Radiation Protection

20.01. Dosimetry in therapy (experiments, calculations)

Verification of dose deposited of IMRT fields with OSLD detectors

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In vivo dosimetry is a complement to the quality assurance (QA) protocol in radiotherapy and radiosurgery (RT/RS). In reports of several accidents it is suggested that if as part of the QA an in vivo dosimetry protocol had been applied, the accident could have been avoided. This work describes the process that is being used to start an in vivo dosimetry protocol based on optically stimulated dosimetry (OSLD) detectors (nanodots) and radiochromic film (RF) EBT3 in a RT/RS unit.
The OSLD and RF EBT3 were calibrated with a photon beam generated from a linear accelerator (TrueBeam Stx) with nominal energy of 6MV with flattering filter modality, for the dose interval of 0 to 13Gy (low and high doses). Several IMRT fields were irradiated in a solid water phantom. The OSLD and RF were placed at 1.5cm depth with SSD=98.5cm at the beam center. They were compared with the dose calculated with the treatment planning system (TPS) Eclipse13.6 (Varian) and with the dose distributions measured with the RF EBT3.
The OSLD measurements show a very good agreement if they are compared with the TPS (less than 2%) for IMRT fields that do not have very high dose gradients. The agreement between the TPS and the radiochromic film, is in average 90.95% of the gamma index, irradiated at the same geometry of the OSLD.
As the TPS does not give the dose distribution at the surface, the radiochromic film will be used to verify the dose at that point and verify if the measurements done with the OSLD are consistent with the values expected. Further analysis has to be done to verify if for complex IMRT fields the OSLD detector can still be used as verifying system for radiotherapy treatments.

Contribution ID: 735
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

An alternative method of determining the primary dose component of a Varian Clinac 2300 6 MV photon beam

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Introduction and Aim: This method offers an alternative approach to obtain the primary dose component of a 6 MV photon beam without the need for an uncertain non-linear extrapolation.
Method: The total dose in a broad beam can be described as the sum of the primary and scattered dose components. A small diameter central axis absorber is placed between the source of radiation and the point of interest, resulting in additional attenuation of primary photons without appreciably changing the scattered component of the beam. For a specified depth d in a phantom, the ratio of primary components is independent of field size, and this ratio can be measured by a series of ionization measurements with and without the attenuator in a narrow beam. The value of this ratio, together with the total doses with and without the central axis attenuator in the beam enables one to calculate the primary dose component of the beam. Lead attenuators of 1 cm and 2 cm thickness were used.

RESULTS: The value for the primary dose at dmax in a 10 cm x 10 cm field obtained in this 6 MV beam using this method is Dp (dmax, 10 cm x 10 cm) = 0.935 Gy/100 MU for the 1 cm attenuator and Dp (dmax, 10 cm x 10 cm) = 0.943 Gy/100 MU for the 2 cm attenuator.
CONCLUSION: The obtained value of the primary dose component compares well with the value in use on the treatment planning system as well as with Monte Carlo simulations. One can thus conclude that this method has the potential to provide an independent measurable verification of calculations of primary dose.

Contribution ID: 776
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

The small field PTW microDiamond correction factors for Cyberknife, Leksell Gamma Knife Perfexion and linear accelerator

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Purpose: Dosimetry of small radiation fields in radiotherapy and radiosurgery has become important and discussed issue in recent years. There is completely new Alfonso dosimetric formalism. This formalism includes the use of the correction factors that need to be calculated using Monte Carlo or measured for particular detector.
Materials and methods: Correction factors following small field Alfonso formalism were calculated by comparison of PTW microDiamond measured ratio Mx/My with Monte Carlo (MC) based field output factors determined using Dosimetry Diode E or with MC simulation itself. Diode measurements were used for the CyberKnife and Varian Clinac 2100C/D linear accelerator. PTW microDiamond correction factors for Leksell Gamma Knife (LGK) were derived using MC simulated reference values from the manufacturer.
Results: PTW microDiamond correction factors for CyberKnife field sizes 25–5 mm were mostly smaller than 1% (except for 2.9% for 5 mm Iris field and 1.4% for 7.5 mm fixed cone field). The correction of 0.1% and 2.0% for 8 mm and 4 mm collimators, respectively, needed to be applied to PTW microDiamond measurements for LGK Perfexion. Finally, PTW microDiamond Mx/My for the linear accelerator varied from MC corrected Dosimetry Diode data by less than 0.5% (except for 1 x 1 cm2 field size with 1.3% deviation).
Conclusions: Regarding low resulting correction factor values, the PTW microDiamond detector may be considered an almost ideal tool for relative small field dosimetry in a large variety of stereotactic and radiosurgery treatment devices.

Contribution ID: 799
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Small fields correction factors determination for silicon-diode and diamond detectors for the Elekta VersaHD linac at 6MV, 6MV-FFF and 10MV-FFF

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Introduction: The widespread application of IMRT, SRT/SRS and Flattening Filter-Free (FFF) techniques has increased the use of small and nonstandard fields. Accurate dosimetry in these fields still remains challenging due to the lack of lateral electronic equilibrium and high dose gradients. Measurements performed with existing active dosimeters hence require the application of correction factors for volume avering effects and beam perturbation [1]. This work aims at determining a set of correction factors for 6 MV, 6 MV-FFF and 10 MV-FFF beams of the Elekta VersaHD linac, derived for several commercially available active dosimeters and a diamond-based dosimeter developed in our lab [2].
Methods: Gafchromic films EBT3 were tested against Monte Carlo simulations using the code PENELOPE to demonstrate they may be used as a gold standard for relative dosimetry. Output Factors (OF) and profiles were measured with several detectors (Ediode PTW60017, microDiamond PTW60019, in-house diamond dosimeter), for square field sizes ranging from 0.5 to 10 cm. Correction factors were derived for 6MV, 6MV-FFF and 10MV-FFF beams. All detector measurements were performed at 10 cm depth in a water phantom, with a SSD of 90 cm and were compared with reference OF determined from EBT3.
Results: The results confirm that correction factors need to be applied to Si-diode and diamond detectors to make them suitable for consistent and accurate small field dose measurements. Profile measurements show an underestimation of the penumbra value using the diode.
Conclusions: The detector specific correction factors derived from this study may be potentially useful as a reference data set for small beam dosimetry measurements with the Elekta VersaHD.
[1] Alfonso et al., A new formalism for reference dosimetry of small and nonstandard fields, Med. Phys., 35 (2008) 5179–86
[2] Marsolat et al., Diamond dosimeter for small beam stereotactic radiotherapy, Diam. Relat. Mat., 33 (2013) 63–70

Contribution ID: 806
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Dose distribution during whole brain radiation therapy treatment with IMRT-RapidArc technique

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Whole brain radiation therapy (WBRT) is used to treat brain metastasis. Hippocampus should be avoided in the treatment planning system (TPS), mainly for memory preservation. Intensity modulated radiation therapy (IMRT) RapidArc technique allows the simultaneous treatment of multiple lesions in the brain, using photon fluence variation for delivering steep dose gradients. In these treatments, small beams are used which compromise the accurate dose distribution measurements. In this work, the absorbed dose distribution in WBRT is investigated to verify that provided by the TPS. First, the performance of 3 ionization chambers was investigated in a 6 MV x-ray reference field (10 cm x 10 cm) generated by a Novalis Tx linear accelerator finding agreement within 1%. Gafchromic film EBT3 has been calibrated in liquid water using the reference field and the minimum absorbed dose limit has been established. An acrylic phantom of 20 cm x 20 cm was built to simulate the patient head. A computer tomography image of the phantom has been taken to mimic the dose distribution delivered to the tumour volume from the TPS. The phantom includes specific space to collocate Gafchromic film of 10 cm x 10 cm size to measure the dose distribution in 3D. Thereafter, measurements of dose distribution is compared with the treatment planning system using the statistic t-test and gamma index analysis.

Contribution ID: 810
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Preliminary study about dose difference measured on skin and radiation detector

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Many times, patients submitted to radiotherapy treatments show skin reactions. According to the literature, the dose measurement on the skin is dependent of many factors like electronic contamination by the beam, field size and patient's geometry. In the clinical routine of the total body irradiation treatment technique, there is a great interest in reaching a more homogeneous dose distribution in the patient, however the way this procedure is currently made there is no dose uniformity through the patient's body because of a few factors such as regions with different thickness and due the size of radiation field. An initial analysis was made to determine the difference between the delivered dose to the patient's skin and the experimental reading deposited in the ionization chamber, because the set composed of ionization chamber and build up cap are 1.84 cm distant from the surface. The experimental readings with solid water board were made in the São Paulo's Beneficência Portuguesa Hospital using the Varian Unique 6 MV linear accelerator to determine the load deposited in the ionization chamber. The dosimetric parameters considered were the same ones adopted by the radiotherapy department of the hospital for the technique of treatment of total body irradiation, namely, field size of 40 x 40 cm² on the diagonal, that is, rotated 45°, and surface source distance of 370 cm. The experimental apparatus was simulated by the MCNP6 code in order to reproduce the experiment and compare the difference between these dose measurements. The statistical uncertainty of the Monte Carlo method remained below 0.92%. Preliminary results ensure that the lower the dimensions of the build up cap, the more the simulated values approach the experimental one.

Contribution ID: 927
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Research, analyze the dose results calculated with AAA algorithm in eclipse software of new treatment planning system

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Key words: Analytical Anisotropic Algorithm, dosimetry, relative dose, absolute dose
In this paper, the authors investigate the differences between the dose results calculated with AAA algorithm in Eclipse 13.0 treatment planning system, which has just commissioned, with the measured doses. The AAA algorithm in the Eclipse software is used to calculate the absolute dose, relative dose in profile line, and percent depth dose of some specific field size in Blue Phantom. The calculated dose results were compared with measured dose based on Technical Reports Series No.430 of International Atomic Energy Agency (IAEA No430). The authors have used CC13 ion chamber, Famer Chamber, water phantom, and Omnipro software to measure relative, absolute doses of these fields size. The AAA algorithm was also used to calculate the

doses in IMRT plan of fifty head and neck cancer patients. These IMRT plans were controlled quality in some points with plastic phantom, and famer chamber FC65. The differences between calculated dose, and measured doses are in the limit of IAEA 430 report. The results of the QA IMRT plan processing are suitable with ESTRO Booklet No.9.

Contribution ID: 928
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Compare the difference between doses calculated with Analytical AAA, doses calculated with PBC algorithm in Eclipse software, and measurement doses

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Keywords: AAA, PCB, HI index, and CI indexs
Abstract
In the paper, the author research to know between the dose results are calculated with AAA (Analytical Anisotropic Algorithm), and the dose results are calculated with PCB (Pencil Beam Convolution), which results are more accuracy when those are compared with measurement dose. When using AAA algorithm and PCB algorithm calculate dose for patient which dose result are more homogeneous, more conformity.
The method:
Use the AAA algorithm and PCB algorithm to calculate profile and PDD of rectangular, square, off-set fields in water phantom, calculate absolute dose at center of these fields. And then using system of water phantom, ion-chambers (IBA CC13, EXRADIN A14SL, IBA diode RFD-3D, PTW Famer Chamber), and Omnipro software to measure profiles, PDD, absolute dose of these fields in water phantom. It calculates the difference between doses, it is calculated with AAA algorithm, and measurement dose, also calculates the difference between doses, these are calculated with PCB algorithm, and measurement dose.
Choose randomly one prostate cancer patient, one rectum cancer patient, one cervix cancer patient. Then using the AAA algorithm and PCB algorithm calculate dose of IMRT plans of those patients, calculate Homogeneity Index (HI) and Conformity Index (CI), compare the HI and CI of plan calculated with AAA algorithm with HI and CI of plan calculated with PCB algorithm. The author also use QA Delta4 system to QA IMRT plan calculated with AAA algorithm, and IMRT plan calculated with PCB algorithm.
Conclusion:
- The doses calculated with AAA algorithm are more accuracy than the dose calculated with PCB algorithm.
- The IMRT plan calculated with AAA algorithm are more homogeneous and conformity than IMRT plan calculated with PCB algorithm.

Contribution ID: 960
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

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Clinical complications do result from high doses received by parts of the bladder and rectum during intracavitary brachytherapy of the cervix. The aim of this study is to assess the dose delivered to the bladder and rectum using Gafchromic films and compare it with the optimized dose calculated by the Brachy Prowess 4.60 Treatment Planning System (TPS) reports for empirical validation and system verification. Fletcher suite applicators were used to perform thirty (30) different clinical insertions on the constructed cervix phantom and results evaluated. The mean difference between the doses calculated by the TPS and the doses measured by the Gafchromic film for the bladder at the distance of 0.5cm from the edge of the film was 16.3 % (range -35.33 to +39.37). At a distance of 1.5cm for the bladder, the mean difference was 19.4% (range -49.48 to +30.39). The mean difference between calculated dose and the measured dose for the rectum at a distance of 0.5cm from the edges of the film was 23.1% (range -42.42 to +40.41). At a distance of 1.5cm for the rectum the mean was 22.5% (range -49.45 to +46.48). The TPS calculated maximum dose was typically higher than the measured maximum dose. However, in some cases, the measured doses were found to be higher than the doses calculated by the TPS. This is due to positional inaccuracies of the sources during treatment planning. The data obtained suggest that generally, dose reduction to the rectum was higher than dose reduction to the bladder. It is recommended that in vivo dosimetry should be performed in addition to computation.

Contribution ID: 1037
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Linear energy transfer of secondary electrons generated by 6 MV X-ray beam and its impact in small field size

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The level of damage or effect produced by a given radiation type in a medium depends on the amount and/or distribution of energy deposited. Electrons generated in matter by photons (primary electrons) and those originated during electron-electron interaction (secondary electrons) have been suggested to be fundamental for an adequate analysis of the effects and damages produced by radiation. The use of new radiotherapy techniques for advanced and specialized treatments require small radiation fields with dimensions less than one centimeter. However, the dose determined experimentally and/or by Monte Carlo simulation in these fields is generally dependent on the dosimeter, which has been associated to a possible dependence of the dosimeter response with the track-average linear energy transfer (LET,T) of the secondary electron spectra generated by the photon beams. In this work, LET,T of secondary electrons produced by a 6 MV X-ray beam in liquid water as a function of small field size is being investigated using the Monte Carlo code EGSnrc in order to evaluate the impact on the Gafchromic film response. For this, a Varian iX linear accelerator has been designed and validated with experimental percentage depth dose curve data, showing good agreement. The next step is to calculate the electron spectra generated by the photon beam and perform experimental measurements using ionization chambers and Gafchromic EBT3 films. A relationship will be established between the secondary electrons spectra produced by small radiation fields and their respective LET as well as an analysis of their influence on the dosimeter response. This work is partially supported by Royal Society-Newton Advanced Fellowship grant NA150212 and PAPIIT-UNAM grant IN115117.

Contribution ID: 1059
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Verification of clinical dosimetric parameters of total skin electron therapy using thermoluminescence dosimeter in indigenous wax phantom

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The total skin electron therapy (TSET) technique is used for the treatment of mycosis fungoides. The patient plan of TSET was made having six dual field electron beam treatment for Clinac-iX (Varian Medical Systems, Palo Alto, USA) with gantry angle 270±18.5 for 6MeV with HDTSe-mode at dose rate of 888 MU/Min. The dose rate for six dual field was measured by determining factor A (=0.97061) and factor B (=3.1363) to find the required MU to deliver the prescribed dose. It was found that the required MU to deliver 200cGy at 400cm SSD for each beam of 6MeV electron with HDTSe- mode is 504MU. PMMA acrylic sheet of 6 mm is used as a energy degrader to increase surface dose. The aim of the present study is to verify the six dual field TSET treatment technique using thermoluminescence dosimeter (TLD) in indigenously developed wax phantom. The present study analyzed various characteristics of the electron beam such as energy, dose rate, and horizontal and vertical flatness profiles at 100 cm SSD and extended SSD at 400 cm. All dose measurements were performed on Clinac-iX units in indigenously developed wax phantom. Parallel plate ionization chamber (PTW, Freiburg, Germany) used for dose rate measurement. The thermoluminesense dosimeter system used in the study is a commercial TL reader system with CaSO4: Dy powder, manufactured by Nucleonix Systems Pvt Ltd, India. Thermoluminesence dosimeters were used to measure the horizontal and vertical flatness profiles within ±10 cm from isocentre at an interval of 1 cm, during the external beam radiotherapy treatment. TLD has been proven to be a promising dosimeter for in vivo phantom dosimetry. Six dual field TSET dosimetry was performed using CaSO4:Dy thermoluminescence powder dosimeter in indigenously prepared wax phantom. The horizontal and vertical profile was measured and the flatness was found within ±10%.

Contribution ID: 1077
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Accurately evaluating settling responses of ionization chambers used in radiation therapy depend on the accelerating tube

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Recently, small field dosimetry has become more important with increasing use of multiple small fields in radiotherapy treatments such as intensity-modulated radiation therapy. In this study, we investigate the settling response of a set of ionization chambers, which are exposed to 4, 6, and 10 MV stereotactic radiotherapy x-ray fields. Previous studies have reported that a lack of preirradiation may result in settling response errors up to several percentage points. While the use of ionization chambers contributes to this behavior, the most obvious factors appear to be the area of the insulator, the material used for the central collector electrode, and the Bending Magnet System. The results show that Farmer-style ionization chambers having electrode connections that are guarded up to an active air volume settle quickly (within 5 min) and the change in the response

is small. On the other hand, small ionization chambers exhibit settling times of 11–24 min. In this study, the settling times of the small ionization chambers were found to be depend on Bending Magnet System.

Contribution ID: 1123
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Development of freely deformable neutron shielding for the reduction of normal tissue dose in boron neutron capture therapy

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(Purpose)
Since treatment neutron beam of boron neutron capture therapy do not come out in parallel from the collimator, it is necessary to set the incident point as close as possible to the hole of the collimator during irradiation. Dose outside the irradiation field is given because neutrons leak out from the gap between a patient and a collimator. An appropriate shielding is required for each patient setting. We aim to develop freely deformable neutron shielding and evaluate the shield effect by using treatment planning system.
(Material and methods)
The deformable shielding is formed by a suction-type fixed bag containing polyethylene pellets loaded with LiF with the size of 3mm in diameter. The size of fixed bag is 30 cm x 35 cm with the thickness of 2.5cm. Total weight of polyethylene pellets is 2 kg. This fixed bag was applied to the case of brain tumors using a head phantom in order to confirm the shielding ability. This fixed bag was filled in the gap between the collimator and neck and fixed. We compared the thyroid gland dose using treatment planning system when the limit dose of normal brain was 12 Gy-eq.
(Results)
The thyroid glands dose decreased by 70% in nitrogen and boron doses due to thermal neutrons in the presence of a shielding. On the other hand, the hydrogen dose due to epithermal and fast neutrons decreased by 50%. There was not change for gamma rays.
(Conclusion)
We developed a freely deformable shielding material for BNCT. It was confirmed that the neutron dose outside the irradiation field can be effectively reduced. In the future we will evaluate various cases and apply to clinical study.

Contribution ID: 1307
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Dosimetric validation of volumetric modulated arc therapy in three 6MV beam-matched linear accelerators

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To avoid inconvenience to the patient due to linear accelerators down time in busy radio therapy department, the patient treatment plan can be switched between any one of department's linear

accelerators without change in patients treatment plan provided all the accelerators exhibits same dosimetric characteristics. In other words the liner accelerators should be beam matched.
The aim of this study is to evaluate the clinical significance of beam matching using VMAT plans.
Materials and Methods: Dosimetric data of 6MV beam of Clinac 2100CD is taken as baseline value and other two units, 2300CD and Unique Performance are factory tuned with respect to that. An analysis of PDD data was performed for different field sizes to evaluate the energy match. Beam profile for different field sizes at depths 1.5 cm and 10 cm are analyzed. Output factor and MLC dosimetric properties were compared with each machine to determine the variability between the different models. Thirty patients from our data base are selected which includes head and neck, thorax and pelvis cases and for each site ten patients were selected. VMAT plans were created in Eclipse treatment planning system for Clinac 2100 CD machine and it is taken as a reference plan. For all the VMAT plans verification plans were created to measure point dose measurements.
Results: The TPR 20/10 for 10 × 10 cm2 was well matching, showing no energy difference. Point dose measurements data were compared and the deviation of all point dose measurements fell within ±3%.Planar dose maps were measured and compared and all of them have shown greater than 95% of points passed area γ-value less than 1.
Conclusion: The study reveals that evaluation of beam matching with treatment planning modeling shows good agreement between the 6 MV beams of all three linear accelerators in the clinical environment.

Contribution ID: 1438
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Comparison of dosimetry audit results in radiotherapy determined with new AAPM/IAEA CoP on small field dosimetry and with previous methods

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The National Radiation Protection Institute performs independent dosimetry audits of all units used in radiotherapy after acceptance testing in the Czech Republic. Absorbed dose to water under reference conditions is determined within audit together with relative dosimetry parameters such as output factors for different field sizes.
In November 2017, new AAPM/IAEA Code of practice was published for dosimetry of small static and non-standard fields used in external beam radiotherapy, but indeed these fields were used clinically before. The non-standard fields started to be audited in 2010 in the Czech Republic when the first CyberKnife has been installed in the Czech Republic. Since then, linacs with FFF beams at 5 centres and 2 TomoTherapy units at 2 centres were commissioned. The auditing group had to cope with challenges in terms of choice of reference conditions, suitable and available detectors, sufficient phantoms, published correction factors, dose uncertainty estimation, etc. Determined doses have been compared to doses calculated by treatment planning system and/or measured by audited centre.
The aim of this contribution was to compare the results that were obtained for non-standard fields in external radiotherapy in a traditional way (using the concepts described in TRS 398 and related papers available formerly) and recalculated according to the TRS 483. In total, 4 FFF linac (10 FFF beams) measured with PTW 30013 ionisation chamber, 2 Tomotherapy units measured with NE 2571, 1 CyberKnife measured with PTW 30013 and CC01, 1 Leksell Gamma Knife measured with PTW 31010. Additional measurements were performed to confirm recalculated values. The influence of new paradigm to former dose results and uncertainties was estimated including formerly used and recently recommended correction factors in small field dosimetry.

Contribution ID: 1499
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Study of output factor and dose profile for different detectors in small fields dosimetry using the TRS-483 formalism

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Small fields are commonly used in the treatment planning of Stereotactic Radiosurgery (SRS). The output factor and dose profile of these fields is likely to be affected by size detector. The aim of this study is to evaluate the correlation of physical and dosimetric parameters among different detectors used in small field dosimetry for radiotherapy in a clinical flattening-filter-free (FFF) linear accelerator. This study will be performed using PTW detectors: three ionization chambers of different shapes and volumes (0.6 cm3; 0.125 cm3 and 0.016 cm3), two diodes (E and SRS) and a diamond detector (MicroDiamond),
The clinical FFF LINAC used was an Elekta Versa HDTM and Elekta stereotactic cones. The output measurements are presented as a function of the detector size for 5 mm to 35 mm cone sizes and 0.6 x 0.6 cm2 to 4 x 4 cm2 fields for micro multileaf collimator (mMLC). The correction factor for output values measured were perfomed using the IAEA TRS-483 formalism. The dose profiles were measured using the same three ionization chambers, as well as diodes and a diamond detector. To obtain the penumbra width, the cross-profiles from measurements was introduced. All measurements were performed using the 6 MV photon beam in water at the isocenter plane at 5 cm and 10 cm depths. A deconvolution method was also used to interpret the correlation of output factors and penumbra measured with the different detectors. This study is part of the implementation of the IAEA TRS-483 protocol in the institution.

Contribution ID: 1713
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Head and Neck Immobilization Masks: Increase in Dose Surface Evaluated by EBT3, TLD-100 and PBC Method

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Positioning and immobilization tools are considered essential in order to guarantee that the planned dose distribution could be efficiently reached in radiotherapy treatments. However, the benefits brought by its use are confronted by the apparent increase in the patient skin entrance dose. In this work, the authors studied the dose surface effects provoked by the use of immobilization thermoplastic masks in head and neck radiotherapy treatments, performed in a 6 MV linear accelerator beam. The study was conducted using an anthropomorphic head-neck phantom and three different dosimetric techniques: thermoluminescent (TL) dosimetry, radiochromic film dosimetry and computational simulation using the Pencil Beam Convolution (PBC) method. For calibration purposes, TLD chips and radiochromic EBT3 small 2.0 cm2 strips dosimeters were positioned between two virtual solid water plates and exposed to absorbed doses ranging from 25 to 200 cGy. The use of an anthropomorphic head-neck phantom allows taking into account the dose variation in non-flat surfaces. TLD chips, positioned in the surface of the SCF

(supraclavicular fossa) anatomic region, covered with a thermoplastic mask, detected an entrance skin dose around 38.4% higher than that measured without mask. The EBT3 dosimeters, averaged among all strips used, also detected a medium increase of 58.6%. Both TLD and EBT3 detected increased doses for all measured points and have measured similar averaged surface doses without the presence of immobilization masks, i.e. 50.5% for EBT3 and 53.7% for TLD-100. The PBC simulation results pointed to an increase for most of the measured points. However, no increase and even decreased doses were also observed. Surface dose data evaluated for three other commercial thermoplastic masks irradiated in a solid water phantom are also provided.

Contribution ID: 1723
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Dose shaping in 3DCRT for cervical and uterine cancers with inguinal lymphatic node involvement: technical aspects

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Accurate delivering of high radiation dose to a defined target volume with curative intent while minimizing exposure to surrounding healthy tissues in three dimensional conformal radiotherapy (3DCRT) is largely dependent on the advantages of computer based planning, verification and treatment systems. These advantages are the reasoning for developing technical capacities.
In the study, technical guidelines for dose shaping in a 3D conformal forward planning environment for gynecological cancers with inguinal lymphatic nodes involvement is described, and validated with the classical three field (3-FLDs) and conformal (4-FLDs) planning techniques.
The ‘Dose shaping technique’ (DST) potentially can minimizes bladder, bowel bag and rectal toxicities and allows for dose escalation. This procedure (DST) is feasible, especially with the use of beam-shaping static multileaf collimator (sMLCs) segments which also serve in shielding out organs at risk (OARS).
Fifteen cervical and twenty-five prostate cancer cases with lymphatic nodes invasion previously planned and treated with either 3-FLDs or 4-FLDs were re-planned with the ‘DST’ to investigate superior conformity and well as optimum OAR sparing. Analysis of generated Dose Volume Histograms (DVH) based on a 46Gy per 23 Fractions for both 3-FLDs and 4-FLDs showed dose coverage ranging between 90.43% and 91.46% respectively, compared with 94.87% for DST. OAR sparing in terms of DVHs and dose values was observed to be superior with the DST among the other techniques.

Contribution ID: 1724
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Left-sided breast cancer radiotherapy with 3DCRT forward planning: does 3D FiF minimize cardiac dose any further

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Dose optimization in left-breast cancer radiotherapy is mostly confronted with cardiac morbidity and mortality owing to anatomical motion. While the breath-hold technique has been useful in minimizing cardiac dose, and in improving coverage to the internal mammary nodes with 85% to 95% isodose, it is usually limited by patient’s discomfort and treatment verification.

In this study, cardiac doses are compared using the multiple segmented field-in-field (FiF) technique and the traditional two tangential wedged-field (TwF) in a 3DCRT forward planning workspace; utilizing 6MV beams in a supine breast setup. It is anticipated that a formidable alternative cardiac dose reduction strategy shall be established, while exploiting the optimum potential of FiF for an improved dose homogeneity.
20 patients previously planned and treated with the two TwF were re-planned using FiF. In both approaches, RTOG and QUANTEC recommendations were applied. This was achieved in the TwF by moving the med-tangential jaw of each field to cover the heart volume to less than 2cm. In the FiF however, MLCs in the first opposing subfields were drawn to shield out both the heart and lung volume. These subfields were weighted appropriately to exploit the full effect of these shields. Using a 50Gy/25Fx prescription, the dose was normalized to the isocentre in the FiF. In the TwF however, it was at a point within the PTV volume which generated adequate dose coverage. Analysis of average dose (Daverage) and Maximum dose (Dmax) based on generated DVHs was done.
With heart and lung contoured as OARs, QUANTEC and RTOG constraints were applied. The average cardiac doses were 21.82Gy and 16.8Gy for TwF and FiF respectively. Analysis of DVHs based on these procedures suggested superior dose coverage of V95 = 48.91 for the FiF compared with V95=46.20 for the TwF. The dose homogeneity index also followed a similar trend

Contribution ID: 1729
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Calibration of scintillator targets for remote patient skin surface dosimetry

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Introduction: We have developed a remote, scintillator-based, imaging system for conducting surface dosimetry in total skin electron therapy (TSET). A methodology for calibration of scintillator targets has been established for converting camera pixel output to dose. Using an intensified camera synchronized to linear accelerator (linac) pulses, scintillation imaging provides quantitative dosimetry measured wirelessly real-time.
Methods: A patient was positioned according to the modified Stanford technique and received TSET with a Varian Trilogy linac set to high dose rate total skin electron mode. Disc-shaped (1.5cm Ø x 1mm thick) polyvinyl toluene scintillators were attached to both the patient and TSET patient stand. Thermoluminescent Dosimeters (TLD) and Optically Stimulated Luminescent Detectors (OSLD) were placed adjacent to scintillators on the patient to obtain an absolute dose reference. To convert scintillator signal to dose, calibration factors for dose, energy, scintillator-camera distance and angular dependency were computed. Doses read from scintillators were compared to those reported by OSLDs and TLDs.
Results: The time-gated camera system consistently provided at least a 4:1 signal-to-noise ratio of scintillator light output. For a patient undergoing TSET, cumulative images, TLD, and OSLD measurements were collected during eight therapy sessions. Calibration tests showed that scintillator light yield was energy independent, had a linear response to dose, and decreased following an inverse squared relationship as camera-scintillator distance increased. Furthermore, it was found that source-to-scintillator and scintillator-to-camera angles of 0º – 40º caused < 10% variation in scintillator signal. Overall, calibrated scintillators attached to the body surface were able to report dose within a 5% accuracy compared to TLDs and OSLDs.

Conclusion: Absolute surface dosimetry can be achieved with an accuracy of <5% of total dose by calibrating a camera system to scintillator targets. Remote imaging of patient dosimeter scintillation has the potential to provide real-time, absolute, surface dosimetry for patients undergoing TSET.

Contribution ID: 1741
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Influence of beam spoiler and air gap on dose distribution in build-up region for X6 MV static field

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The aim of this study was to determine the influence of air gaps between bolus and phantom on dose distribution in build-up region for X6 MV. The novelty of the work is using low-density boluses fabricated with 3D printer.
Depth dose measurements were performed for X6 MV 10x10 cm2 open field. The measurements were carried out with the Markus plane parallel ionization chamber, connected to Unidos electrometer. As 1 cm thick beam spoilers we used 3D-printed thermoplastic polyurethane cuboids filled with 5%, 10%, 15% and 20% honeycomb structure (thickness of 0.5 g/cm2, 0.17 g/cm2, 0.22 g/cm2). To generate air gap we used homemade styrofoam frames. Measurements were performed at a physical depth of 1, 5, 10 and 15 mm for all beam spoilers without air gaps and with 10, 20, 30 and 40 mm air gaps, at constant 90 cm SSD.
Our results showed that beam spoilers without air gap increased the dose in build-up region. The bigger spoiler filling is, the larger is surface dose. The same dependence can be seen on PDD curves, irrespectively of air gap size. Regardless of spoiler percentage filling with honeycomb structure, the larger air gap size is, the smaller dose on 1 mm depth.
Influence of beam spoiler filling and air gap on dose distribution in build-up region for X6 MV was investigated. Beam spoiler increased the dose in build-up region. The larger thickness of beam spoiler- the larger influence on build-up dose. Occurrence of air gaps lowers the surface dose. However, the influence of air gap in the range of 10-40 mm is not very visible. For bolus with density of 0.22 g/cm2, regardless of air gap size, the dose on 1 mm depth was always larger than 95% of maximum dose. The issue will be investigated for wedged and dynamic fields.

Contribution ID: 1765
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

AAPM TG-51, IAEA TRS-398 and IPEM recommendations: a protocol comparison for Flattening Filter Free beams

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Flattening Filter Free beams have become widespread in current radiotherapy practice; an assessment of different dosimetry codes of practice is necessary. The British Institute of Physics and Engineering in Medicine (IPEM) Topical Report 1 (2016) recommendations include a FFF spectral correction, to be utilized with the current British code of practice, IPSM 1990. Neither IAEA TRS-398 nor AAPM TG-51 or its Addendum has yet included this type of correction.
Two Varian Truebeam linacs were used, both with 6FFF and 10FFF beams. A PTW Roos parallel-plate chamber and an IBA CCU electrometer were used for PDD measurements. For absolute dose measurements, a Farmer chamber (NE 2571) and a PTW Unidos E electrometer were used. Absolute dose, polarity and recombination factors were measured according to all protocols recommendations: 5cm (IPSM 1990) and 10cm (AAPM and IAEA) deep. Our secondary standard chamber (NE 2561) and electrometer (NE 2670A) were calibrated at the National Physical Laboratory (UK), all our measurements are subsequently traceable to NPL standards. Ion chamber Farmer 2571 was cross-calibrated against our secondary standard using the replacement method recommended by IPEM Topical Report 1, intercomparisons were carried out at each of the recommended depths.
NPL ND,w calibration coefficients were used for each beam quality for IPSM 1990; whereas for TG-51 and TRS-398, the option of using ND,w for Co-60 along with its tabulated kq factors was utilized.
A detailed absolute dose study was carried out to compare IPSM 1990 and IPEM recommendations with two international codes of practice, TRS-398 and TG-51: correction factors, ion chamber intercomparisons and absolute dose measurements at recommended depths were performed. Results were accompanied by a rigorous uncertainty analysis, according to ISO GUM. Absolute dose measurements according to the three protocols fall within 0.5% for both beam qualities, well within uncertainty estimates.
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Contribution ID: 1771
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Thermal luminescence efficiency of Al2O3:Cr ceramic to heavy charged particle

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Introduction: Recent research has shown alumina-based ceramics TLD (A8, Chibacera Mfg. Co.) is easy to handle and owns a less LET-dependent glow peak which is potential for measurement in heavy charged particle (HCP) therapy beam. However, the sensitivity of is not stable enough for implantation in radiotherapy field. Therefore, a TLD made by chromium-doped alumina (A10, Chibacera Mfg. Co.) was developed to improve the sensitivity.
Purpose: This study aims to provide basic dosimetric properties of A10.
Material and methods: To obtain the thermal luminescence (TL) efficiency, A10 were irradiated using a 160 MeV/u proton beam, a 150 MeV helium beam, a 290 MeV/u carbon beam, a 400 MeV/u Neon beam and a 500 MeV/u Argon beam. TL efficiency was normalized by a 6MV X-ray. A10 was heated to 400 oC at a heating rate of 0.2 degree per second and the glow curves were read by an in-house developed readout system. To improve the accuracy, the timeline of the readout procedure was consistent for each experiment in the present study.

Results: The dose to response curve of A10 was linear in the range of 0.5-5 Gy for each beam but the slope was different to each other. The TL efficiency of A10 increased from 0.84 to 1.18 at LET range from 0.5 keV/µm to 13.2 keV/µm and decreased to 0.6 when keV/µm was 197 keV/µm.

Contribution ID: 1791
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Verification of field output correction factor for plastic scintillation detector

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Introduction: IAEA TRS-483 has provided field output correction factors (kQclin,Qmsr) for relative dosimetry of small photon fields. According to IAEA TRS-483 report, the W1 plastic scintillation detector (W1) doesn't require the correction factor (kQclin,Qmsr = 1.000) as the result of Monte Carlo (MC) simulation. The purpose of this report is to confirm by actual measurement whether the correction for the W1 needs or not.
Materials and Methods: We measured output factors (OFs) for 6MV photon beam for field sizes ranging from 0.5 x 0.5 cm2 to 10 x 10 cm2 by three detectors: W1, microDiamond detector (MDD), and PinPoint 3D Ion chamber (PC). It was corrected by multiplying the value of kQclin,Qmsr to OFs which obtained by MDD and PC, and then OFs of W1 were compared with the corrected OFs of the two.
Results and Discussion: In the field sizes of 6.0 x 6.0 cm2 or more, there was almost no difference between the OFs of W1 and the corrected OFs of the two. In even the small field sizes of 5.0 x 5.0 cm2 or less, the OFs of W1 was the small difference (less than only 1.0%) compared with those of the two. According to TRS-483 report, the relative standard uncertainties of kQclin,Qmsr in MC simulation were more than 0.4%. Furthermore, the relative standard uncertainties of actual measurement were approximately 0.1%. Therefore, the combined expanded uncertainties (coverage factor =2) for measured values were estimated to be more than 0.8%. The combined expanded uncertainties were approximately same as the differences between OFs of W1 and those of the two.
Conclusions: From the facts described above, we conclude that W1 would not need the correction by kQclin,Qmsr.

Contribution ID: 1835
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Application of 3D printing in radiotherapy on the example of bolus dedicated for patient with head and neck cancer

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3D-printing technology potentially allows better bolus fitting to patient's anatomy, what can significantly affect on dose delivery to skin and subcutaneous tissues. The aim of this study was to compare dose on phantom’s surface calculated by treatment planning system (TPS) and the one measured with Gafchromic films.

The CT of head and neck anthropomorphic phantom was performed. Afterwards, we drew bolus in the area of larynx in the treatment planning system (Eclipse , v. 13.6). Basing on DICOM file converted to STL format, three different boluses were printed: filled with honeycomb structure (A), empty inside (B) and filled with gelatine. All boluses were printed using FDM technology from polylactic acid polimer. Head and neck phantom was irradiated using X6 MV 10x10 cm2 open field and IMRT treatment plan (prepared for each bolus). Moreover, phantom with bolus A and B was irradiated with IMRT plan prepared for bolus C. Surface dose was measured with EBT3 Gafchromic films (Radiation Products Design Inc.) and calculated in TPS. Afterwards, analysis of Hounsfield Unit (HU) of printed boluses was performed.
Differences between measured and calculated surface doses for opend field were 3,7%, 9,4%, 4,0% for A, B and C bolus, respectively. The differences for IMRT plan were 1,6%, 7,8% and 5,3% for A, B and C bolus, respectively. In case of irradiation A and B bolus using IMRT plan prepared for bolus C, the differences were 4,3% and 4,4%. Analysis of HU showed, that electron density of bolus C is close to electron density of soft tissues (HU = -48). HU of bolus A and B was -595 and -808, respectively.
Basing on preliminary results of our work, each of printed boluses allows preparing acceptable treatment plan. However, only bolus C has HU similar to soft tissues.

Contribution ID: 1854
20. Dosimetry and Radiation Protection
20.01. Dosimetry in therapy (experiments, calculations)

Phantom size dependence of a radiophotoluminescent glass dosimeter for measurement of HDR 192Ir brachytherapy source

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Purpose: We determined influence of phantom size dependence for dose measurements around an HDR 192Ir source using a radiophotoluminescent glass dosimeter (RPLD) calibrated with a 4-MV photon beam.
Methods: To evaluate the phantom size dependence for RPLD, the energy correction factor calibrated with a 4-MV photon beam using 40×40×40 cm3 and 12×12×12 cm3 water phantom were calculated with Monte Carlo simulations. This simulations were performed using the egs_chamber usercode in the EGSnrc Monte Carlo code system.
Results: For 4 cm from the 192Ir source, the energy correction factor for 40×40×40 cm3 water phantom was 5% lower than values for 12×12×12 cm3 water phantom. The correction factor decreases with increasing phantom size. The mean photon energy decreases with increasing phantom size, because low-energy photons are increasingly scattered at further distances from the source. The RPLD response is higher for low-energy photons. This explains how the correction factor decreases with increasing phantom size.
Conclusions: These results demonstrate that corrections are required for each phantom size for dose measurements around an 192Ir source using an RPLD.

Contribution ID: 59
20. Dosimetry and Radiation Protection
20.02. Dosimetry in imaging (experiments, calculations)

Men are from Mars, women are from Venus, and DRL's are from the 20th century

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Any definition, metric or their application is worth periodic review. Initial methods and metrics for dose review may have been based upon limitations of tools and practicality as prevailed when first established.
Determination of dose in diagnostic radiology is either for the purpose of estimating risk or provides a comparator of acceptability, either for regulation or optimisation. It is right then to question the appropriateness for each, risk, regulation or optimisation.
The basic precept of a DRL is to determine the average dose for a minimum sample of 10 or more patients within a defined weight range for patients of 'normal' stature. This was based on obtaining reasonable statistics and limiting the burden for manual collection of data by radiographers. An average of 70kg provided a link to the ICRP 70kg reference man for the purpose of estimating Effective Dose.
This approach takes no account of typical local populations or of gender, and assumes standard examinations including any additional acquisitions or repeats to be reflective of practice and hence a basis for estimating 'risk'.
The advent of computerised extraction of large volumes of data, revised models for determining Effective Dose and of dosimetry methods that cater for a wide range of body size, shape, weight and gender necessitates a rethink. However, neither weight nor body habitus are captured within information systems (RIS, PACS, DMS etc), important information about the 'reference patient' must be determined by other means.
An upgraded approach for establishing representative protocol doses that are relevant to local populations, practice, gender and risk, is presented supported by analysis of patient dose data metrics. The outputs are directly relevant to optimisation of individual protocols on specific items of equipment, and remain relevant for a more refined definition of DRLs, from which national or international values may still be derived.

Contribution ID: 131
20. Dosimetry and Radiation Protection
20.02. Dosimetry in imaging (experiments, calculations)

Evaluation of effective energy distribution of 320-multidetector CT using GAFCHROMIC EBT3

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Knowledge of the effective energy of the 320-multidetector CT is important for QA and QC. Evaluation in two dimensions is necessary because the effective energy varies depending on the

shape of the wedge filter located in the CT device. The purpose of this study was to measure the two-dimensional effective energy distribution of the CT using the GAFCHROMIC EBT3 (EBT3) that has a weak energy dependence. The exposure parameters of the 320-multidetector CT were 120 kV, 500 mA, and 5.0 s, and the X-ray tube was stopped at the 0 o'clock position. To avoid scattered radiation, the distance between EBT3 and other scatterers was set to 200 mm or more. The Al filter thickness was increased from 2 mm to 20 mm (2, 4, 6, 8, 10, 15, 20 mm). The irradiated area was divided into 54 compartments (6 × 9), and the density attenuation ratio was measured, respectively. The half-value layers (HVLs) were determined using the density attenuation ratios. The effective energies were obtained from the HVLs, and the two-dimensional effective energy distribution was evaluated. Because the thickness of the wedge filter in the longitudinal direction (parallel to the bed) remained unchanged, the variation in the effective energy was negligible in this direction. On the other hand, in the lateral direction (perpendicular to the bed), because the wedge filter gradually thickened from the centre to the side, the mean of the effective energy distribution from the centre to the side (9 compartments along the lateral direction) were 53.0, 53.6, 54.3, 56.8, 61.9, 63.2, 75.1, 99.6 and 220.3 keV, respectively. The two-dimensional effective energy distribution of the CT could be thus measured using EBT3. Therefore, it is considered that the method provides a precise estimation of the effective energy of the CT for QA and QC.

Contribution ID: 213
20. Dosimetry and Radiation Protection
20.02. Dosimetry in imaging (experiments, calculations)

Efficiently X-ray CT dosimetry procedure using radiochromic film and film-folding type phantom

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Recently, one of important topics for X-ray computed tomography (CT) examination is reducing radiation exposure. The dosimetry using ion chamber, radiochromic (RC) film, thermoluminescent dosimeter are used as the evaluation methods of radiation exposure. The dosimetry by RC film takes time compare with the dosimetry using ion chamber. However, RC film has the advantage of obtaining 2-dimensional dose distribution. We have tried to establish the dosimetry of X-ray CT using RC film and film-folding phantom. There is a possibility that our method can obtain 3-dimensional (3D) dose distribution of X-ray CT. In this study, we optimized RC film dosimetry process such as data acquisition and image processing to become more efficient.
XR-QA2 film was exposed by a clinical CT scanner (Aquilion Lightning, Toshiba Medical Systems). Image processing and analysis were performed by MATLAB (The Mathworks, Inc.). The irradiated films were scanned by a commercial scanner (EPSON ES-10000G, Seiko Epson Co.). First, the area of RC film needs to extract from the scanned image. For this purpose, the scanned image was separated Red, Green and Blue component. Then the image of red component was binarized. The threshold value for binarization was determined by a histogram of pixel value. Next, the

binarized image was applied labeling process, and calculated the image feature for each label. The biggest and largest aspect ratio label was selected as the area of RC film. The original image was multiplied by the selected label to generate the analysis image. The contour lines of the same pixel value were drawn on the analysis image.
In conclusion, we automated data acquisition and specifying irradiated area for X-ray CT dosimetry. Our future work is to calculate 3D dose distribution using these data.

Contribution ID: 258
20. Dosimetry and Radiation Protection
20.02. Dosimetry in imaging (experiments, calculations)

Analysis of lens absorbed dose in head CT scan using a male anthropomorphic phantom

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This study aims to perform a dosimetric study on lens in head CT scan. A GE CT scanner, model Discovery with 64 channels, was used for irradiate an male anthropomorphic phantom , model Alderson Rando and radiochromic film strips were used for dose measures. Two headscans were performed using the routine protocol used in the radiodiagnosis service, programming the appliance with a voltage of 120 kV, a current of 175 mA and a pitch of 0.984.Experiments were performed with the phantom in supine position without bismuth lens shielding, supine with bismuth lens shielding and supine with inclination of skull without bismuth lens shielding. Radiochromic film strips were placed in the both lenses for each scan. Recorded absorbed doses were among 7.80-18.23 mGy. The analyze of noise indexes in the image of the head central slice presented acceptable values for soft tissues, less than 1%.

Contribution ID: 637
20. Dosimetry and Radiation Protection
20.02. Dosimetry in imaging (experiments, calculations)

Survey and comparison of thyroid and eye safety effective radiation dose in Cranial multi slice CT scans in selective Hospitals.

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Survey and comparison of thyroid and eye safety effective radiation dose in Cranial multi slice CT scans in selective Hospitals.
Background and Aim: CT.scan as a medical imaging modality deliver high radiation dose to patient.Scince eye and thyroid are two radiosensitive organsin this study,those effective doseswere evaluatedin brain CT.Scan.
Materials and Methods:This cross-sectional study was done in three selective hospitals in Rasht on Septamber and October in 2016.TLD was used as personal dosimeter. To measure effective dose TLDs were being put on the patient eyes and thyroid.
Results: The mean effective doses of eyes and thyroidin three hospitals with codes of H1, H2 and H3 were obtained 2.66 ±2.037mSv and 0.033 ±0.009mSv, 1.8035 ±1.107mSv and 0.02829±0.022mSv, 1.935 ± 0.95mSv, 0.03757±0.013 mSv respectively. We found significant differences among effective doses of the eyes and thyroid in three hospitals ($p<0.05$). Despite the

difference in effective doses betweenright and left sides of eyesthyroid, we don't find any significant difference.
Conclusion: Radiographers have a main role in patient dose during CT.scan examinations.

Contribution ID: 794
20. Dosimetry and Radiation Protection
20.02. Dosimetry in imaging (experiments, calculations)

Effective dose per patient age in Computed Tomography

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Purpose: This work aims to evaluate the accumulated effective dose (ED) to patients and analyse its distribution by patient age in multi-slice computed tomography (MSCT) devices.
Material & Methods: From eighteen months of use, a total of 17440 examinations performed in two MSCT devices were analysed. The Radiation Dose Structured Report (RDSR) of each examination was retrieved using a proprietary tool provided by the vendor of the MSCTs that collects the dose report of the procedures and shows the main radiation parameters associated, such as volumetric computed tomography dose index (CTDIvol) or dose-length product (DLP). All data were transferred into a spreadsheet to carry out the statistical analysis.
Patient ED was calculated from DLP values taking into account the k-factors derived from ICRP-103 tissue-weighting factors. Several global indicators, such as ED per patient age and total number of exams by patient were obtained.
Results & Discussion: Results show that every patient under 15 received an accumulated ED less than 20 mSv. On the whole, elderly patients received higher doses. The highest accumulated ED in one single patient was 220.1 mSv, receiving a total of 7 examinations over the period under study. Nevertheless, the maximum number of MSCT examinations per patient was 8.
Conclusions: Patient doses in two MSCT devices were evaluated. The higher accumulated doses are those in adults and older patients. Many examinations to an individual patient could be performed in a relative short period of time, so care must be taken to prevent a considerable amount of radiation dose in such a patient.

Contribution ID: 798
20. Dosimetry and Radiation Protection
20.02. Dosimetry in imaging (experiments, calculations)

Patient doses in an interventional procedure room

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Purpose: This work aims to evaluate the doses delivered to patients undergoing x-ray guided interventional procedures by means of the information extracted from the Radiation Dose Structured Report (RDSR).
Material & Methods: A multipurpose interventional procedure room equipped with a dual axis x-ray imaging system was recently updated, with the device to be able to send the RDSR accompanying the images acquired. From six months of use, a total of 170 interventions that required the use of x-ray were analysed according to the following parameters, extracted from the RDSR:

interventional reference point dose (IRPD), dose-area product (DAP) and irradiation time. Average and the maximum values of each data series were obtained.
Results & Discussion: Average IRPD reached 0.53 Gy and the average DAP was 108.0 Gycm2 with maximum values of 4.7 Gy and 970.9 Gycm2, respectively.
With respect to irradiation time, on average, each intervention lasted 08:41 minutes, with a maximum value of 1:26:19 hours. On average, fluoroscopic mode accounts for 91% of the irradiation time while the acquisition mode accounts only for 9%. Nevertheless, the acquisition mode accounts for 70% of both IRPD and DAP, while the fluoroscopy does only for 30%.
Conclusions: Patient doses in an interventional procedure room were evaluated. The heterogeneity of the interventions that are performed leads to a large variability in the dosimetric results obtained. More than two-thirds of the patient dose was due to the acquisition mode, despite it represents about 9% of the total irradiation time. A few interventions have long values of irradiation time and reference point dose, so care must be taken to prevent the possibility of deterministic effects in patient's skin.

Contribution ID: 1265
20. Dosimetry and Radiation Protection
20.02. Dosimetry in imaging (experiments, calculations)

Assessment of patients' entrance skin and effective dose in a mathematical human phantom for the most common interventional radiological examinations

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Nowadays, we are witnessing an exponential use of interventional radiology techniques in different communities. After CT, interventional techniques are the second factor of increasing patients' doses in different societies. Measuring patient doses from aforementioned methods has been recommended by many radiation protection professional organizations such as ICRP and IAEA. Our aim was to measure/calculate the patients' entrance skin and also necessary parameters required to estimate relevant effective doses for common diagnostic and therapeutic interventional radiology examinations. After reviewing and analyzing interventional radiology examination data in an imaging center of a public hospital over 6 months, five most commonly used examinations, including cholangiography, chemoembolization liver, uterine fibroids embolization, bile duct stenting and coronary angiography and brain embolization were selected for the dose measurements/calculations. For each examination, 50 patients were selected and their skin doses were measured using TLDs. Effective doses resulted from these examinations were also calculated by using the Monte Carlo based PCXMC software for an average human phantom. The average entrance skin dose measured for the patients undergoing cholangiography, chemoembolization liver, uterine fibroids embolization, bile duct stenting and coronary angiography and brain embolization examinations were: 57, 141, 447, 241, 587 mGy and their estimated effective doses were 3.5,11, 31, 15.5, 10 mSv respectively. As expected, the patient doses in interventional radiology examinations varied, since the amount of doses depends on many factors including the complexity and difficulty of interventional procedures, operators' experience and skill, and patients' weight. In interventional radiology examinations a small field of view is used. Hence, appropriate voltage potentials and pulse durations must be used to reduce effective doses while achieving highest image qualities (resolution, contrast-to-noise ratio, and signal to noise ratio).
Keywords: Interventional radiology, entrance skin dose, effective dose, TLDs,

Contribution ID: 1272
20. Dosimetry and Radiation Protection
20.02. Dosimetry in imaging (experiments, calculations)

Influence of radiation field size and angle on organs' doses in unconventional angiography: Monte Carlo study on a voxelized phantom

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Effective doses were calculated for the patients undergoing interventional cardiological examinations based on Monte Carlo (MC) simulations made on a phantom. The simulations were carried out for energies obtained from experimental measurements on the left ventricle phantom with an Axiom Artis angiography system using MCNP4c code. Measured mAs values were used for dose calculations. The voxelized whole body phantom model of ICRP110 was employed to represent a patient. The patient was considered at posterior-anterior position. The approximate spherical coordinates to guide the x-ray source were set at: 27, 27.135. The collimated x-rays for 16×16 and 25×25 cm2 field sizes were directed toward the patient's body for twenty proposed techniques. The effective doses were calculated in mSv for six coronary angiography techniques used in Shahid Rajaee Hospital (Tehran/Iran) including LAO40-CAUD40, LAO45, LAO60-CRA20, PA-CRA45, RAO20-CAUD20 and RAO30 and compared with the dose computations made for the proposed techniques. The results of effective doses for the six routine techniques are not expressed in this paper, but compared for the proposed techniques from which our conclusions are maderegarding the angles and field of views (FOVs). The effect of angle and FOV variations for the 25×25 cm2 field size represented dose reductions for some of the proposed techniques, including: LAO20-CAUD20, LAO20-CAUD45, LAO60-CAUD20, LAO60-CAUD45, LAO30, LAO60-CRA30, RAO10-CAUD30, RAO30-CAUD30, RAO20 and RAO40 being 12, 15, 27, 74, 40, 54, 50, 56, 13 and 38 percent respectively. For the 16×16 cm2 field size, the dose reductions observed for the LAO60-CRA30, RAO10-CAUD30 and RAO30-CAUD30 were equal to 41, 16 and 38 percent respectively. Variations of the angle and FOV can reduce the number of the critical organs exposed directly to primary x-rays while keeping the target in radiation field.
Keywords: Coronary unconventional angiography, Monte Carlo, effective dose

Contribution ID: 1677
20. Dosimetry and Radiation Protection
20.02. Dosimetry in imaging (experiments, calculations)

Measurements of patients' doses and estimations of fetal cancer in diagnostic digital radiography

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Ionizing radiation has been frequently delivered in both diagnostic and treatment of cancer cells. In radiography, a dose to patients' primarily depends on the Entrance Surface Dose (ESD). The main goal of this study was to measure ESDs to assess patient (s) dose in conventional digital radiography examinations by means of optimization of radiation protection thereby facing the increasing probability of fetal cancer risk and other biological effects. Patient (s) dosimetry was carried out on 15 patients (males 26.66%; female 73.33%) of age ≥18 years where, minimum and

maximum ages of the patients were in between 20 and 69 years. The non-invasive kVp-Meter; DIAVOLT locating at 100 cm from Focus to Surface Distance (FSD), DAP meter (KERMAX-plus; M:120-131 Tino) for different field sizes for measurement of radiological parameters such as kVp, mAs, FSD and tube output that were recorded for calculating air kerma incident on the patient (s) skin. The ESD has a wide range even for the same examination carried out on the patient (s) of different ages and gender: 0.045 to 0.348 mGy (chest) and the corresponding effective doses range: 0.005 to 0.035 mSv; for L-Spine AP and Lat: ESD values are 1.240 mGy and 2.060 mGy and EDs are 0.133 mSv and 0.052 mSv; for Foot ESD is 0.066 mGy and corresponding ED is 0.0003 mSv respectively. The ESD values obtained are found to be within the standard reference having maximum uncertainty was ±5.6% and ±9.6% while measurement done with non-invasive meter and DAP meter respectively. For thorax minimum and maximum EDs are 0.153 and 0.698 mSv; for pelvis 0.896 and 5.945 mSv respectively, for 4 × 4 and 12 × 12 cm2. Finally, fetal cancer risk is calculated with ICRP publication.

Contribution ID: 1680

20. Dosimetry and Radiation Protection
20.02. Dosimetry in imaging (experiments, calculations)

Development and progress of the web-based CT exposure dose calculator WAZA-ARIv2

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X-ray CT (Computed Tomography) is very popular as a useful diagnostic method, so it is important to assess high exposure dose of CT in terms of justification and optimization. WAZA-ARI version 2 (WAZA-ARIv2, https://waza-ari.nirs.qst.go.jp/) is the web-based open system for X-ray CT dose calculation, which has been developed by National Institute of Radiological Sciences (NIRS), Oita University of Nursing and Health Sciences and the Japan Atomic Energy Agency (JAEA). The organ doses of various CT exposures were calculated using Monte Carlo simulation and voxel phantoms. In WAZA-ARIv2, can provide organ doses taking into consideration of the body type of patient using Japanese voxel phantoms developed by JAEA. And it can also provide exposure doses of children using child voxel phantoms developed by the University of Florida. In this system selectable CT scanners are 31 models. The number of CT models in WAZA-ARIv2 system is still increasing. Furthermore, we added the database function of storing the calculation results in each facility in order to check the exposure level of the CT examination in the facility in the stored distribution data in Japan. In January 2015, WAZA-ARIv2 system started, and currently over one thousand users are registered. In order to acquire more data on the actual situation of medical exposure in Japan, we plan to expand the number of users and to improve functions of WAZA-ARIv2 system. In this presentation, we will report the development and progress of WAZA-ARIv2 system.

Contribution ID: 1773

20. Dosimetry and Radiation Protection
20.02. Dosimetry in imaging (experiments, calculations)

Radiation dose associated with PICC insertions for patient and staff

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Peripherally inserted central catheters (PICC) are used to deliver intravenous therapy to the bloodstream. PICC insertion is sometimes fluoroscopically guided and thus associated with radiation dose to both the patient and the staff members within the room. The objective of this study is to assess the radiation dose to the patient using Monte Carlo simulations and directly measure the exposure to staff members in simulated procedures.
A retrospective audit of patients undergoing Permacath and Hickman's insertions was conducted. The patients were grouped by the pulse rate used for the duration of the study; 4 pps (n=24) and 7.5 pps (n=33). PCXMC V2.0 was used to estimate the effective dose to the patients from the procedures. A STEP OD-2 monitor and PMMA was used in a simulated environment to estimate the radiation exposure to locations that a Radiologist, Nurse and Radiographer would be standing during the procedures. Measurements were conducted at heights to reflect a whole body estimate and an estimate to the lens of the eye. The results show that the median patient dose resulting from a PICC insertion is 0.2 mSv and 0.1 mSv for procedures done at 7.5 pps and 4 pps respectively. The radiologist, nurse and radiographer were exposed to 5.4 uSv, 1.4 uSv and 0.7 uSv when 7.5 pps was utilised and 2.7 uSv, 0.7 uSv and 0.3 uSv when 4 pps was utilised. The exposure to the head of radiologist, nurse and radiographer was 2.1 uSv, 1.4 uSv, and 0.6 uSv in the 7.5pps studies and 1.1 uSv, 0.7 uSv, and 0.3 uSv. The radiation dose to the patient is of the same magnitude as a plain film chest X-ray. The staff exposure was measured unshielded. If lead aprons and lead glasses are worn, the radiation exposure to the staff would be negligible.

Contribution ID: 1850
20. Dosimetry and Radiation Protection
20.02. Dosimetry in imaging (experiments, calculations)

Effective dose and ocular dose investigations for head and neck CBCT examinations

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To evaluate the effective dose and the lens dose of a patient undergoing kV CBCT scans, a Monte Carlo beam modeling on the basis of measurements in air was proposed with a mathematical phantom incorporating a detailed stylized eye model. The beam characteristics in air were calculated and then compared with measurements using radiophoto-luminescent glass dosimeters (RPLGDs). The measurements were corrected for the energy dependence of the RPLGD, along the off x-axis distance, by applying air-to-RPLGD ratios of mean mass energy absorption coefficient calculated for the beam energy spectra at each position. The positional and the orientation dependence of the effective dose and the lens dose was calculated with the supine and prone setup at several positions. The air dose profiles calculated by using a stationary beam were in a good agreement with the measured profiles. The calculated mean energy and the mean mass energy absorption coefficient ratios for air to RPLGD were varied with the thickness of a bowtie filter. Especially in case of the stationary beam with the bowtie filter, the maximum difference of the

air-to-RPLGD ratios was up to 30%, although the maximum difference was only 5% in case of the rotational beam. For the rotational beam, the doses calculated within a CTDI phantom with a couch were also comparable with the measured dose within 7.5%. The calculated effective dose varied from 0.6 mSv to 0.2 mSv for the SDH mode according to the isocenter position and the patient orientation. However, except for the neck position, the effective doses were almost constant regardless of position or orientation in most cases. On the other hands, the calculated lens dose showed strong dependence of position and varied from 0.3 mGy to 5.7 mGy. The maximum lens doses appeared at prone setup.

Contribution ID: 19
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Comparison of UV-A sensitivity exposed from front side and back side in Gafchromic XR-RV3: preliminary study

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Introduction:
A thickness irregularity of the active layer of Gafchromic XR-RV3 (XR-RV3) becomes the density heterogeneity. It is need to correct this non-uniformity error. It is planned to solve this problem that the ultraviolet radiation A (UV-A) is used as an X-ray substitute to double irradiation technique.
The pre-irradiation method of UV-A, there is the orange UV protection layer at front side of XR-RV3. Therefore, amount of duration of UV-A irradiation is needed. In this study, to confirm whether UV-A irradiation can be performed from the back side (white polyester layer).
Materials and Methods:
An XR-RV3 piece (2 x 15cm) was placed on the 3 mm thick acrylic plate. An UV- A (385nm) was irradiated from front side (orange layer) to the half of a XR-RV3 (2 x 7.5cm) for 35 minutes by a UV-A ray irradiation device. The XR-RV3 was performed first scan. The UV-A ray was irradiated again from the back side (white polyester layer). Second scan was performed. Histograms of both pixel values and profile curves were compared.
Results:
The pixel value of mean ± standard deviation of the UV-A irradiated from the front side and from the back side were 40292.867 ± 236.979 and 40277.922 ± 228.950, respectively. Both histograms and profile curves were indicated similar shape and data.
Conclusion:
The sensitivity of XR-RV3 irradiated from the front side and from the back side of the UV-A irradiation were approximately same. Therefore, Pre-irradiation of the UV-A is able to perform both front side or back side.

Contribution ID: 22
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Designing and construction of a physical chest phantom for calibration and photonic dosimetry studies

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Physical phantoms constructed from tissue-equivalent materials can be used for radiation dosimetry studies. High prices, low compatibility of equivalent material with the real tissues in low energies and the use of epoxy resin for fabrication of tissue equivalent materials, are the most common problems of existing phantoms. In this regard, this study tries to design and construct a suitable physical phantom with high accuracy and low price in diagnostic energy range. The phantom geometry was similar to the cross sectional slice of adult chest with a thickness of 5 cm. Phantom body was made of PMMA and 17 holes were considered in the phantom for placement of different tissue substitutes. Due to the physical properties of real tissues, a wide range of available polymers were studied and finally Polypropylene, Polyethylene, Acrylonitrile butadiene styrene, Polyurethane, Polyamide and Poly oxy methylene were selected and prepared for replacement of adipose, breasts, muscle, liver, cartilage and ribs, respectively. In addition, two different Polyurethane foams were made of their raw materials for replacement of the lungs in inhalation and exhalation modes. Eventually, the constructed phantom was scanned by Siemens sensation 64-slice scanner at tube voltage of 120 kVp and materials' Hounsfield unit (HU) values were measured. On the other hand, using theoretical relationships their HUs were calculated. It was observed that, the calculated values are able to predict the measured values with the accuracy of 99%; and for all tissue equivalent materials, the relative error between the calculated and measured HUs was less than 10%.

Contribution ID: 77
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Evaluation in the use of bismuth shielding on cervical ct scan using a female phantom

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Computed Tomography (CT) has become an important tool to diagnose cancer and to obtain additional information for different clinical questions. Today, it is a very fast, painless and noninvasive test that can be performed high quality images. However, CT scans usually require a higher radiation exposure than a conventional radiography examination. The aim of this study is to determine the dose variation deposited in thyroid and in nearby radiosensitive organs, such as: lenses, pharynx, hypophysis, salivary gland, spinal cord and breasts with and without the use of bismuth shielding. A cervical CT scan was performed on anthropomorphic female phantom model Alderson Rando, from the occipital to the first thoracic vertebra, using a GE CT scanner, Discovery model with 64 channels. Dose measurements have been performed by using radiochromic film strips to recorder the individual doses in the organs of interest. After the phantom cervical CT scan, the radiochromic film strips were processed for obtaining digital images. Digital images were worked to obtain the dose variation profiles for each film. With the data obtained, it was found the organ dose variation. The results show us that the thyroid received the highest dose, 26,43 mGy, in the phantom, according to the incidence of the primary X-ray beam.

Contribution ID: 133
20. Dosimetry and Radiation Protection

20.03. Dosimetric techniques and phantoms

Fabrication of the variable density phantom varying the infill values of the 3D Printer for quality assurance in radiotherapy

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The variable density samples fabricated with varying the infill values of 3D printer to provide more accurate dose verification of radiotherapy. A total of 20 samples of rectangular shape were fabricated by using the FinebotTM (AnyWorks; Korea) Z420 model (width×length×height=50 mm×50 mm×10 mm) varying the infill value from 5% to 100%. The samples were scanned with 1mm thickness using a Philips Big Bore Brilliance CT Scanner (Philips Medical, Eindhoven, Netherlands). The average Hounsfield Unit (HU) measured by the region of interest (ROI) on the transversal CT images. The average HU and the infill values of the 3D printer measured through the 2D area profile measurement method exhibited a strong linear relationship (adjusted R-square=0.99563) in which the average HU changed from -926.8 to 36.7, while the infill values varied from 5% to 100%. This study showed the feasibility fabricating variable density phantoms using the 3D printer with FDM (Fused Deposition Modeling)-type and PLA (Poly Lactic Acid) materials.

Contribution ID: 467
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Experimental and Monte Carlo dosimetry of I-125 seed in heterogeneous phantom

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The AAPM TG-43 brachytherapy dosimetry formalism, introduced in 1995, has become a standard for brachytherapy dosimetry worldwide. Subsequent dosimetry development, based on Monte Carlo calculations allow to determine directly the dose to different tissues using model-based dose calculation algorithms (MBDCA). Currently, several studies are performed to evaluate the heterogeneity effects of different tissues and organs in brachytherapy clinical situations and a great effort has been made to incorporate this new methodology with greater accuracy. The objective of this study is to contribute to assessments of heterogeneous effects on dose due to I-125 brachytherapy source in the presence of different materials with different densities and chemical compositions. Experimental and Monte Carlo calculations were performed in heterogeneous phantoms using materials that simulate human tissues, such as: breast, fat, muscle, lungs (exhaled and inhaled) and bones with different densities. Thermoluminescent dosimeters TLD-100 and TLD-700 were used for dose measurements. A way to correlate absorbed dose in homogeneous and heterogeneous mediums at clinically relevant distances for low-energy photon emitting seed was proposed. It factor is based on the ratio of the absorbed dose in the TLD in homogeneous-to-heterogeneous phantom. The methodology of this study is suitable for accurate dosimetry evaluation for different types of brachytherapy treatments, contributing to improve the efficiency of dose distributions in different tissues and in brachytherapy planning systems.

Contribution ID: 493
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Development of Water Equivalent Multi-Layer Ionization Chamber with Liquid Crystal Polymer

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The dose distribution of the therapeutic carbon beams, especially, the depth dose distribution (DDD) is important, because the physical DDD of SOBP that can be converted to the homogeneous DDD biologically and clinically is not homogeneous but become decreasing according to the depth from the surface. So we have developed the water equivalent multi-layer ionization chamber (W.E.MLIC) that enable us to measure the physical DDD at one time with the equivalent results obtained by scanning an ion chamber in the water phantom which it takes much longer time.
In the study we developed new prototype of W.E.MLIC with Liquid crystal polymer (LCP). In the last study we evaluated stability of W.E.MLIC which consisted of PMMA and cupper plates and we found the short-term and long-term instability of the output from MLIC. Furthermore, there were proved two possible causes of these instability problem. The first cause was the irradiation of the carbon beams to the readout patterns which conducted collected charge. The second cause was that signal substrate made from PMMA, which has hygroscopicity, could be shrunken in a different manner of the cupper plates in a dry environment and resulted in the sensitive volume decreasing.
On the base of these results, we improved the readout pattern whose width was narrower (from 0.5mm to 0.1mm). In addition, we adopted substrate made from LCP which has lower hygroscopicity instead PMMA and cupper plates. By using carbon beams of 400Mev/n accelerated by HIMAC, we measured the water equivalent thickness of LCP and examined the water equivalence and stability of the new prototype of W.E.MLIC.
We obtained the results that the water equivalence was good like previous studies and the stability of the output from the new W.E.MLIC with LCP was better than previous one.

Contribution ID: 505
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Assessment of the usefulness of the treatment plan verification on multileaf collimator logfile analysis system

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We are assessed the usefulness of patient adaptive quality management using a MLC log file analysis system.
For the IMRT treatment planning, we used 4 targets and organ contours along with IMRT phantom as presented in TG-119 Report. The treatment planning was implemented via Eclipse treatment planning system using 7 and 9 beams. In relation to dose evaluation, point dose was evaluated by using CC13 chamber. The gamma index was analyzed for allowable limit of 3%/3mm by using MobiusFx system, a dose analysis software using MLC log file, in tandem with 2D array detector and Compass software that evaluates dose based on fluence.
The passing rate of 99.5% in multiple targets, 100.0% in prostate, 99.5% in head & neck, and 99.8% in C type. Based on results of analysis of gamma index for dose distribution, which was

performed on the basis of dose distribution calculated by MobiusFX system and MLC log file actually investigated, the pass rate was found to be 100.0% in multiple targets, 100.0% in prostate, 99.7% in head & neck, and 99.5% in C type. Meanwhile, gamma index was analyzed based on dose distribution under treatment planning for 4 targets and dose distribution measured through Compass system, and the results indicated that the pass rate was 99.9% in multiple targets, 99.6% in prostate, 99.2% in head & neck, and 98.8% in C type. In addition, the results of point dose evaluation, performed based on point dose under treatment planning using CC13 chamber and point dose actually measured, showed that difference in pass rate was 1.2% in multiple targets, 1.5% in prostate, 1.3% in head & neck, and 0.4% in C TYPE.
This study assumes that during clinical treatment, the MLC log file analysis system can be reduced in time for patient care and may be usefully used.

Contribution ID: 551
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Development of bone equivalent polymer gel dosimeter: R2-dose response curve

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Purpose:
Radiotherapy treatment planning systems with Monte Carlo algorithm can calculate the dose to medium, such as dose to bone.The dose couldn’t be verified with ordinal dosimeters. So, we have been developing a bone equivalent polymer gel dosimeter (bPGD). R2 value of bPGD is read out with magnetic resonance imaging system. Although R2 value is related to amount of irradiated dose, the dose to bPGD is not clear. In this study, we aimed to obtain R2 – dose response curve.
Method:
We prepared bPGD which was added 3.5M DCPD based on PolyAcrylamide Gelatin and THPC(PAGAT) with MgCl2, and it was poured into glass vials (φ19 mm,12 mL). The mass density of bPGD was 1.22 g/mL. One day after preparation, the bPGD was placed at 5 cm depth in water and irradiated 200 to 1000 MU with 10 MV X-ray of Elekta Synergy(Elekta). The irradiation field size was 15×15 cm2. One day after irradiation, we obtained T2 value using multi spin echo sequence with APERTO Eterna (hitachi). Each T2 relaxation rate (R2) was calculated from the T2. A Monte Carlo simulation code(MC), Particle and Heavy Ion Transport code System was used to calculate relative dose to vials of water and bPGD. The condition and geometry setup were the same as when irradiation. The absolute dose to water was measured with a reference dosimeter at the same position in a water tank. The dose to bPGD was calculated from the MC results then R2 – dose response curve was obtained.
Result and conclusion:
According to the result of MC, the relative dose to bPGD / the relative dose to water was 0.96. The dose to water was corrected with the bPGD /water ratio for the dose to bPGD and then the R2 – dose response curve of bPGD was obtained.

Contribution ID: 634

20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Particle Therapy secondary neutron characterisation with the MONDO project

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Particle Therapy (PT) is a non-invasive technique mainly devoted to the treatment of tumours untreatable with surgery or conventional radiotherapy, because localised closely to organ at risk. Despite the largest fraction of dose is released to the tumour volume, a non-negligible amount is deposed in other body regions, mainly by the secondary neutrons produce in the patient body. The risk of developing a radiogenic second malignant neoplasm, up to decades after undergoing a treatment is one of the main concerns in PT administration and planning.
A precise measurements of neutron flux, production energy and angular distributions is eagerly needed in order to improve the TPS codes, so to predict the normal tissue toxicity in the target region and the risk of late complications in the whole body. The request becomes particularly relevant in the case of paediatric treatments where life expectancy is a fundamental parameter.
The MONDO (MOnitor for Neutron Dose in hadrOntherapy) project is devoted to the construction of a secondary ultrafast neutron tracker and to their characterisation in the range of [20-400] MeV. The detector, based on the recostruction of the recoil protons produced in two consecutive (n,p) elastic scattering interactions, is a matrix of thin scintillating fibers , arranged in layers orthogonally oriented (10x10x20 cm3). A tailored readout sensor, based on SPAD (Single Photon Avalanche Diode) array in CMOS technology, has been developed with Fondazione Bruno Kessler (FBK). The detector is under development and a prototype has been tested with protons at Proton Therapy Centre of Trento .
Experimental results, efficiency studies, light yield measurements and the Monte Carlo simulation work performed to characterise the detector response to the incoming neutron radiation will be presented.

Contribution ID: 704
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Radionuclide internal dosimetry using GATE and PENELOPE for experimental validation in geometrical phantoms

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With the increased use of administered radionuclides for therapy and diagnosis, there is a great interest in developing easily implementable internal dosimetry schemes for clinical use. The available techniques consider MIRD to calculate internal dose, widespread through OLINDA

software using anthropomorphic phantoms, not allowing the use of simple geometries. The aim of this study is to investigate the use of two freely available Monte Carlo (MC) codes to allow radionuclide internal dosimetry with simple geometries, which can be compared to experimental measurements or analytical calculus. Three spherical geometries were simulated using GATE 7.1 and PENELOPE 2008 codes: (1) a point source centered in a 10 cm radius sphere; (2) a 5 cm radius sphere with homogeneous distribution positioned inside a 10 cm radius sphere; (3) two separated spheres (5 cm and 10 cm radius) 5 cm apart, the acting as source and second as target. All spheres were filled with water and 107 primary gamma emissions with 140 keV were simulated. Total doses were analyzed using 3D Dose Point Kernel (DPK). In the first case, 15 mGy and 14.25 mGy, in GATE and PENELOPE, respectively, were determined, showing 5% of statistical differences. The second case showed a higher difference (44%), from 7.4 mGy and 13.25 mGy, in GATE and PENELOPE, respectively. The third case showed total doses in 10 cm sphere target of 0.928mGy and 0.97 mGy, in GATE and PENELOPE, respectively. Concluding, GATE and PENELOPE MC codes can be easily used to simulate simple geometries, allowing for validation of experimental measurements or analytical calculus. Further studies are required to compare these simulation results with experimental data, collected by TLD and dosimetry using polymeric gel, in geometrical phantoms in clinical practice.

Contribution ID: 720
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Surface dose measurements using Gafchromic EBT-XD film

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Purpose:
A new GafChromic EBT-XD film was investigated as a dosimeter for surface dose measurements, due to its small thickness and near tissue equivalence properties. The results were compared with those measured using an Attix chamber.
Methods:
EBT-XD film is a very thin, near tissue equivalent dosimeter with a 24 micron active layer sandwiched between two polyester bases (125 microns thick each). The surface dose was measured for 6 MV at field sizes 5x5, 10x10 and 25x25. For a given field size, two films stacked on top of one another were irradiated at the surface and one film at the depth of maximum dose in a polystyrene phantom. The films were read using a document scanner and the readings were converted to dose using the FilmQA Pro software. To determine the dose at or near the surface, the measured doses of the two stacked films at their water equivalent depths were linearly extrapolated. To verify the film results, the surface and buildup dose was also measured using an Attix chamber in a water equivalent phantom.
Results and Discussion:
Preliminary results showed that the percentage surface doses measured using the EBT-XD film agreed with those measured using the Attix chamber within about 1% for all field sizes. The agreement was within the standard deviation (2 sigmas), which was determined by repeating the measurements two times using films from the same batch. Since the film is relatively energy independent in the MV range, similar results are expected with other energies.
Conclusion:
GafChromic EBT-XD film was investigated for surface dose measurements for 6 MV and various field sizes. The results agreed well with those measured using an Attix chamber, making it a potentially ideal surface dose dosimeter.

Contribution ID: 777
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Dose verification with a radiochromic film modeled in Monte Carlo simulation code

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A radiochromic film dosimetry is an attractive tool to verify a dose distribution in radiotherapy. It is a material containing a dye which changes colour and reflects the absorbed dose upon irradiation. The aim of this study was to model a radiochromic film in a simulation toolkit Geant4 (GEometry ANd Tracking) and to compare the theoretical predictions and the experimental data. A modeled radiochromic film was successfully implemented in Monte Carlo codes. For the purposes of this experiment, Gafchromic HD-V2 Dosimetry Film (Ashland Global Specialty Chemicals Inc., the USA) was used. The composition of this element was implemented according to information provided by the producer. Simulation of radiochromic film shows a good reproduction of the experimental data for high dose therapy called Microbeam Radiation Therapy (MRT). The MRT is based on doses delivered with spatially X-ray micro-fractionated beams and requires high resolution dose measurements.

Contribution ID: 787
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

On-line treatment verification during brachytherapy using miniature inorganic scintillation detectors

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In brachytherapy, a sealed radioisotope is guided inside pre-inserted catheters in the tumor volume to deliver high doses to the tumor with steep dose gradients to spare adjacent organs and normal tissue. On-line treatment verification is presently not performed during brachytherapy, partially because commercial technology does not exhibit adequate signal intensities over the entire dose range. The limited use of treatment verification is problematic because errors can occur unnoticed. Scintillation-based point detectors could have an important role as on-line verification during brachytherapy to detect treatment errors that can lead to harmful consequences for the patient.
We have developed miniature inorganic scintillation detectors (ISDs) for brachytherapy that are based on the scintillators Al_2O_3:Cr, Y_2O_3:Eu, YVO_4:Eu, ZnSe:O or CsI:Tl. The ISDs consist of a 1 mm-size scintillator that is optically coupled to a 1 mm-diameter and 15 m-long fiber-optic cable. The fiber-optic cable transmits the scintillation to the photodetector system which consists of a charge-coupled device camera or a spectrometer spectrograph. We tested the ISDs under brachytherapy treatment irradiation conditions using an Ir-192 source, and compared their performance with organic scintillators BCF-12 and BCF-60 which are the current standard for scintillation detectors in radiotherapy.
The scintillation intensities of the inorganic materials were up to 3 orders of magnitude greater than those of the organic scintillators. The large intensities of the ZnSe:O and CsI:Tl based ISDs made it possible to develop an in vivo dosimetry system based on low-cost photodetector and data

acquisition components. The system measured dose rates with <0.2% measurement uncertainties for source-to-detector distances up to 10 cm, and with negligible stem signals.
High-intensity ISD materials, e.g. ZnSe:O and CsI:Tl, make it possible to develop low-cost in vivo dosimetry systems that precisely can monitor brachytherapy treatments. Miniature ISDs can therefore facilitate dissemination of on-line treatment verification technology for brachytherapy.

Contribution ID: 802
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

ArcCHECK data display artefacts

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Quality Assurance experiments of irradiation machines used in complex radiation delivered treatments stands as a challenging task, such as the ones used in VMAT, where conformational set up involves both gantry rotation, multileaf collimator movement which must be synchronized with dose rate deliverance. ArcCHECK detector (sun nuclear) is a dosimetric system which stands as a powerful tool to perform these experiments. It is cylindrical PMMA phantom with a set of more than 1.000 diodes. These diodes are placed in a helicoidal fashion which forms an array of diode turning around the central axis 20 times. As one of the results ArcCHECK displays a map of dose distribution along the cylindrical surface at the detectors array depth. However due to its dose interpolation algorithms, dose map presented by ArcCHECK is made of number of points 4 times as large as the number of diodes it has. A rectangular disposition of real and interpolated data adds subtle differences between the expected and the displayed data. In this work we present a series of set of experiments which stresses the displayed artefacts. It is expected that the ArcCHECK user may gain a better understanding of its results and may make a better use of it.

Contribution ID: 829
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Real-time optically stimulated luminescence from beryllium oxide ceramics

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Fibre-coupled luminescence dosimetry systems utilising beryllium oxide (BeO) ceramics as the probe material have shown some promise in their application to radiotherapy dosimetry due to their closely matched atomic number with water. One major issue with all fibre-coupled luminescence dosimetry systems is the stem effect. The purpose of this study is to investigate the real-time optically stimulated luminescence (rtOSL) properties of a fibre-coupled BeO dosimetry system, using a constant high dose-rate, therapeutic energy x-ray source.
Two fibres were used side by side, one to guide the luminescence from the BeO to a PMT, and the other used to guide the blue stimulation laser light to the BeO. By pulsing the laser during the irradiation, pulsed OSL readings are performed. By subtracting the count rate measured between

the laser pulses from the count rate measured during the laser pulses, an rtOSL signal may be obtained which is potentially independent of the stem effect. Measurements were taken with the use of a superficial x-ray unit with different focal to detector distances to deliver varying dose-rates. During irradiation, the rtOSL signal is observed to increase over time and hence sensitive to the accumulated dose. Therefore the rtOSL measured at any point in time is not only the OSL accumulated in the time between laser pulses, but also of the previous accumulated OSL with some reduction due to laser stimulation. The change in rtOSL was observed to have a linear dose-rate response, with a variation of ±1.5% in the inverse square law corrected response. However the radioluminescence response is observed to increase as distance is increased. This is expected as more of the optical fibre is being exposed and hence the stem effect contribution is increasing. Therefore the rtOSL from BeO was observed to have a linear dose-rate response and be stem effect free.

Contribution ID: 837
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Small phantom evaluation to compare the radiation dose for medical linacs

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Recently commercialized glass dosimeter is being increasingly used as an ultra-compact design is possible to measure dose in small radiation fields and slopes. For many years radiation dosimetry comparison program using TLD have been performed, but the nature of TLD are many inconveniences in the usage. In this study, a small type portable phantom was designed and developed to evaluate the radiotherapy quality assurance (QA) system in radiation oncology facilities. In present paper the evaluation of glass dosimeters used for the phantom were performed to verify the practical applications of the phantom. In results, the uniformity and reproducibility of the glass dosimeter set were 1.32% and 1.42%. For the assessment of reliability, the cross comparison with the secondary standard dosimetry laboratory was performed and the results are agreed within 2-3% in dosimeter responses for same dose. The radiation output comparison was performed to evaluate the practical usage of the phantom for 10 medical linear accelerators installed in 6 hospitals. The developed a small type portable phantom can used in dose comparison between radiation oncology facilities as a verification of dosimetry and QA system of the medical linear accelerators.

Contribution ID: 958
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Dose measurements in mammography using PVAL hydrogel phantoms and TLDs

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Dose was evaluated for different thickness phantom and different compression force. For this experience, 100 Harshaw TLDs 200 inside capsule were used, they were calibrated in air Kerm for 24-26-28-30 kV in a FujiFilm Amulet S equipment working in W Rh.
8 hemi cylindrical phantom of 15mm thickness and 100mm diameter were used.
Gel was prepared with PVAL concentration 10%, gamma irradiation 10kGy/h 45kGy.
First a breast of 30mm was simulated, with 2 slices of phanton and the 5 TLDs were colocated between slices, in the center of the phantom. Shoot CAE W-Rh with compressed force 50 100 150 N.
Breast of 45mm thickness , formed by 3 slices, TLDS first at all put beween the lowest slices, 50 100 150N,
after the TLDs beween the highest slices 50 100 150N.
Breast of 60mm thickness, formed by 4 slices,TLDS first at all put beween the lowest slices, 50 100 150N, then TLDs between the medium slices 50 100 150N.
after the TLDs beween the highest slices 50 100 150N.

Contribution ID: 1038
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Dose measurements in mammography using PVAL hydrogel phantoms and TLD-200

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Around the world the breast cancer is the most common cancer disease for women and mammography is the gold standard study to diagnose diseases in breasts.
To know mean glandular dose (DMG) and depth dose during mammographic studies it is important to decrease biologic effects due to the ionizing radiation.
The objective of this work was to analyze depth dose for different values of compression force using thermoluminescent dosimeters (TLDs) and a compressible hydrogel (polyvinyl alcohol - PVAL) breast phantom .
Hydrogel plates were obtained from PVAL and deionizing water with concentration 10 % and gamma irradiation with 10 kGy/h reaching 45 kGy. 4 hemi cylindrical plates of thickness 15 mm , approximately, and 160 mm diameter were used.
A total of 100 Harshaw TLD-200 chips were calibrated in a FujiFilm Amulet S equipment with W-Rh for 24, 26, 28 and 30 kVp. A 48 mm thick phantom, formed by 3 plates, was located in the mammograph. First at all 5 TLDs was located between the lowest plates and a shot was done, after others 5 TLDs were located between the highest plates. Compression forces were 50, 100 and 150 N.
It was repeated for a phantom of thickness 61.5 mm (4 plates) and 38 mm (2 plates).
Depth dose resulted: for a phantom of 48 mm: 100% to at a height of 38 mm and 33 % to 18 mm and for 61.5 mm: 100 % to 50.5 mm, 49 % to 38 mm and 27 % to 18 mm.
Relative values of dose measured in the center of each phantom of 38 , 48 and 61.5 mm were 34 %, 69 % and 100 %, respectively.
Variation of DMG from different compression forces were less than 10 %.
Results agreed to expected, considering uncertainties TLDs of 10 %.

Contribution ID: 1045
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Characterisation of optical fibres for real time dosimetry of low energy proton beams

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The aim of this project is to develop a fibre optic based dosimetry system for proton beam monitoring. The system allows for small size dosimetry (approximately the diameter of a fibre) with a fast dose-rate measurement (0.1 second). These characteristics are ideal for the requirements necessary for real time, in-vivo dosimetry of proton beams in biological specimens or for proton beam therapy applications.
In these initial experiments, the radio luminescence (RL) generated in optical fibres exposed to proton irradiation were investigated as function of proton dose rate. Two fibres were compared: poly methyl methacrylate (PMMA) and silica. A photomultiplier tube (PMT) was used for photon counting and a spectrometer was used to analyse the optical spectrum emitted through the different types of optical fibre. Irradiations were performed with proton beam currents ranging from 0.1 nA to 120 nA.
Both fibres showed a linear response to dose rate. The PMMA fibre emitted 709±31 count/s /nA and the Silica 1653±31 counts/s /nA. The optical spectra differed significantly between the two fibre types. PMMA emitted light at a wavelength of 500 nm, while the silica spectrum showed two peaks; one peak at 460 nm and one peak at 650 nm. The 650 nm peak showed a linear response to proton dose rate while the 460 nm showed an over response to higher dose rates.
These preliminary results suggest that the silica fibre could be used at lower beam currents but a band pass filter may have to be applied to isolate the linear response of the 650 nm emission. Further investigation into proton energy dependence of the fibres will be performed.

Contribution ID: 1195
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Study of the Dosimetry Response of the MAGIC-f Gel to Low Voltage X-Rays

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The presente study aims to evaluate the response of the polymer gel MAGIC-f dosimeter when irradiated using low energy and high dose rate, source caracteristics using in radiosurgery. In order to verify the dosimetry performance for the MAGIC-f gel was used a 50 kV X-Ray beam. The gel calibration curve evidenced a gel sensitivity of 0.59 1/sGy using a dose rate of 29 mGy/s and the relaxometry technique from a data acquired in a 3T Magnetic Resonance Imaging (MRI) scanner. The dosimeter gel presented a reliable response for low energy and high dose rate allowing a 3D dose distribution from the MRI data. The experimental dose maps were compared with the results produced using Monte Carlo simulation, PENELOPE code, resulting in a high concordance. The

polymer gel was able to obtain verifiable results at a depth of up to 20 mm into the gel, with 95% of reliability in comparison to Monte Carlo simulation. These initial results stimulate more experiments at low energy with MAGIC-f gel.

Contribution ID: 1207
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Characterization of a 2D diode array used for verification of radiosurgery treatments

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In this study, we investigated the characteristics and performance of a commercial 2D diode detector used for the verification of radiosurgery and radiotherapy treatments. The detector consists in 1013 N-type diode arranged in a 77 mm x 77 mm matrix. The absorbed dose linearity, reproducibility, output factors, dose rate and source to surface distance dependence was investigated. All the measurements were compared with ionization chambers in the same conditions. Finally, the detector array attached to a cylinder phantom was used for the irradiation of radiosurgery treatments and the results were compared to treatment planning dose calculations.

Contribution ID: 1361
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Organ doses assessment in the anthropomorphic phantom of one-year-old child – verification of measurement by Monte Carlo simulation

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Organ doses were assessed for paediatric radiographic procedures of skull, chest and abdomen.
Firstly, organ doses were measured by thermolumniscence dosimeters (TLD) LiF:Mg,Cu,P placed in an anthropomorphic phantom of one-year-old child (ATOM 704-B, CIRS, Norfolk). Batch of 100 dosimeters was used for every procedure to cover the volume of interest sufficiently. The phantom was irradiated in the NRPI calibration laboratory using clinical x-ray machine DRGEM. Exposure parameters were set in accordance with clinical protocols (from four faculty hospitals). TLDs were calibrated in air kerma in spectra equivalent to spectra used for the phantom irradiation. The reference dosimeter was ionization chamber Radcal 6 cm3. The TLD glow curves were obtained by Harshaw 4500.
Measured organ doses were compared with organ doses calculated in PCXMC. There was no systematic correspondence or difference, due to differences in tissue densities and shape of the organs.
Consequently, Monte Carlo simulation using a voxelized phantom was considered. At the time of submitting this abstract, the voxelization was being performed using CT images of the anthropomorphic phantom. CT conversion ramp was created from tissue pixel value distributions determined in selected CT slices using ImageJ. Proper voxelization from dicom images was performed by EGSnrc ctcreate. Head and abdomen parts were voxelized separately to avoid stack overflow. The application EGSnrc dosxyznrc was used for this Monte Carlo simulation.

Contribution ID: 1385
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Development of 3D printed phantom for dose verification in radiotherapy for the patient with metal artefacts inside

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The verification of patient dose plans in radiotherapy can be performed comparing them with the experimental results of in vitro dose measurements using phantoms. However due to the possible artefacts inside the oral cavity (metal teeth, metal implants for the dentures, etc.) of head&neck cancer patients, deviations between the doses are possible, because these artefacts were not accounted when performing initial dose planning. Exploiting 3D printing technologies dosimetry phantom with precisely positioned artefacts can be produced, which will enable more accurate dose planning, thus more efficient treatment. DICOM images of the patient provide an efficient way for 3D model reconstruction of the selected anatomic structure. The advantage of 3D printing is that the internal organs, tumor itself and bone structures can be produced separately and then fixed at certain positions within a printed scaffold, which repeats the outside shape of the patient's body part. In this way some artificial objects like metal teeth or metal implants for dentures can be easily placed at the certain positions making construction more realistic. Dose/dose distribution assessment can be performed filling the whole construction with a special composite, which is tending to change its properties upon irradiation. Since the obtained dose data account the presence of artefacts within the object, they can be used for the treatment plan corrections before the treatment of patient.
Selected 3D printing materials must be as close as possible equivalent to the tissues of corresponding biological objects. Only in this way the relevant recommendations regarding treatment plan improvement can be undertaken. This investigation was dealing with the evaluation of tissue equivalency (different organs) of materials available for Zortrax M300 3D printer and of dose distribution assessment in irradiated composite filled phantom containing inclusions. The results of performed investigation are presented in this paper.

Contribution ID: 1671
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Fabrication of cost effective pediatric computed tomography dose index phantom for CT dosimetry

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In the present work, a pediatric head and body phantom was fabricated using polymethyl methacrylate (PMMA) at a low cost when compared with commercially available phantoms for the purpose of Computed Tomography (CT) dosimetry. The dimensions of head and body phantoms were 10 cm dia and 15 cm length and 16 cm dia and 15 cm length, respectively. The dose from a 128 slice CT machine received by the head and body phantom at the centre and periphery were measured using a CT dose profiler (CTDP). Using these values, the weighted computed tomography dose index (CTDIw) and in turn the volumetric computed tomography dose index (CTDIv) were calculated for different combinations of tube voltage and tube current time product. Relatively inexpensive pediatric CTDI head & body phantom suiting average Indian infant size was developed for measuring CT dose indices to reduce radiation risk to the infants. The performance

of the Siemens 128 slice Somatom Definition Edge CT scanner was evaluated using the calibrated pediatric phantom before ascertaining the performance of the developed phantom. After ensuring the proper performance of the CT scanner, the dose received by the developed phantom was measured at the center and periphery using the calibrated CTDP. Using these values CTDIw and CTDIv was then calculated and compared with the console values. The difference between the values was well within the limits specified by AERB, India. These results indicate that the cost effective pediatric phantom can be employed suitably for QA and patient dose optimization procedures.

Contribution ID: 1709
20. Dosimetry and Radiation Protection
20.03. Dosimetric techniques and phantoms

Breast Dosimetry and treatment : A Phantom study between Tangential Wedges and Multiple Open field-in-field 3D Conformal Forward Planning

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Breast cancer is the most frequent cancer among women in Africa and also the most frequent cause of cancer death in women in less developed countries. Most early stage breast cancer patients receive radiotherapy as part of their treatment. However, treatment related toxicity especially cardiotoxicity increase the risk of death and reduce survival benefit. Treatment planning varies in different institutions and countries, but, in general, the problem of dose delivered to the target and its toxicity remains complex. Many studies have associated these toxicities with dose inhomogeneity (hot spots). A “Poor man's Intensity Modulated Radiotherapy” (IMRT) technique using a 3D conformal forward planning technique using segmented field-in field (FIF) was studied and compared with departmental wedge planning method using a phantom study.
A Rando Alderson female anthropomorphic phantom was CT scanned, planned with the departmental protocol of using two conventional tangential wedge fields and then planned with the proposed FIF technique. A 3D dose distribution for the tangential wedge fields were obtained with the goal of reducing the hot spots in the breast below 110 percent of the prescribed dose. The 3D conformal forward plan employed using the multiple FIF was to achieve an optimal dose distribution and desired homogeneity through a complex manual fluence map optimization process. The FIF plan resulted in smaller “hot spots” far below 110% with a maximum dose of 102.8%, while maintaining greater coverage of the treatment volume. The dose homogeneity index was 1.00 of the treatment volume when using FIF as compared to 1.03 with standard wedges. The proposed method for breast radiotherapy is an efficient and effective method for achieving uniform dose throughout the breast and reducing doses to organs at risks. It is dosimetrically superior to the treatment technique that employs only wedges.

Contribution ID: 1562
20. Dosimetry and Radiation Protection
20.04. Mathematical modelling of radiation protection

An estimation of radiation output based on mathematical model

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In this work, a mathematical model for estimating the tube output for three phases x-ray machine is proposed. A total number of four x- ray machines with almost the same characteristics were used.

The output of each machine was measured using Diavolt. Three types of data were collected during measurement: x-ray machine data, the fixed Kv and the charge (mAs). The output was calculated based on the survey data and a mathematical equation for estimating the output was deduced. A comparison between the calculated output using the equation and the measure one shows that the difference between the two was quite small. This equation could be an alternative method for estimating output and therefore the radiation doses received by patients during diagnostic x-ray examinations particularly in the case of non-availability of dosimeters

Contribution ID: 72
20. Dosimetry and Radiation Protection
20.05. Shielding design

Skyshine neutron dose Monte Carlo calculations from an 18 MeV medical linear accelerator

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Skyshine is a phenomenon wherein radiation scattered by the atmosphere reaches the ground level outside the shield. Previously, simple equations have been proposed; however, their agreement with the experimental data was not satisfactory. From an 18 MeV accelerator, the neutron doses are higher than photon doses for skyshine. In this study, neutron skyshine doses were calculated using a Monte Carlo code, FLUKA, by changing the heights and openings of shield walls.
In the calculation geometry, the distance from the floor of the room to the roof was varied from 3 m to 10 m. The target was located at a height of 2.3 m, into which electrons were injected. The distance between the shield wall and the target was varied from 1.5 m to 5.79 m. Further, the height of the atmosphere was varied from 15 m to 30 m.
As a result, the dose outside of the shield wall increased with the height of the atmosphere and saturated at 20 m; the neutrons that reached the ground were found to be scattered mostly below 20 m. For neutron skyshine, NCRP Report No. 51 gave an expression, in which the neutron dose at ground level was proportional to the solid angle of shield walls and inversely proportional to the square of the distance from the target to the ceiling plus 2 m. In the Monte Carlo results, the doses conformed to the expression below a height of 5 m in height and above a distance of 2.6 m with respect to the distance from the target to the shield wall. In the other conditions, the doses became higher than those predicted by the expression, which indicated the large contribution of neutrons emitted in the direction just above the target to the skyshine doses.

Contribution ID: 500
20. Dosimetry and Radiation Protection
20.05. Shielding design

Linac leakage dose received by patients treated using non-coplanar radiotherapy beams

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Measurements of head leakage completed during linac commissioning often identify regions of increased leakage at the front and top of the linac head, where radiation is scattered from the flattening filter, target, bending magnet and accelerating waveguide. The effects of this multi-directional leakage are ignored when out-of-field dose is measured along the treatment couch with

the at zero degrees (head up). However, as non-coplanar beams are increasingly used to deliver cranial and extra-cranial stereotactic radiotherapy treatments, radiation leakage from different directions becomes increasingly concerning.
In this study, the leakage dose in the patient plane was measured using optically stimulated luminescence dosimeters (OSLDs) placed along the treatment couch, at 10cm intervals. A Varian iX linac was operated in 6MV and 10MV photon mode, with all jaws and multileaf collimators closed. Dose measurements were made (a) using the “standard” setup, with couch and gantry at zero degrees and (b) using a worst-case non-coplanar setup, with the couch at 90 degrees and the gantry at 30 degrees (rotated over the couch).
Results indicated that the leakage dose in the patient plane was uniformly low (less than 2 cGy/10,000MU) at all measurement positions for both energies, using the standard setup. However, when the gantry and couch were rotated, there was a systematic increase in dose towards 4.2 cGy/10,000MU at a point 80cm from isocentre (below the bending magnet). While these doses are within recommended out-of-field dose limits for static beam treatments, if IMRT/VMAT factors are applied, the leakage dose to the patient from non-coplanar treatments may become unacceptable.
Checks of out-of-field dose from non-coplanar beam directions are advisable prior to acceptance of new or modified linacs. Vendors should consider applying additional shielding to linacs that are capable of delivering non-coplanar treatments, especially linacs that are designed and promoted specifically as “stereotactic” treatment machines.

Contribution ID: 1098
20. Dosimetry and Radiation Protection
20.05. Shielding design

Shielding analysis of linear accelerator treatment bunkers at Mpilo Central Hospital Bulawayo, Zimbabwe

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The research analysed the adequacy of radiation shielding of two existing linear accelerator (linac) treatment rooms. The first one being a Varian DMX linear accelerator with dual photon energies of 6 and 10 MV following the detection of neutron radiation in the vicinity areas including the control console during a radiation survey that was conducted by the local regulator. The second linac was a Varian Unique single energy 6 MV linear accelerator earmarked to be installed in a treatment room that previously housed a Cobalt-60 teletherapy unit. Due to energy differences in the linac and the Cobalt-60 unit, shielding modifications were made to the bunker to cater for a higher linac photon beam of 6 MV. The work employed several shielding calculation methods which included the conventional methods that used analytical equations from the IAEA Safety Report Series Number 47 (2006) and the NCRP Report 151 (2005), Monte Carlo simulations based on MCNP6 and direct measurements performed in the vicinity areas surrounding the already installed Varian DMX linac. Results obtained from conventional methods were within recommended dose limits for both treatment rooms while photon dose rates from Monte Carlo simulations were higher than those obtained from conventional methods. Measurements from the Varian DMX linear accelerator showed that photon dose rates were within dose limits whereas neutron doses were above dose limits. The research concluded that radiation shielding analysis can be effectively performed by a combination of different methods. It also realised the need for more work to be done to characterise neutron dosimetry for a better quantification of neutron dose.

Contribution ID: 1199
20. Dosimetry and Radiation Protection
20.05. Shielding design

Advantages in the application of conductive shielding for AC magnetic field in MRI exam rooms

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Due to increasing demand for installation of magnetic resonance imaging (MRI) equipment in clinics and hospitals, and the difficulty to choose the location for installation of these equipments due to high intensity 60 Hz magnetic field sources, this study was carried out to present a practical solution for shielding 60 Hz magnetic field of in the hospital environment.
MRI is a technique that produces 3-D (volumetric) tomographic images of high resolution without the use of ionizing radiations. The quality of images is greatly influenced by magnetic fields of the environment, especially of 60 Hz, which results in the need to shield the space where the equipments are installed. This study proposes the use of aluminum in the construction of the MRI room shield for the many advantages presented by this material when compared to ferromagnetic materials: it is lighter, easier to handle, bend, rivet or weld, does not rust and dispenses sturdy supports for fixing to the walls, resulting in the best cost-benefits ratio in short and long terms. We performed computational simulation and experiments of shields of rectangular geometries assembled with aluminum and ferromagnetic materials. The aluminum shield has proved to be advantageous, since it presents shielding effectiveness properties similar to those of Fe-Si GNO, which is currently used for this purpose, but with a lower cost in the installation and maintenance of shielding in MRI rooms and better effectiveness because of its ability to shield both 60 Hz magnetic field and radio frequencies.

Contribution ID: 1555
20. Dosimetry and Radiation Protection
20.05. Shielding design

Validated Software for Performing Shielding Calculations based on NCRP Report 147 Methodology

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Structural radiation shielding calculations for diagnostic X-ray facilities is most commonly performed using the recommendations of NCRP Report No. 49 which continues to be the primary guide for diagnostic x-ray structural shielding design for a while. Many changes have occurred over the years that have caused the NCRP Report 49 calculation methodology to become essentially obsolete in that it did not address technology advances in Radiology. The methodology was remedied with the release of NCRP Report No. 147 by enabling shielding designers to specify effective barriers to diagnostic radiation environments.
FANR developed software for performing shielding calculations based on NCRP report 147 methodology to enable designers to calculate appropriate barriers easily and effectively. The software has selection boxes and drop lists related to the design choices between primary and secondary barriers, select the X-Ray Modality, occupancy factors , use factors with descriptions of typical barriers, targeted area, shielding design goals, workload, distance and Shielding Material .
The software has been made available on FANR's website and have been used worldwide by many researchers and designers. IAEA had been made an independent review, test and validate

this software. The software results were evaluated and compared with an independent analytical verification, based on methodology presented in NCRP 147. The validation was performed for the X-Ray Modalities included Radiographic Room, Radiographic & Chest Bucky, Rad Tube (R & F), Chest Room, Fluoroscopy Tube (R & F), Mammography Room, Cardiac Angiography and Peripheral and Neuro Angiography.
Subsequently, all the parameters such as use factors, occupancy type of the areas, annual dose limits, distances, weekly number of patients and shielding materials were methodically varied, in order to verify if the agreement is maintained. After this process, IAEA's independent reviewer found that the results produced by the code completely agree with the NCRP 147 established methodology.

Contribution ID: 1558
20. Dosimetry and Radiation Protection
20.05. Shielding design

Neutron dose evaluation at mazeless radiotherapy rooms

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Introduction: A shielding design suitable for rooms with accelerators is an important security measure for the protection of IOEs and members of the general public. NCRP 151 lays out the general considerations for the calculation of shielding in standard radiotherapy rooms, although it is noted that many shield designs differ from this standard room, such as mazeless rooms. Labyrinth-free rooms have been more commonly used, as they require less space to be built. As they are recent constructions there is no international norm or recommendation for those types of rooms. Therefore, the goal of this study is to evaluate the absorbed dose relative to neutrons in a room model without labyrinth, and to verify if these doses are within the limits established by the Brazilian National Nuclear Energy Commission (CNEN). Methods: The absorbed doses due to neutrons were calculated using computer simulation with the code MCNPX. The main interest is about the door, which is the most sensitive point in mazeless rooms. The Accelerator was simulated with energy of 15 MeV and it was considered a work load of 1000Gy/week. The simulated neutron spectrum was validated according to data published in the literature. Results and Discussion: First the neutron doses without the door were calculated, and the final dose was 48mSv/week. Then it was included 10 cm and 20 cm of 5% borated polyethylene, a widely used material for shielding neutrons. The final neutron doses were 0,7mSv/week and 100μSv/week, respectively. It is important to note that those doses are only due to neutrons. Conclusions: This study shows the equivalent doses due to neutrons in non-labyrinth radiotherapy. This will be important to evaluate the public and occupational doses in those kinds of bunkers, which are becoming more common in Brazil, and establish guidelines for the construction of this type of room.

Contribution ID: 1790
20. Dosimetry and Radiation Protection
20.05. Shielding design

Hybrid nanofibrous materials with ionizing radiation attenuation properties

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The aim of this project is to investigate the possibility of using rare earth and heavy metal compounds incorporated in polymeric nanofibrous matrix for ionizing radiation attenuation. The materials investigated are stable, insoluble compounds of iodine, tungsten, bismuth, hafnium and several elements from the lanthanide series, combined with polymer polyvinylbytural (PVB). The materials selected and produced should be able to attenuate photon energies in range of up to 100 keV. PVB as a matrix polymer was selected because of the ease of manipulation and sufficient radiation resistance for the desired application. The concentration of heavy metal compounds in hybrid materials possible to achieve was up to 90 %, while retaining breathability. Major attention is also given to the form of inorganic compounds and reducing the scale of particles to as small as possible via several methods, including variations of electrospinning, self-combustion synthesis and green synthesis methods. For pilot measurements, a sample of americium 241 was used in combination with Geiger counter and sound analysis software Audacity. The measured attenuation properties show, that when compared to conventional, bulk shielding materials, the prepared hybrid materials posses the same shielding properties, while being 30 to 40 % lighter. The materials produced were analyzed chiefly by scanning electron microscopy, energy dispersive x-ray analysis and thermogravimetric analysis.

Contribution ID: 547
20. Dosimetry and Radiation Protection
20.06. Micro– and nanodosimetry

Investigation on the effect of boron distribution inside a silicon microdosimeter

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Two commonly utilised boron drugs for BNCT is Sodium Borocaptate (BSH) and p-boronphenylalanine (BPA). The essential difference between the two drugs is how it is accumulated and distributed within a tumour cell. A silicon microdosimeter, designed by University of Wollongong, is comprised of an array of micron sized sensitive volume which simulates a human cell. The purpose of this study was to investigate the different method of boron distribution inside the silicon microdosimeter and its effect on delivered dose. A novel 3D mesa bridge microdosimeter is comprised of an array of 4248 individual silicon cells fabricated on a 10 micrometer thick n-type silicon-on-insulator substrate. Different boron distribution methods were simulated using the Particle and Heavy Ions Transport Code System (PHITS). A BPA and BSH setting was simulated by adding the 10B inside the sensitive volume and outside the sensitive volume, respectively. The energy deposition inside the detector for each particle present in the field was calculated and the microdosimetric spectrum was calculated by dividing the energy deposited per event by the average chord length of the detector. The thermal irradiation mode of the Kyoto University Reactor (KUR) was used in this study. The energy of the boron dose component (alpha and 7Li) was found to be larger for the BPA case, 191 keV/micrometer as compared to 118 keVmicrometer for the BSH. The total dose delivered to the sensitive volume of the detector was found to be 14 times larger for the BPA case. A simulation study using PHITS was performed and it was found that placing 10B directly inside the sensitive volume, i.e. BPA case, resulted in larger dose and higher energy delivered to the detector. Validation of the calculation will be performed once KUR has returned to operational use.

Contribution ID: 1109

20. Dosimetry and Radiation Protection
20.06. Micro– and nanodosimetry

Monte Carlo evaluation at a sub-cellular scale of targeted α-particle therapy

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Radionuclides have been increasingly used in cancer treatment, with varying degrees of success as both diagnostic and therapeutic agents. α-particles are of particular interest for the treatment of micrometastases. However, the stochastic nature of α-particles poses some challenges for dosimetric studies. One emitter, Astatine-211 offers many advantages for targeted therapy.
The TOPAS modelling tool was used to simulate the effects of 211At. The deposited dose and number of particle hits were calculated for two different cell models, one with a central nucleus and the other with the nucleus located at the periphery to evaluate the effects of the nucleus eccentricity. Cross-fire doses to non-target cells was also evaluated as a function of the source separation. Lastly, we explored the relationship between the energy deposited in the target and that in nearby marrow.
The influence of cellular geometry on the internal-dose shows an increased effect of the radiation on the nucleus in the eccentric model when the activity is distributed on the membrane. This effect decreases when the activity is distributed in the cytoplasm or medium. For the cross-fire dose, the dose and number of hits decrease with distance and for distances equal or greater than 5μm the sub-cellular localization of the activity in the source cell does not influence the cross-fire dose. Lastly, the limited range of the energy deposited is clearly shown as significant fractions of adjacent normal marrow components would see no α particle radiation.
As the clinical implementation of α-particles emitters is increasing, this type of study may be useful in interpreting clinical results. Currently, 211At is the subject of extensive study for targeted therapy. Due to its production cost and the capability to produce a stable radiopharmaceutical in addition to our simulations, 211At is an optimal candidate for the application of targeted α therapy.

Contribution ID: 1315
20. Dosimetry and Radiation Protection
20.06. Micro– and nanodosimetry

Synthesis of the Synchrotron Radiation Induced Gold Nanoparticles(GNPs) as a radiosensitizer in radiotherapy

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The goal of this study is to produce a gold nanoparticle based on high index facets(HIF) to maximize the effectiveness of radiotherapy. But the maximum dose enhancement factor of 3.7 is limited to existing research methods such as size and concentration of the nanoparticles, energy of the radiation sources. In this study, we synthesized gold nanoparticles using the synchrotron radiation induced gold nanoparticles.
GNP synthesized from HAuCl4 containing aqueous solution with synchrotron x-ray irradiation at the 4B X-ray micro-diffraction beamline of the pohang accelerator laboratory. GNP were examined by a variety of characterization methods using the Atomic Force Microscope (AFM), Scanning Electron Microscope (SEM) and Energy Dispersive X-ray Fluorescence Spectrometer (EDX) and Transmission Electron Microscope (TEM).
This study showed that the feasibility synthesizing GNP using the synchrotron radiation x-ray.

Contribution ID: 63
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Comparing the response-correction factors of different ion chambers employed in high dose per pulse intraoperative electron beam

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Intraoperative electron beam calibration through ionometric dosimetry is a sophisticated process because of high dose per pulse nature of produced beam and introduced uncertainties in determining the recombination correction factor (Ksat). Furthermore, dosimetry of intraoperative electron beam is performed at the depth of maximum dose (dmax), instead of reference depth. As a consequence, one cannot use the conventional protocols to determine the quality conversion factor (Kq,q0). In this study, Ksat and Kq,q0 of three different electron dosimeters including Advanced Markus, Roos and Pinpoint ion chambers (PTW, Germany) in intraoperative electron beam were measured and compared.
To determine the Ksat, Laitano formalism was employed. Kq,q0 was obtained at dmax according to recommendations of TRS-398 protocol. Measurements were performed inside MP3-XS water phantom using intraoperative electron beam produced by LIAC dedicated accelerator.
The values of Ksat for Advanced Markus, Roos and Pinpoint chambers at 6 MeV energy were 1.002, 1.027 and 1.001, respectively. Ksat values at 12 MeV energy were equal to 1.005, 1.218 and 1.004, respectively. The values of Kq,q0 for Advanced Markus, Roos and Pinpoint chambers at 6 MeV energy were obtained as 0.931, 0.930 and 1.072, respectively. Kq,q0 values at 12 MeV energy were 0.915, 0.914 and 1, respectively.
The results showed that both Ksat and Kq,q0 are energy dependent. For all studied chambers, Ksat increases with increment of electron energy, while Kq,q0 shows a reverse behavior. The values of Ksat were considerably lower than those obtained by the standard two voltage analysis (TVA) method. Therefore, employing the standard TVA method for Ksat determination overestimates the intraoperative electron dose. The Roos and Pinpoint chambers had the lowest and highest values of Ksat, respectively. This fact can be justified by operating voltage and electrode spacing of chambers understudy. Therefore, Pinpoint chamber has the best performance in intraoperative electron dosimetry.

Contribution ID: 71
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Absorbed dose-to-water primary standard for high energy photon beams and the BIPM.RI(I)-K6 comparison

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The primary standard for absorbed dose to water in high-energy photon beams operated at the national institute of metrology (NIM) is a sealed water calorimeter. The water calorimeter operated at 4 ºC to eliminate the problems associated with convection in water phantoms at room temperature. Using the cylindrical sealed glass vessel and bead thermistor of 10 kΩ, the resistance was measured by Wheatstone AC bridge. The correction factor for convective heat transfer is taken to be unity because the calorimeter is operated at 4 ºC, where water has its maximum density. The correction for perturbation of the radiation field by the vessel and probes was determined by the NIM using a small ionization chamber. The non-uniformity of the dose profile

was measured in the detector plane using an ionization chamber. The chamber positions describe a grid and gave the possibility to evaluate the entire dose-surface rather than a single profile. The heat defect has been assumed as zero for the N2 and H2 aqueous systems applied. After calibrating thermistor and bridge separately, absorbed dose to water is absolutely measured with the combined standard uncertainty of 0.38%.
NIM participate in the BIPM.RI(I)-K6 comparison for accelerator photon beams with the Bureau International des Poids et Mesures (BIPM). The comparison was based on the determination of absorbed dose to water at 10 g cm–2 for two radiation qualities at the NIM. The results, reported as ratios of the NIM and the BIPM evaluations (and with the combined standard uncertainties given in parentheses), are 0.9917(60) at 6 MV, and 0.9941(59) at 10 MV.

Contribution ID: 107
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Two independent dosimetry audits and comparison of two different calculation algorithms in the Leksell GammaPlan

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Purpose of this study was to make a dosimetry audit after Leksell Gamma Knife (LGK) Co-60 sources reload and comparison of both algorithms in the Leksell GammaPlan (LGP). Audits were performed by two institutions: 1) National Radiation Protection Institute, Prague, Czech Republic (NRPI) (on-site audit) and 2) The MD Anderson Dosimetry Laboratory (MDADL), Houston, USA (postal audit). Measurements were made in three different phantoms: 1) ABS Elekta plastic spherical phantom, 2) adapted anthropomorphic Alderson Rando phantom and 3) Stereotactic Radiosurgery Head phantom from MDADL. Calibration of the LGK unit was verified in the Elekta phantom by two independent PTW 31010 ion chambers. Then comparison between planned and delivered dose in anthropomorphic Alderson Rando phantom was done for a test treatment plan calculated by both TMR10 and Convolution algorithms. Additionally, irradiation of MDADL head phantom was made. The head phantom consisted of imaging insert with nylon ball target and dosimetry insert with TLDs and Gafchromic films. After on-site irradiation, the phantom was sent back to MDADL for an evaluation. Deviation between measured and reported calibration dose rate in the ABS plastic phantom was 0.7 %. Deviation in mean dose measured by ion chamber positioned within target volume in heterogeneous anthropomorphic head phantom was -1.1 % and 2.5 % for TMR10 and Convolution algorithms, respectively. Mean deviation between TLD measured and reported dose in Stereotactic Radiosurgery Head Phantom was from two TLDs 1.02. Gamma Index for coronal and sagittal films were 97% and 94%, respectively. Convolution algorithm generally calculated always longer irradiation times by 2-3 % on average compared to TMR10. This fact was also supported by measurement results. Based on results from this study the statement that Convolution algorithm provides more accurate calculation is not supported. Both on-site and postal audits used in this study showed very reasonable agreement.

Contribution ID: 187
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Investigation of the energy dependence of Wair in high energy electron beams

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The mean energy required to create ion pair in air, Wair, is considered to be energy independent above 10 keV. However, an extreme interpretation of the available data would allow a variation of up to 2% in the clinical energy range. To investigate this, a graphite ionization chamber and calorimeter with the same geometry and sensitive volume were irradiated with high energy electron beams to yield a value for Wair. Fourteen different configurations were used (varying incident energy, depth, and irradiation time) to investigate influence factors, with particular focus on the calorimeter response and analysis algorithm.
Thermal modelling was used to analyse the calorimeter measurements and various fitting techniques were tested for robustness against electrical and thermal noise. Applying an EGSnrc calculation of the restricted stopping power ratio (to convert from dose-to-graphite to dose-to-air) yielded a value of Wair of 34.0 ± 0.2 eV over the electron energy range of 9 to 27 MeV. This is consistent with the recommended value but does not take into account the perturbation corrections of the ionization chamber and calorimeter. A simplified model of detectors has been built and initial EGSnrc calculations indicate that this more accurate dose conversion method could lead to a value approximately 0.7 % lower.
The results indicate the feasibility of the method and analysis algorithms have been optimized. However, the variation in Wair with different experimental configurations indicates that some influence quantity is not being controlled, leading to an elevated standard uncertainty above what is desired. In addition, further, detailed Monte Carlo calculations are required to investigate perturbation corrections and yield the dose-conversion factor. Despite these limitations, this data, combined with that recommended in ICRU Report 90 indicate that the variation in Wair over the energy range of clinical interest is likely of the order of 0.5 %.

Contribution ID: 211
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Evaluation of Calibration curve for the EBT3 film in the 60-Co gamma rays

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Purpose: The aim of the study was to analyzed and evaluated uncertainty to measure calibration curve for the EBT film in the 60- Co gamma rays.
Materials & Methods: 60-Co gamma unit (Gamma Beam ™ 100-80, Best Theratronics, and Canada) was used for this study and it was irradiated from 0.5 Gy to 8.0 Gy to measure the calibration curve of EBT3(ISP, Wayne, USA). Several factor was evaluated to certify uncertainty of calibration curve. First the dependence of direction of scan plane was evaluated compared to the EBT2 film and the film scanner was used flat bed color scanner of the Epson Expression 1680 Pro (Seiko Epson Corporation, Nagano, JP) type. The stability of scanner was evaluated with repeated measurement after stability of film (24 hour). Second, the dependence of slab phantom size for measurement, the calibration curve was obtained by changing the slab phantom size.
Results: The stability of the scanner was evaluated according to the direction of the scan surface, and it was confirmed that the coefficient of variation of the value was within 0.05% when it was scanned, repeatedly. Calibration curve was fitted with quadratic function, function of EBT3 was y = -226.1x2 + 4075.x + 32569 (R^2 = 0.990) and y = -227.5x2 + 4073.x + 32763, R^2 = 0.988. In case of EBT2 was y = -267.7x2 + 5045.x + 24824 (R^2 = 0.992) and y = -263.3x2 + 5001.x + 24905 (R^2 = 0.994). It was confirmed that there is almost no difference in the calibration curve according to the size of the phantom.

Conclusion: Based on these results, Gafchromic EBT3 film may be useful for the dosimetry of 60-Co irradiation.

Contribution ID: 388
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Comparison of various detectors for Leksell Gamma Knife Perfexion small field dosimetry

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The purpose of this study was to perform an assessment of a large variety of detectors. Following detectors were used and tested for LGK Perfexion ROF measurements in this study: i) two types of micro ion chambers: Exradin A16 (volume 0.007 cm3) and PTW 31016 PinPoint 3D (volume 0.016 cm3); ii) two types of diode detectors: IBA dosimetry PFD (diameter 2.00 mm, thickness 0.06 mm) and IBA dosimetry SFD (diameter 0.60 mm, thickness 0.06 mm); iii) MicroDiamond PTW 60019 detector (volume 0.004 mm3); iv) three different film dosimeters: Kodak EDR2, Gafchromic EBT and Gafchromic MD-V2-55; v) radiochromic gel dosimeter based on Turnbull blue dye (TB gel); vi) alanine dosimeters: standard pellets (diameter 4.8 mm, thickness 3.0 mm) and mini pellets (diameter 3.0 mm, thickness 3.0 mm). All measurements were performed in the ELEKTA spherical ABS plastic phantom (160 mm diameter) except the measurements with TB gel. Home-made spherical PMMA phantom of diameter 160 mm was used for TB gel dosimeter measurements. Independent MC simulation was also done by using Geant4 for water as a phantom material. Results were compared with vendor’s default values. Independent MC Geant4 calculation agreed with vendor’s value by 2.0% and 1.5% for 8 mm and 4 mm ROFs, respectively. Overall the best agreement with vendor’s recommended values for 8 mm and 4 mm ROFs was seen for measurements performed with following detectors: Gafchromic EBT film (1.9% and -0.5%, respectively), Gafchromic MD-V2-55 film (0.7% and 0.6%, respectively), PTW MicroDiamond (-0.1% and 2.1%, respectively) and IBA dosimetry SFD diode (-0.8% and -0.2%, respectively). Other detectors appeared to have too large volume and/or too large uncertainty for this measurement, especially for the 4 mm collimator. The worst appeared to be PTW 31016 PinPoint 3D ion chamber with deviation -24.3% for 4 mm ROF compared to vendor’s value.

Contribution ID: 393
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Commissioning of the NIMTT China primary standard water calorimeter in Co-60 beam

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A collaborative project was completed to commission the primary standard water calorimeter of the National Institute of Measurement and Testing Technology (NIMTT), Chengdu, China, in the NIMTT Co-60 facility in September 2017. Measurements were made with two calorimeter vessels – a sealed vessel prepared at the National Research Council (NRC), Canada, and an open vessel prepared at the NIMTT laboratory. The open vessel can be re-filled and saturated with various

gases to investigate the radiochemistry of water systems. In this case it was cleaned, filled with high-purity water and saturated with H2. The sealed vessel was filled once, saturated with H2 and flame sealed at NRC.
The calorimeter was used to determine the doserate in a water phantom. The calorimeter is operated at a temperature of 4 °C to remove convection, but otherwise the setup conditions are as stated in the IAEA TRS-38 protocol (SSD = 1 m, field size = 10 cm × 10 cm, measurement depth = 5 cm). The average standard uncertainty on a set of 15 runs was 0.15 % for the sealed vessels and 0.22 % for the open vessel (dose per run ~ 3 Gy). Very good agreement was obtained between the results for the two calorimeter vessels, with a difference of 0.28 % (within the combined uncorrelated uncertainties).
A comparison in terms of absorbed dose to water was carried out between the water calorimeter and transfer standard ionization chambers traceable to the NRC primary absorbed dose standard. Three different Farmer-type ionization chambers were used in this investigation: IBA FC65-G, Exradin A19 and PTW30013. There was very good agreement between the dose rates measured by the ion chambers (standard deviation = 0.15 %) and a final value of the dose ratio D_NIMTT/D_NRC of 0.9961 (standard uncertainty = 0.6 %).

Contribution ID: 521
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Temporal characterization of the flat-bed scanner influencing dosimetry using radiochromic film

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Radiochromic films (RF) have been developed for measurement of the absorbed dose of low-energy photons. RF are self-developing and radiation sensitive, and the amount of darkening is proportional to the absorbed dose. RF are easy to handle due to their insensitivity to interior room light. However, the precision of the measurement was questioned because of the change in density caused by the scan timing of image acquisition using a flat-bed scanner.
In this study, the density change of a flat-bed scanner were investigated the temporal and the repetition scans. To obtain the image density, GAFCHROMIC XR-QA2 films (XR-QA2) were irradiated at 0 and 20 mGy (air-kerma) using 75 kVp (30 keV). XR-QA2 were scanned every hour (0-6 h) from power activation to investigate the temporal light source change of a flat-bed scanner (EPSON ES-10000G). In addition, ten consecutive scans were performed every hour. Scan parameters were RGB (48 bit) mode, 100 dpi, the reflection mode. Image data of XR-QA2 was divided into R, G, and B modes, and the R (16 bit) mode was used.
The temporal light source change of after power activation was little. However, in ten consecutive scans, the density of first scan was most high. The densities decreased with increasing number of scans. This result indicated that the precision of the dose measurement contains about 3% error due to the repetition scans.

To obtain an accurate dose measurement, the image data obtained the same conditions, such as same time from power activation or same number of consecutive scans, must be used.

Contribution ID: 590
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Development of a novel uncertainty budget determination methodology for small field dosimetry

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The use of small and irregular composed fields in radiotherapy has substantially increased due to the development of advanced equipment and treatment techniques, such as Intensity Modulated Radiotherapy (IMRT), Volumetric Arc Therapy (VMAT), Tomotherapy or Stereotactic Radiosurgery (SRS), among others. An accurate determination of the beam dosimetric properties under small field conditions with low levels of uncertainty is crucial to achieve a proper dose delivery to the patient. However, reported results often lack of a detailed uncertainty analysis and little mention is made on how it was determined, leading to discrepancies of up to 10% between different institutions.
We present a simple and easy-to-implement methodology for the determination of the uncertainty associated to the process of beam measurement in small fields. The uncertainties related to detector positioning were taken into account, as well as their characteristics. Contributions of the beam limiting device (BLD), scanning system, instrumental and correction factors introduced for field output factor () calculations were also analyzed in detail. Relative dosimetry measurements were carried out to determine according to the new small field dosimetry formalism, using nominal square field sizes from 5 x 5 mm2 up to 40 x 40 mm2. Different detectors, including ionization chambers with different active volumes and one stereotactic diode were used, presenting an uncertainty budget based on the new methodology for every experimental set-up tested. To complement the presented data, inline-crossline profiles and percentage depth dose (PDD) curves were acquired, allowing the assessment of each detector's performance.
We were able to demonstrate that the presented methodology is easy to implement and reproduce, recommending thus its implementation for small field dosimetry measurements, with the objective of providing different institutions and working groups with a reliable means of comparison of results.

Contribution ID: 729
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Verification of linearity and dose rate dependence in micro MOSFET on a linear accelerator at 6 MV

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In vivo dosimetry is an essential tool for quality assurance programs, being a procedure commonly performed with thermoluminescent dosimeters (TLDs) or diodes. However, a type of dosimeter that has increasing popularity in recent years is metal-oxide-semiconductor field effect transistor (MOSFET) detector. MOSFET dosimeters fulfill all the necessary characteristics to realize a in vivo

dosimetry, since it has small size, good precision and feasibility of measurement, as well as easy handling. Nevertheless, its true differential is to allows reading of the dose in real time, enabling immediate intervention in the correction of physical parameters deviations and anticipation of small anatomical changes in patient during treatment. In order for the MOSFET dosimeter to be better accepted in clinical routine, informations related to its performance should be available frequently. For this reason, this work proposes to verify linearity and dose rate dependence of the standard sensitivity MOSFET detector, model TN-502RDM-H. Experiments were performed at the Hospital Beneficência Portuguesa de São Paulo in a Varian Clinac CX Linear Accelerator in 6 MV under a field of 30 x 30 cm². Results demonstrate that the detector has good dose response linearity, especially at higher doses. In addition, the TN-502RDM-H MOSFET detector showed dependence on the dose rate, a fact that contradicts some data published in the literature for this same detector. Finally, it is concluded that the MOSFET detector is an instrument of great potential for applications in medical physics in areas such as in vivo dosimetry, for example, due to its good precision, easy handling, easy data extraction and satisfactory linearity. However, attention should be paid to the fact that the detector depends on the dose rate, and its frequent calibration is especially important when the dose rate settings are changed.

Contribution ID: 741
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Verification of energy dependence in MOSFET detector

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In vivo dosimetry is an essential tool for quality assurance programs, being a procedure commonly performed with thermoluminescent dosimeters (TLDs) or diodes. However, a type of dosimeter that has increasing popularity in recent years is metal-oxide-semiconductor field effect transistor (MOSFET) detector. MOSFET dosimeters fulfill all the necessary characteristics to realize a in vivo dosimetry, since it has small size, good precision and feasibility of measurement, as well as easy handling. Nevertheless, its true differential is to allows reading of the dose in real time, enabling immediate intervention in the correction of physical parameters deviations and anticipation of small anatomical changes in patient during treatment. In order for the MOSFET dosimeter to be better accepted in clinical routine, informations related to its performance should be available frequently. For this reason, this work proposes to verify the energy dependence of the standard sensitivity MOSFET detector. Experiments were carried out both in the Laboratório de Calibração de Instrumentos (LCI / IPEN) and in the Hospital Beneficência Portuguesa de São Paulo in a Varian Clinac CX Linear Accelerator. Radiation qualities used were RQR 3, RQR 10, Cs-137, Co-60 and linear accelerator at 6 MV and 15 MV. Data show that the dosimeter has a higher response to lower energy beam quality, such as RQR 3 and RQR 10, presenting a response of 13.4 mV/cGy and 12.3 mV/cGy, respectively. As the mean energy of the photon beam increased, the dosimeter showed a decrease of up to a quarter in its response when compared to energies of radiological level. This response was virtually constant for Co-60, and linear accelerator at 6 MV and 15 MV. Experimental data agree with literature and lead to conclusion that detector requires a moderate frequency calibration, especially for radiological level energies, where response changes considerably for a small variation of energy.

Contribution ID: 1033
20. Dosimetry and Radiation Protection

20.07. Dosimetry and calibration

Long-term reliability of optically stimulated luminescence dosimeters

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Optically stimulated luminescence dosimeters (OSLDs) are an attractive solution for in vivo radiotherapy dosimetry due to their small size, ease of use, sensitivity and reusability. OSLDs have been observed to decline in sensitivity with repeated use and it is important to determine whether this decline in sensitivity is associated with a decline in reliability.
This study used three batches of OSLDs (purchased in 2012, 2014 and 2016) that had been repeatedly re-used in a mature in vivo dosimetry programme over a period of up to five years and evaluated the consistency of their response over repeated irradiation-readout-annealing cycles. Each irradiation delivered 100 cGy to all OSLDs, using a 12 MeV electron beam from a Varian iX linear accelerator.
The five- and three-year-old OSLDs respectively displayed 86% and 89% of the sensitivity of the one year old OSLDs, but when a correction factor for each OSLD was derived based on the first measurement result and applied to each subsequent reading, all OSLDs were able to measure the 100 cGy test dose accurately, within standard deviations of 1.9 cGy for the 2012 OSLDs, 1.6 cGy for the 2014 OSLDs and 1.3 cGy for the 2016 OSLDs. If a mean calibration value was applied to the readings from each batch of OSLDs, instead of applying a measurement-derived sensitivity correction factor to each individual OSLD reading, the standard deviations increased to an unacceptable 6.1, 5.6 and 2.9 cGy.
A batch of well-used five-year-old OSLDs was shown to be capable of providing measurements with similar accuracy to more recently-purchased batches of OSLDs, provided that measurement-derived sensitivity correction factors were applied to each result. If this extra step is included in the OSLD measurement process, then the same OSLDs may be reliably used for years without needing to be retired and replaced.

Contribution ID: 1071
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Feasibility study of alanine dosimeter for carbon-beam dosimetry

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Alanine dosimeters are often used as a transfer standard in a kilo-gray level dosimetry, e.g. at radiation processing facilities. Nevertheless, alanine dosimeters have good characteristics also for therapy-level dosimetry: tissue equivalent and long-term stability of their response. Recently, we have started an alanine dosimeter evaluation for carbon beams used in radiation therapy. In this study, we have compared the response of alanine dosimeters between for Co-gamma ray and carbon beam irradiations in a therapy dose level.
The irradiation with Co-gamma ray was performed at the National Metrology Institute of Japan (NMIJ), the primary standard in Japan for absorbed dose to water. The carbon beam irradiation was conducted at Heavy Ion Medical Accelerator in Chiba at National Institute of Radiological Sciences (QST/NIRS-HIMAC). The nominal accelerated energy of the carbon beam was 290

MeV/u. The spread out Bragg peak was 6 cm in width and the dosimeters were irradiated at the center of SOBP. The dose rate was 0.3 Gy/mim for Co-gamma ray and 4 Gy/min for carbon beam. Alanine dosimeters and a calibrated ionization chamber were irradiated in the air in both irradiations. The irradiated dose was in a range from approximately 10 Gy to 30 Gy. The delivered dose to alanine dosimeters was determined by using the ionization chamber. The alanine signals, the number of the radicals created by the irradiations, were measured at the NMIJ using an ESR spectrometer.
The alanine response for the carbon beam were about 20% to 30% smaller than that for Co-gamma ray. This is due to the difference of linear energy transfer between Co-gamma ray and carbon beam. However, the response shows good linearity in each irradiation. In the future, we will extend the dose range of irradiations, and investigate what level of dose alanine dosimeter have linearity for the carbon beam.

Contribution ID: 1073
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

The effectiveness of morning QA measurements in detecting Linac target failure

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Aim: The aim of this study is to investigate the effectiveness of morning QA measurements in detecting target failure on Varian Trilogy linear accelerator (Linac).
Materials/Methods: A QA device was used to measure Linac beam parameters such as output, symmetry, flatness and energy in a single measurement. This was done every morning before the start of patient treatment for each Linac beam. Software provides trending of these QA results over time. These were monitored closely for any pattern that may provide early indication of Linac failure.
Results: We observed a continuous dropped in 6MV flattening filter free (6FFF) beam output. The output dropped from approximately -2% to -30% over a month. The symmetry of 6FFF beam also started to deviate from baselines. As 6FFF is a non clinical beam, no intervention was done at this stage as all other clinical beams were within tolerance. Only after 2 months since the first problem was detected on the 6FFF beam did the energy and symmetry of the 6MV flattening filter (6FF) beam showed signs of deviation from baselines. Further investigations with water tank measurements confirmed that the Linac target was degrading. After the Linac target was changed, morning QA measurements for all beams including 6FFF stabilized and remained well within the 3%tolerance.
Conclusion: 6FFF beam was found to be most sensitive in indicating problem with Linac target. Dropped in output and non symmetry of 6FFF beam showed up before others beams indicated a problem. Morning QA measurements was effective in detecting target failure that was confirmed by water tank measurements. Morning QA device is easy to use and provides valuable information that can be used to detect Linac issues at its early stage before patient safety is affected. It also allows early intervention that can prevent prolonged downtime on the Linac.

Contribution ID: 1338
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

X- Ray Calibration for Measuring Times and Central Ray

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X-ray equipment is used to create an image of diagnosing or treatment by using X-ray beam. X-ray beams are harmful to the body’s cells when the radiation dose is high enough. Therefore, the X-ray machine must always be calibrated to ensure that the X-ray machine is accurate to keep users safe. To check the X-ray machine, the machine must be measured reproducibility of kV, accuracy of kV, accuracy of time, accuracy of timer, radiation output, central ray, field of view, resolution and linearity of imaging system. The equipment used to measure each of these is expensive. In this research, we design the x-ray calibration phantom that is affordable and yet effective. The phantom consists of a central ray calibration unit, focal-to-object distance calibration unit and exposure time calibration unit. The central ray calibration unit and focal-to-object distance calibration unit consists mainly of a hollow metal cube. The x-ray image of the hollow-metal cube can be analyzed automatically using digital image processing to determine the central ray and focal-to-object distance. The exposure time calibration unit consisted of photo-transistor coated with x-ray phosphor and the signal conditional unit. When exposed with x-ray unit, the light detected photo-transistor is a full-wave rectification waveform corresponding to the 100-Hz high voltage supply of the x-ray tube. The waveform is digitized, and peak detected with Arduino. The number of peak is then converted to exposure time, i.e. one peak corresponds to 10 milliseconds. All other parameters calibration unit is left for future works.

Contribution ID: 1406
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

The metrological electron accelerator facility (MELAF) for research in dosimetry for radiotherapy

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The PTB, Germany’s national primary standard laboratory, operates the Metrological Electron Accelerator Facility (MELAF) for service and research in the field of dosimetry for external beam radiotherapy. The PTB also offers access to its metrologically well characterized radiation fields for external researchers also with other research projects beyond dosimetry. The purpose of this work is to outline the capabilities and the properties of our facility in order to foster new collaborations. Our facility is equipped with two conventional medical electron linear accelerators (LINACs) for the generation of high-energy photon and electron radiation as well as a research LINAC, which operates on the same principle as medical LINACs, but with free adjustable energy up to 50 MeV and adjustable charge (dose) per beam pulse also suitable for research in dosimetry for high dose-rate radiotherapy. In contrast to conventional medical LINACs the spectral electron fluence (monoenergetic beam) and the charge per beam pulse can be measured here in absolute values with small uncertainties. Therefore, radiation effects can be studied as a function of the fundamental physical quantities. Monte Carlo (MC) simulations, as for instance of the response of ionization chambers, can be verified in absolute manner. An electromagnet with magnetic flux density up to 1.4 T and sufficient space between the pole shoes in order to place a water phantom can be positioned in front of each accelerator for tests of dosimetry procedures for Magnetic-Resonance guided Radiotherapy (MRgRT). Examples for the experimental determination and verification of MC calculations of ionization chamber typical corrections factors, needed for dosimetry for MRgRT in order to take into account the deviations due to the magnetic field, will be presented.

Contribution ID: 1607
20. Dosimetry and Radiation Protection

20.07. Dosimetry and calibration

Dosimetry of blood irradiator using the Frike dosimeter

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Introduction: Blood products are irradiated using photons to diminish the risk of transfusion-associated graft vs. host disease (TA-GVHD). The radiation dose recommended by the Food and Drug Administration (FDA) is 25 Gy at the center of the canister or box and a minimum dose of 15 Gy elsewhere. There are several dosimetric systems already employed for the dosimetry of radiation dose in the process of blood irradiation. In this work, we propose the use of Fricke solution dosimeter to perform the dosimetry of a GammaCell blood irradiator. Methods: The Fricke solution was prepared according to the literature, 15 polypropylene bags of 5 X 2.5 cm2 with the solution were made and used for irradiation. A Gammacell 3000 Elan (Best theratronics), located at the Hemocenter in Rio de Janeiro/Brazil, with 2 Cs-137 sources was used for the irradiations. The dose rate at the center of the irradiator is 119,7 cGy/min, according to previous dosimetry made with EBT film by the physicist of the institution. 20 bags were distributed homogeneously over the irradiation holder walls, and irradiation was calculated to give 25 Gy, the same dose used for the blood bags. 5 bags were used as the control, submitted for the same conditions, but weren't irradiated. Results and Discussion: The mean dose delivered to the Fricke bags was 36.11 ± 2.02 Gy, which is 44% higher than the expected dose, 25 Gy. Conclusions: This is a preliminary study to analyze if the Fricke dosimeter can be used for quality control of blood irradiators. More irradiations are needed to have a final conclusion, but the obtained results showed that the delivered dose is much higher than the expected. It is important to control all the parameters during the irradiation to ensure the correct dose at the blood bags.

Contribution ID: 1638
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Calibration of well-type chambers for 192Ir HDR sources in Brazil

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The results and observations of four years providing calibration coefficient for well-type chambers used in the dosimetry of 192Ir high dose rate sources used in brachytherapy facilities in Brazil is presented. The calibration methodology developed by the LCR using a 60Co instead of 137Cs to determinate the air Kerma rate of 192Ir HDR source in the calibration procedure was endorsed by the IAEA. Appropriate Nk for a Farmer-type ionization chamber PTW model TN30001 are provided by Brazilian National Standards. A constancy check of the chamber is conducted every two months. During the last four years 139 calibrations were done and it was possible to verify a number of unsuitable measuring equipment, inadequate processes of chambers storage, no preventive maintenance of the equipment and the use software for quality assurance without knowing their algorithms and its limitations. Those problems appeared in 5% of the institutions that

use our calibration service. It can be finally said that almost all 98 different chambers in the country are now calibrated and traced to our National Laboratory.
In addition to the chamber calibration it was possible to provide continuous educational guidelines to help the institutions and physicists the correct way to use the calibration data and to establish quality assurance programs.
Keywords: calibration, well-type ionization chambers, dosimetry of 192Ir HDR brachytherapy source.

Contribution ID: 1650
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

A feasibility study of a postal dosimetry system using Fricke dosimeter

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Cobalt-60 irradiators and soft X-ray machines have been used for research, but its dosimetry is not always performed using the recommended protocols. This may lead to confusing and not trustable results for the conducted research. The Fricke dosimeter is the most widely used liquid chemical dosimeter with potential to be a standard of absorbed dose to water. Postal dosimetry systems are already recommended by IAEA, and TLD and OSL are the most common dosimeter system. This study tests the Fricke dosimeter properties as a potential system to be used in a postal dosimetry project. The Fricke solution was prepared according with literature the linearity and fading tests performed accordingly. All calculated doses were verified using a farmer ionization chamber NE2571 as a monitor. Doses ranging from 25 to 300 Gy were delivered by a research irradiator with 150 kV and 22 mA to the solutions inside the polypropylene bags (5x2.5 cm2). The results compared with the ionizing chamber response showed a linear response to the range of doses used. Fading tests have shown a standard deviation in the dose over 10 days of 0.6 % and type A uncertainties of 0.2 % Gy. Fricke dosimeter presented good linearity, for low and high doses and low uncertainties for the fading even for 10 days interval after irradiation. These preliminary results are encouraging, and as the next step is to design a postal dosimetry system using the Fricke bags arrangement. This work enables the use of Fricke dosimetry for X-rays, concomitantly, another works using 137Cs the 60Co are already in progress, and open the opportunity for the use of the dosimeter throughout the clinical area including different beam qualities from accelerators used to radiotherapy treatments.

Contribution ID: 1676
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Effective Point of Measurement (EPOM) of some ionization chamber for high energy photon beam from LINAC

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The volumetric effect occupied by the air cavity of ionization chamber(s) for high energy photon beams dosimetry inside water phantom is not completely negligible. So, aim of this study was to measure experimental values of EPOM of some ionization chambers by Percentage Depth Dose (PDD) method. The shift of effective point of ionization chamber is recommended as 0.75r (r being the chamber radius) for photon beam in TRS-277, DIN 6800-2 recommends 0.5r, TG-51 recommends 0.5r under reference condition and latest IAEA protocol TRS-398 recommends EPOM by a shift of 0.6r for non-reference condition which are valid for all energies. The present study is performed with PDD curves by placing chambers (PTW 30013, FC-65G and Semiflex-31010) at the geometrical centers for field size(s) from 5 × 5 cm2 to 30 × 30 cm2 at 100 cm SSD for various photon energy 6, 10, 15 MV. The shift of the cylindrical chambers were calculated from PDD values in comparison with reference PDD values by Parallel Plate Chamber (PPC-40 and Murkus-23343) for 100%, 80%, 50% and 30% depth in the water. In the current measurement, the shift of effective point at 6 MV photon lies in between 0 to 3.23r for chamber PTW 30013 and FC-65G. The effective shift of FC-65G has been found in between 0 to 1.06r for 15 MV photon beam. On the other hand, the shift of EPOM for Semiflex-31010 chamber have been found 0 to 2.55r for high energy photon beam. The uncertainties of EPOM measurement were within ±0.6-0.7% which are in good tolerance limit with literature published works. From the experimental value it is seen that the shift of the effective point of ionization chamber is not always fixed to any values and it varies with field size, beam energy and depth in water.

Contribution ID: 1710
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Comparison of radiation chemical yield G(Fe3+) values for Fricke dosimetry using different techniques for 192Ir HDR sources

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Fricke dosimetry has been recommended by both AAPM and ICRU as an absolute method for the determination of absorbed dose to water. For high dose rate (HDR) brachytherapy using 192Ir sources Fricke has been shown to be a feasible option as an absorbed dose standard. The key parameter needed to determine the absorbed dose to Fricke solution is the radiation chemical yield G(Fe3+) defined as the number of molecules of Fe+3 produced per Joule of energy absorbed in the solution. Most papers on the literature compare the G (Fe3+) value to 60Co and different beam qualities obtained from interpolations. The aim of this work is to compare the G (Fe3+) value for the same quality (192Ir) calculated by two different methods. For the first set of measurements three X-rays beam qualities; 150 kV (68 keV), 250 kV (132 keV) and 300 kV (159 keV); and 60Co gamma rays using small polypropylene bags filled with Fricke solution in a PMMA support. The G (Fe3+) value for 192Ir was calculated using the best curve-fitting of the data for those beam qualities. The second method used PMMA rods filled with Fricke solution. The irradiation was done using a 192Ir HDR brachytherapy (GammaMed Plus HDR 232, Varian). The rods have the same volume, geometry, and internal dimensions as an ionization chamber 0.6 cc. The absorbed dose to water was determined by ionometric means following the protocol TRS-398 using a calibrated ionization chamber (NE2571, Farmer 0.6 cc). The first method was carried out in collaboration with the IRD/CNEN and the second method was carried out at the LCR/UERJ. The preliminary results are encouraging and have shown differences of only 0.4% between the G (Fe3+) calculated value by the first and the second methods.

Key words: Fricke dosimeter; Radiation chemical yield; HDR brachytherapy.

Contribution ID: 1785
20. Dosimetry and Radiation Protection
20.07. Dosimetry and calibration

Overview of Radiation Metrology Laboratory at Radiation and Nuclear Safety Authority in Finland

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The purpose of this presentation is to give an overview of irradiation and calibration facilities and services, as well as quality management used in Radiation Metrology Laboratory (DOS) of Radiation and Nuclear Safety Authority (STUK) in Finland.
The national standards for radiation quantities of air kerma, absorbed dose to water and dose equivalent are maintained at DOS by secondary standards with metrological traceability to Primary Standard Dosimetry Laboratories, PTB and BIPM. DOS has been established in early 1970s and joined the Mutual Recognition Arrangement (MRA) of national metrology institutes established by the Committee for Weights and Measures (CIPM) in 2003. The key Calibration and Measurement Capabilities (CMC) are covered by regular intercomparisons with other national metrology laboratories.
DOS provides a wide range of irradiation and calibration services with gamma, beta, neutron and X-ray radiation. Calibrations for contamination meters with alfa, beta and gamma reference sources for surface emission rate (activity) are also provided. In addition to existing calibration services for survey instruments by Am-241Be and Cf-252 neutron radiation, the calibrations of personal dosimeters with neutrons are expected to be available in the near future. Customers of calibration services are mainly hospitals, radiation meter manufacturers, industrial companies, Finnish military, nuclear power plants and universities.
The calibration and irradiation facilities include three separate irradiation rooms committed for calibrations of radiotherapy, radiation protection and kV-range X-ray radiation. The Co-60 irradiation unit and the multisource gamma irradiator can be moved via tram rails between the three different irradiation halls providing the flexibility for use of facilities.
DOS performs research on radiation metrology and applied dosimetry supporting the regulatory and emergency preparedness of STUK. STUK and DOS has contributed to a vast number of EURAMET- operated research projects in the field of dosimetry and metrology.

Contribution ID: 9
20. Dosimetry and Radiation Protection
20.08. Radiation protection optimization

Assessment of neonatal entrance surface doses in chest radiographic examinations at East Avenue Medical Center

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A significant development in the initial diagnosis and evaluation of illnesses of neonates is the use of a chest x-ray. The technology is essentially useful to hospitalized and prematurely-born neonates suffering from respiratory and cardiovascular complications. Neonates are known to be more radiosensitive than adults because of the high mitotic rate of neonatal cells. There is also a higher risk of inducing stochastic effects to the neonates due to their long life expectancy. Despite such risk, physicians still require neonates to undergo radiographic examinations to monitor treatment progress while in the Neonatal Intensive Care Unit (NICU). Therefore, radiation doses received by neonates during a radiographic examination should be kept at a minimum without compromising the diagnostic image quality. In this study, the entrance surface dose (ESD) for neonates undergoing diagnostic chest radiography in the NICU at East Avenue Medical Center was measured. The ESD for the chest AP and LAT projections were found to be in the range of 0.022 – 0.080 mGy, and 0.023 – 0.080 mGy, respectively. Reference levels set by international organizations were used for benchmark comparisons of the results of the present study.

Contribution ID: 55
20. Dosimetry and Radiation Protection
20.08. Radiation protection optimization

On the effect of ursolic acid in radiation-induced impairment of neurogenesis, learning and memory in mouse

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The acute irradiation effect with 5 Gy or fractionated exposure with 0.5 Gy continuously for 10 days (i.e. a total dose of 5 Gy) was evaluated in an immature BALB/c mouse model. Radioprotective effect of ursolic acid (at 25 mg/kg/daily administered 1 h after acute or each of fractionated irradiations, and continuously for 30 days) was also investigated. It is found that both the acute and fractionated irradiation at a total dose of 5 Gy did not induce any mortality within 30 days after exposure to postnatal day 26 (P26) BALB/c mice, but reduced animal weigh gain in the first few weeks. At 90 days after irradiation, the weight of animals with acute irradiation was still significantly lower than the control group; no significant difference though was observed for those fractionatedly exposed mice compared to the control group. Behavioral tests indicated that acute irradiation at 5 Gy induced deficits in learning and memory in the contextual fear conditioning test. The memory for novel object recognition was also impaired. Similar changes were not observed in mice with fractionated irradiation. Our immunohistochemical study has clearly demonstrated that acute and fractionated irradiations induced impairment of neurogenesis in the subgranular zone (SGZ) of the dentate gyrus although fractionated exposure induced much lesser loss of newly generated neurons. Ursolic acid administered at 25 mg/kg/daily for 30 days after irradiation greatly improved acute irradiation-induced deficits in contextual learning and memory and in novel object recognition memory although it exacerbated radiation-induced reduction of neurogenesis in SGZ

Contribution ID: 134
20. Dosimetry and Radiation Protection
20.08. Radiation protection optimization

Errors in radiotherapy- experiences and issues in Nepal

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Background

Radiotherapy has been an essential component of the treatment of cancer for many years. Approximately half of all cancer patients require radiotherapy at some time in their illness. Radiotherapy is a complex, multi-step process that requires the involvement of different group of staffs such as Radiation Oncologist, Medical Physicist, Radiotherapy Technologist and Nurses in the planning and delivery of the treatment. Though errors are rare, but when they do occur the consequences can be significant for the patient.

Aim

The aims of the study were as following.

- Review the causes of errors and incidents
- Find ways of reducing occurrence of errors
- Increase detection before harm can occur
- Find ways of reporting errors and prevent repetition.

Material and Methods: We have tried to gather the information both by prospective and retrospective way. Some errors are found on the spot and some are found at the middle of treatment and some are at the end.

We have attempted to collect the errors, near misses, faulty data, miscalculation, wrong planning in Cobalt-60, High Dose Rate (HDR), Brachytherapy, Linear accelerators and Treatment Planning System (TPS)

Result: About 10 types of errors were detected in beam data configuration in TPS, Beam data output printing, planning in 2 Dimensional and 3 Dimensional Conformal Radiotherapy (3DCRT), Calculation, Brachytherapy planning and External radiotherapy treatment

Conclusion: Majority of the errors are hidden and not brought forward for discussion hence they are repeated and could not be minimized. Lack of radiation act, lack of manpower, external QA and monitoring system and lack of consumer right and awareness, poorly trained or untrained manpower, fear of being accused etc. are the issues to be addressed. Many errors can be corrected if proper recording and reporting culture is encouraged.

Contribution ID: 499

20. Dosimetry and Radiation Protection

20.08. Radiation protection optimization

Verification of the Structural Shielding for Tomotherapy in Korea

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Purpose/Objective: The purpose of this study was to verify the structural shielding by home-made program to calculation for Tomotherapy in South Korea.

Material/methods: We developed a suite of tools (“Tomo-SC”) using MATLAB software to shielding calculation base on the radiation safety reports and used to calculation. A total 20 units, which installed from 2005 to 2017 in South Korea, was analyzed for the workload (W), concrete thickness of ceiling, bottom, sidewalls (sidewall-1 and sidewall-2), and door, as well as recommend report for the effective dose and shielding calculation from collected radiation safety reports.

Results: The range of W factor was 600 – 14,045 Gy/week. The daily dose was 2 – 3 Gy. The number of daily treatment patients was 10 – 70 persons. The quality assurance (QA) dose was 45 – 1,000 Gy/week. IMRT factor was mostly used 15 values and maximum was 20 values. The recommend report for shielding design was mostly used the national council on radiation protection and measurements (NCRP) No. 151 report that the effective dose limit in controlled and uncontrolled areas were 0.1 and 0.02 mSv/week, respectively. The concrete thickness and

effective dose for primary structures including the ceiling, bottom, sidewalls, and door was satisfactory for radiation shielding.
Conclusion: Radiation delivery type of Tomotherapy was different than the conventional the linear accelerator (LINAC) unit. To ensure the safety of radiation shielding, it is necessary to use NCRP No. 151 report as standard recommendations. The W factor affects calculation of the structural shielding design, and can be varied various parameters, such as IMRT factor, daily and QA dose, daily treatment patients, and type of shielding structure. The Tomo-SC can be provides with a verify radiation shielding calculation tool for Tomotherapy unit in easily, quickly, and accurately.

Contribution ID: 535
20. Dosimetry and Radiation Protection
20.08. Radiation protection optimization

Optically stimulated luminescence dosimeters as an alternative to radiographic film for performing “head-wrap” linac leakage measurements

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The linac “head-wrap”, where a new or modified linac is covered with radiographic film as a means to identify regions of increased radiation leakage that could affect out-of-field dose to patients, is an important part of the linac acceptance/commissioning process. Qualitative results of the head-wrap allow ionisation chamber measurements to be localised in regions of maximum leakage, to verify the linac’s compliance with international leakage radiation limits. However, as radiographic film and developing equipment decrease in availability and increase in cost. a simple, reusable, non-chemical solution becomes increasingly desirable.
This study investigated whether discrete dose points measured using optically stimulated luminescence dosimeters (OSLDs) could be used to detect regions of increased radiation, as a substitute for radiochromic film.
Initially, a proof-of-concept study was completed, where OSLDs were taped to the exterior housing of a Varian iX linac in known high and low leakage regions (based on previous radiographic film measurements), to establish the ability of the OSLDs to detect leakage and differentiate between high and low leakage doses. When that study produced positive results, a second experiment was undertaken, where 60 OSLDs were positioned at regular intervals over the linac head by a member of the research team who was unfamiliar with the usual patterns of linac leakage and the specific leakage pattern of the linac under investigation.
Both sets of OSLD measurements were able to detect linac head leakage and quantify high and low doses (from 0.6 to 44.7 cGy per 10,000 MU) with sufficient geometric precision to guide the use of an ionisation chamber to measure leakage doses in the patient plane.
Reusable point dosimeters such as OSLDs are a promising solution to the problem of diminishing availability (and increasing expense) of film stock for linac head-wrap tests.

Contribution ID: 824
20. Dosimetry and Radiation Protection
20.08. Radiation protection optimization

Study of the X-Ray attenuation as a function of the density and thickness of the absorbent: cortical bone and BaSO4

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Radiation protection is responsible for ensuring the safety of people against the harmful effects of ionizing radiation, which can occur even at low doses of radiation; however there are procedures in which it is not possible to use the current radiation protection elements, because these interfere in the expected results. In the present work, a non-metallic X-ray attenuator material is proposed, mainly for medical imaging applications, in order to reduce the dose of radiation received by dispersion on patients exposed to ionizing radiation during the process of acquiring diagnostic images. For this purpose, the filing of cortical bone and barium sulfate (BaSO4) were characterized using X-ray diffraction (XRD), Dispersive X-ray energy (EDX) and Raman spectroscopy techniques, obtaining information about the physical, chemical and structural properties of the materials. On the other hand, the attenuation capacity of the X-Rays was determined with a conventional RX equipment (10-30 kV) and a Geiger-Müller detector, taking into account the intensity of the transmitted radiation as a function of the thickness and density of the sample, comparing the results with a sheet of (0.1 ± 0.05) cm of lead. In addition, a comparison of the attenuation of the radiation dose emmited by a dental RX generator (Gendex 770) using TLD-100 thermoluminescent crystals (Thermo Scientific, Massachusets, USA), being able to identify that barium sulfate (BaSO4) is the material that best attenuates this type of radiation compared to cortical bone.

Contribution ID: 1191
20. Dosimetry and Radiation Protection
20.08. Radiation protection optimization

Measurement of indoor radon concentration in three local government areas in ibadan

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Background: Radon has been classified as a human lung carcinogen. For this reason, there has been a lot of concern about the effect of radon exposure to people all over the world and Nigeria is no exception.
AIM: The aim of this study is to investigate the radon concentration in selected houses in three local government areas of Ibadan.
MATERIALS AND METHOD: In this study, indoor radon was measured in both mud and brick houses. 50 houses were considered from the three locations and a calibrated portable continuous radon monitor type RAD7 manufactured by Durridge company was used. A distance of 100 to 200 m away from each houses was maintained between each locations. For all measurement, the RAD7 was put on the table and on the floor in the center of the living room. The living room was kept closed during the measurements.
RESULTS: The mean value of the indoor radon concentration, average annual absorbed dose and average annual effective dose in Egbeda local government was 10.45 Bqm-3 ,0.13 mSvy-1 ,0.38 mSvy-1, Ona-Ara local government 17.95 Bqm-3,0.23 mSvy-1 , 0.54 mSvy-1and Lagelu local government was 16.90 Bqm-3 , 0.21 mSvy-1 and 0.51 mSvy-1 respectively.
CONCLUSION: The study concludes that overall average indoor radon concentration of the three local governments were found lower than the world average value of 40 Bqm-3.

Contribution ID: 1443
20. Dosimetry and Radiation Protection
20.08. Radiation protection optimization

Radiation monitoring at K-Health Radiopharmacy Medical Cyclotron Center in National Kidney Transplant Institute

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Cyclotron is widely known for the production of radionuclides in the field of nuclear medicine. In a cyclotron facility, gamma and neutron radiation are present during production process. Due to this, there might be high levels of radiation at the facility that might contribute to radiation exposure to the staff. Previous studies have shown that a high levels of radiation occurred during the bombardment period of the cyclotron. The study aims to measure radiation levels using radiation monitoring devices during production process of GE PETtrace 800 cyclotron, to determine if it complies with the radiation safety limits and to know if there are high radiation areas that might contribute to the unnecessary exposure of the occupational radiation workers. For a period of three (3) to six (6) months, radiation monitoring devices such as dosimeter-radiometer, advanced survey meter, and BDMN-96 probe were used to monitor before, during, and after the production of radionuclides at 14 points in the facility. The data were compiled to determine if there are any changes in the dose rate levels of neutron and gamma in the facility and if it meets the radiation safety limits set by the regulatory authority. The results of the study can be used to evaluate the safety protocols around the cyclotron facility.

Contribution ID: 1883
20. Dosimetry and Radiation Protection
20.08. Radiation protection optimization

Fundamental Research and Experimental Work on Properties of Tungsten Micro- and Nanoparticle Structured Composite Material

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Tungsten micro- and nanoparticle structured composite have been demonstrated recently as a promising material for protection of the radiation therapy patient against radiation. The shielding properties of the composite to a great extent depends on the homogeneity. The present research concentrates on the experimental investigation of the homogeneity of the synthesized composite in dependence on the material mixing methods, particle size, and concentration. The material radiation attenuation properties were explored as well. It was observed that the tendency to form agglomerates becomes greater if tungsten particle size decreases. The best particle distribution uniformity in the composite was obtained with ultrasound disperser. Most effective radiation absorption was observed for the samples with a particle size of 500 nm and 50 nm.

Contribution ID: 424
20. Dosimetry and Radiation Protection
20.09. Risk and dose optimization

Dose optimization and risk reduction: A tissue-equivalent test environment for malfunction detection of active medical implants caused by ionizing radiation

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Patients in radiotherapy with active implantable medical devices (AIMDs), e.g. pacemakers or implantable cardioverter defibrillators are at risk during treatment. The influence of ionizing radiation can lead to failures in the device function. This study presents a tissue-equivalent test environment to investigate the influence of ionizing radiation on AIMDs and failure of electronic components.
Numerous materials such as polymers, resins or gels were tested for their suitability as tissue substitutes. Two methods were used to identify tissue equivalence. First CT scans (120kV/200mAs, Somatom Emotion, Siemens Healthcare) were used to compare Houndsfield Units (HU) of the material with the HU of the corresponding organ. Then, Monte-Carlo simulations were performed using PENELOPE/PENEPMA to validate the materials by comparing the interaction coefficients to tissue (ICRU44) in the range of 0.1-1MeV. Further criteria for material selection were stability, formability, availability and price. Best fitting materials were then combined to form an anthropomorphic phantom of the torso using additive and subtractive manufacturing methods.
Structures such as the heart, lungs, ribs, spine and soft tissue are replicated tissue-equivalent to allow realistic treatment planning and to simulate the effect of radiation-induced interactions on the implant. Comparisons of HU have shown that PTFE (as rips, spinal column), Carrageenan (as heart), Styrodur (as lung) and Biresin® G27 (as soft tissue) get the tissue-equivalent characteristics close with an mean absolute difference of 13HU ± 3HU (mean ± SD). Monte-Carlo simulations validated the experimental results. A plug-in unit was developed to integrate AIMDs and single electronic components at the same position as in patients. It also accomplishes to lead electrode cables and a 0.125cm³ semiflex ionization chamber (PTW Freiburg) for dose verification to the heart.
The developed test environment is the basis for further standardized and reproducible irradiation on AIMDs to obtain valid evidence for any dose and radiation dependent malfunction.

Contribution ID: 698
20. Dosimetry and Radiation Protection
20.09. Risk and dose optimization

Development of a patient dosimetry record system in an oncological hospital in Mexico

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Nowadays the use of X-rays is increasing in the field of medicine; in the last 15 years, the proportion of people who have been subjected to a diagnostic procedure, has increased, and consequently the rate of radiation received by these techniques.
In most developed countries, it has been observed a considerable increase in dose absorbed by patients who had been subjected to medical imaging, especially in the modalities as CT (computed tomography), which is the one with the highest dose contribution. Because of the social alarm due to high doses, Mexico is begining efforts to obtain a radiological record.

The purpose of this work was to develop a software with the capacity to carry automatically a dose record of all patients who had been subjected to CT scanns or digital mammography in an oncology hospital, these two modalities were mainly considered because the CT is the most used modality for cancer diagnosis and it represents the highest dose contribution reaching up to 40% of the total dose and as for mammography, because this type of studies are recommended recurrently by sieving every certain time.
The system was programmed in Java and was installed on a Web server to be visible in any machine inside of the National Institute of Cancer in Mexico (INCAN). The system has visual alerts when a patient exceeds a radiation threshold; it also displays: Amount of radiation per time, per area and per study, presented graphically allowing the doctor to see more efficiently the information. It also have an intelligent system that continually downloads the studies stored in the PACS allowing to keep the information updated.
It is important to mention that this system does not prevent or restrict the amount of studies done, simply notifies the doctor to make a more informed decision.

Contribution ID: 1657
20. Dosimetry and Radiation Protection
20.09. Risk and dose optimization

Assessment of patient effective dose in certain diagnostic nuclear medicine procedures

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Nuclear medicine imaging has an imperative role in modern medicine due to its numerous advantages over other transmission, emission and reflection imaging procedures. However, patients are exposed to ionising radiation for different tissues and organs, which may results in cancer induction in future. Therefore, assessment of patient doses during nuclear medicine crucial for precise procedures justification and optimisation. The aims of this study are to measure effective doses for patients undergoing cardiac, thyroid and bone scan procedures. Technetium-99m-diethylene-triamine-pentaacetic acid was used for all procedures. A total of 130 procedures were performed (40 cardiac scan, 46 thyroid scan and 40 bone scan) were investigated using Orbiter 37 Gamma camera single head. Patients effective dose were estimated using the administered activity based on body surface area in relation to adult reference values. Regular quality control tests were performed precise activity administration. The mean and range of the administered activity (MBq) is 810.0±246 (740-1665), 177.4±16 (114.7-192) and 751.2±34 (740-925) for cardiac, thyroid and bone scan procedures, respectively. The mean effective dose (mSv) was 7.1±2 (6.7-13.2), 2.3±0.2 (1.5-2.5) and 4.3±0.2 (4.2-5.3) for cardiac, thyroid and bone scan at the same order. The radiation risk per procedure ranged between 1 x10-5 to 4 x10-4 for thyroid and cardiac scan respectively. Patient doses comparable with international atomic energy agency safety standards and international reference levels. Further patient dose reduction is recommended to reduce the radiation risks to its minimal value without affecting the image quality.

Contribution ID: 1690

20. Dosimetry and Radiation Protection
20.09. Risk and dose optimization

Integrity test of lead aprons and dose effect on personnel and carers in the department of radiology

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Background: The use of lead apron is known to help protect radiation workers and carers (mostly patient relatives) from scatter radiation but it has been observed that lead aprons in many radiology departments in Nigeria are carelessly placed anywhere after use. Aims and Objective: The study intends to assess the integrity of lead aprons by checking for defect and estimate mean dose rate to personnel and carers and also to compare percentage mean attenuation with related studies. Materials and Methods: Ten lead aprons were used with three vendors: Wardray Mediphot and Bar-ray denoted as A, B and C. Four of the lead aprons A were “wrapped around” with front/back protection, three of lead aprons B were also “wrapped around” with front/back protection and three lead aprons C having front protection only. A Precision RXI static General Electric (GE) fluoroscopy unit, a floor mounted X-ray unit, survey meter, lead aprons and meter rule was used in the study. Statistical analysis was done using SPSS 16.0 (SPSS Inc, Chicago, IL, USA). Results: Crack and tear were identified with some areas close to critical organ site. 80% of the aprons showed signs of being defective which may not necessarily mean that the aprons failed the rejection criteria. Correlation of the apron mean number of years in use and the number of defective lead aprons were not significant ($P = 0.866$). The mean thickness of apron for the three brands affected percentage absorbance ($P < 0.001$). Conclusion: Mean dose rate were above 20mSv recommended for radiation workers averaged over a single year, indicating that site with crack and tear may increase personnel and carers dose. It was recommended that defective aprons close to critical organ be replaced. Although, sum of area of defects could not be determined in this study.

Contribution ID: 1761
20. Dosimetry and Radiation Protection
20.09. Risk and dose optimization

Personalized estimates of long-term health risks following medical applications of ionizing radiation: Methods and software implementation

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With prolonged patient survival, long-term health risks following medical applications of ionizing radiation become increasingly important. In the German national project PASSOS (https://passos.helmholtz-muenchen.de/en), methods were developed to assess lifetime risks of cancer and heart disease following alternative procedures of breast-cancer radiotherapy and heart diagnostics and to compare them with the underlying spontaneous risks on a personalized basis. The methods combine individual anatomy and the resulting dose distributions with personal risk factors and relevant risk models.
Relatively low dose burden and hence low risk generally follows from nuclear medicine applications including heart diagnostics, although with individual variability due to pharmacokinetic and anatomic factors. Long-term health risks from breast-cancer radiotherapy are substantially higher, primarily resulting from the exposure of the heart, lungs and contralateral breast. Based on a dataset of 128 patients, individual variability in dose-volume distributions in these nearby organs following 3D-CRT, IMRT and hybrid whole-breast and boost irradiations was assessed and

correlated to the patients' anatomic features. The considerably lower doses to more distant organs were estimated from phantom measurements, Monte Carlo simulations and modelling.
To provide personalized estimates of radiation-induced lifetime risks, this anatomy-dependent dosimetric information was used in conjunction with risk estimates that combine relevant low- and high-dose studies in an organ-specific manner, and explicitly consider individual factors such as age or smoking status. Ongoing efforts aim at implementing these methods into a software tool that will provide personalized estimates of radiation-induced lifetime risks and compare them with spontaneous ones, with the goal to enable patient stratification and help in clinical decision-making processes.
Supported by the German Federal Ministry of Education and Research (BMBF) with contract number 02NUK026 (PASSOS).

Contribution ID: 1774
20. Dosimetry and Radiation Protection
20.09. Risk and dose optimization

Precise measurement of the stopping power of water for carbon ions below 6 MeV

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Cancer treatment by means of hadron therapy with carbon ions at intermediate energies enjoys several advantages compared to established approaches with photons or protons. Most important is the well-defined dose profile which allows to deposit the energy in a very localized target volume while affecting the healthy tissue only marginally.
For an accurate description of the dose deposition, it is therefore mandatory to know the stopping power of the tissue (water in good approximation) for carbon isotopes. Knowledge of the stopping power at energies prevailing in the so so-called Bragg peak region, i.e. the energy range for which the energy loss is maximal, is crucial for an optimal treatment and allows to avoid energy deposition in the healthy tissue behind the target volume. However, no experimental data for the stopping power of liquid water for carbon projectiles in this energy regime existed prior to the present work.
We therefore used the Inverted Doppler-shift Attenuation Method to measure the stopping power of water for carbon ions with kinetic energies below 6 MeV [1]. The results agree, e.g., with the recommendation of the ICRU report 73 errata [2] and recent theoretical results [3], but disagree with SRIM2013 calculations. However, a precise comparison is hampered by a large relative uncertainty of the present measurement which accumulates to 12%. Modifications of the present experimental setup are already planned and will allow to reduce the relative uncertainty. In addition, we will extend our efforts to describe the stopping power of tissue-like materials (phantoms).
[1] J.M. Rahm et al., Phys. Med. Biol. 59, 3683 (2014)
[2] J ICRU 5 (2005)
[3] W. Friedland et al., Sci. Rep. 7, 45161 (2017)

Contribution ID: 1870
20. Dosimetry and Radiation Protection
20.09. Risk and dose optimization

Dose optimization through diagnostic reference level, collimation and copper filter utilization

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X-rays are known to cause malignancies, skin damage and other side effects and they are thus potentially dangerous. Therefore, it is essential and in fact mandatory to reduce the radiation dose in diagnostic radiology as far as possible. This is also known as the ALARA (as low as reasonably achievable) principle. However, the dose is linked to image quality and the image quality may not be lowered so far that it jeopardizes the diagnostic outcome of a radiographic procedure. The process of reaching this balance between dose and image quality is called optimization. The aim of this study is to propose and evaluate methods for optimizing the radiation dose-image quality relationship in diagnostic radiography with a focus on clinical usefulness.
The first purpose of this study is to identify the initiative DRL (diagnostic reference level) as baseline for common x-ray examinations (Knee, Cervical spine, Shoulder, Lumbar spine, Chest, and Paranasal sinuses) taken by 6 digital radiography machines of the same brand in Primary Health Centers- radiology unit. We found that additional copper filter was not applied for mentioned examinations.
The second purpose is to investigate the effect of the addition of copper filter (0.1, 0.2 mm) and the proper collimation on effective radiation dose by measuring (DAP) dose area product in 6 digital radiography machines of the same brand.
Parallel to following ALARA principle and in order to optimize the patient's dose, using the specified filter addition, allowed an expressive decrease in (DAP) dose area product from 30% to 60% in different examinations.

Contribution ID: 433
20. Dosimetry and Radiation Protection
20.10. Occupational dosimetry

Activation of QA devices and phantom materials under clinical scanning proton beams – a gamma spectrometry study

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Activation of detectors and phantoms used for dosimetry of clinical proton beams may lead to radiation protection issues. Good understanding of the activation nuclide vectors involved is necessary to assess radiation risk for the personnel working with these devices on a daily bases or to fulfill legal requirements regarding transport of radioactive material and its release to the public. This study focuses on devices manufactured by IBA Dosimetry GmbH. Eleven devices and pieces of material were irradiated in a 220 MeV clinical scanning proton beam at the Proton Therapy Centre in Prague with a known amount of radiation. Gamma spectrometry was then performed for each item on a HPGe detector with a focus on longer lived gamma emitting radionuclides. Activities were quantified for all found isotopes and compared to relevant legal limits for exemption and clearance of radioactive objects. Activation of quality assurance devices was found to be significant after longer irradiation sessions, for example during commissioning of proton beams. Some of the investigated devices may also cumulate activity in time, depending on the scenario of periodic irradiation in routine clinical practice. However, the levels of activity and resulting beta/gamma doses are rather comparable to internationally recommended concentration limits for exemption than to dose limits for radiation workers. Results of this study will help to determine nuclide inventories required by some legal authorities for radiation protection purposes.

Contribution ID: 751
20. Dosimetry and Radiation Protection
20.10. Occupational dosimetry

Scattered doses around a full-body linear slot scanning X-ray unit

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Background: The Lodox Statscan X-ray unit is a linear slot scanning X-ray unit. The design of the system allows the acquisition of whole-body X-ray images: an X-ray tube and a detector system are mounted on a C-arm, which travels along the patient bed during image acquisition. The X-ray beam consists of a narrowly collimated fan-beam (either 0.4 mm or 1 mm wide) and very few scattered X-rays are produced.
Aim: The aim is to measure doses due to scattered radiation in the vicinity of a Lodox Statscan unit, in order to determine distances from the unit where staff and public radiation doses comply with regulatory requirements.
Method: Typical clinical scanning procedures and technique factors were applied to image an anthropomorphic phantom. Absorbed doses due to scatter were measured with a 30 cc calibrated ionization chamber at distances of 60, 75, 105, 135, 165, 200, 250, and 300 cm from the centre point of the bed, at vertical heights of 90 cm and 155 cm above the floor.
Results: Doses due to scatter were measured at different positions for a total of 390 scans. Curves were fitted to the data. The inverse of these equations were then used to determine isodose curves around the Lodox Statscan unit for different scan settings. Exposure rates were determined using the actual scan numbers in combination with occupancy factors.
Conclusion: It was determined that a safety line at 1.82 m from the centre of the bed, running parallel to the length of the bed, extending to 2.62 m on from the centre on the head- and foot-side of the bed, will suffice for the nursing staff's exposure levels to remain below 1 mSv / year.

Contribution ID: 838
20. Dosimetry and Radiation Protection
20.10. Occupational dosimetry

Validation of first TL based Personal Monitoring Service in Ministry of Health, Oman

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Ionising radiation is widely employed in the Sultanate of Oman including in Ministry of Health (MOH). According to the guidelines of IAEA Basic Safety Standards(2014), it is the responsibility of the employer to make arrangements for the assessment and recording of occupational exposures and for the workers' health surveillance. However, the current national radiation protection legislation of Oman does not fully mandate the requirements of BSS for the recording of occupational doses and currently we are outsourcing the personal monitoring (PM) services outside Oman. To overcome this problem in Ministry of Health, Oman; we established an in house Thermo Luminescent(TL) based PMS and a National Occupational Radiation Dose Registry (NORDR) to record, process, maintain and analyse the occupational doses of all its radiation workers.
We have procured two Harshaw 6600 Plus TL readers along with associated equipment for the PM service using Harshaw TL dosimeters 8850MCP series for whole body, DXT-707H MCP for

extremity, XD-107H MCP for eye and 8806MT for neutron dosimetry to record and process the occupational doses. Also, we have developed an in-house NORDR for the management of personal dose. MOH, Oman is having about 1800 radiation workers in about 160 health facilities. Each one of them is monitored by issuing a TL personal dosimeter every month through the CDRS by post for a wear period of one month. End of every month, the collected TLD's are processed for Hp(10), Hp(0.07)and Hp(3) based on the type of dosimeters.
The further details of our TL based PM service & the NORDR dose registry and its validation will be discussed during presentation. This dose registry can be emulated by other countries those who do not have a national dose registry for their radiation workers especially for those who are having relatively smaller number of radiation workers with less resources.

Contribution ID: 854
20. Dosimetry and Radiation Protection
20.10. Occupational dosimetry

Monitoring internal contamination from OEW of an 18F-FDG production plant: WBC or brain counting setup?

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The Nuclear Technology Development Center (CDTN), a Brazilian public research institute, has an 18F-FDG production plant. The risk of internal contamination at this facility is low and 18F has a short half-life (109 min). Thus, a triage monitoring is being adopted in accordance with EURADOS recommendations. When a radiation portal Monitor at the controlled area exit detects internal contamination, the occupationally exposed worker (OEW) is sent for special monitoring at Internal Dosimetry Laboratory (LDI). A setup for evaluation of the 18F-FDG activity incorporated into the OEW brain, called Brain Counting System, was established in previous work. In this study, the whole body setup (WBC) was evaluated for IOE monitoring contaminated with 18F. The Monte Carlo Virtual Software (VMC) and the MCNPx code were used to assess the system efficiency. Three 18F distributions were simulated: i) uniformly distributed in soft tissue (UDST); ii) Na18F biodistribution (NAFB); and iii) 18F-FDG biodistribution (FDGB). The efficiency was compared to the current brain counting system efficiency under the same biodistribution conditions. The ICRP reference voxelized phantoms were used in the simulations. The results showed that the WBC setup was more efficient than the brain counter for all the studied 18F distributions: UDST = 570%, NAFB = 280% and FDGB = 190%. Despite this, especially for 18F-FDG, the possibility of bladder voiding before measurement can lead to considerable uncertainties when the WBC setup is used. On the other hand, bladder activity does not show great influence the calibration factor of the brain counting system. Future work will evaluate the WBC sources of uncertainties in the measurement of 18F incorporated activity.

Contribution ID: 1489
20. Dosimetry and Radiation Protection
20.10. Occupational dosimetry

Relationship between eye lens doses and occupational doses for different centres of interventional cardiology

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This study shows the level of eye lens doses and the relationship between eye lens doses Hp(3) and doses above the apron Hp(10) for 14 interventional cardiologists in 3 different centres of interventional cardiology.
The doses were measured repeatedly with TLDs simultaneously placed above the apron and close to the left eye. For each patient's procedure, the kerma-area product value (PKA) was known; values of Hp(3) and Hp(10) above the apron were normalized to total patients' doses for procedures performed by a given cardiologist in the measuring period.
The Hp(10)/PKA values for IC 1 : IC 2 : IC 3 were as follows: 0.00019 : 0.00069 : 0.00035 mSv/Gy*cm2 respectively. The Hp(3)/PKA values for IC 1 : IC 2 : IC 3 were as follows: 0.00015 : 0.00034 : 0.00029 mSv/Gy*cm2 respec-tively. The values in IC 1 were 2-4 times lower than in IC 2 and IC 3. The ex-pected annual Hp(3) doses were estimated; the highest was almost 16 mSv, the lowest 2 mSv.
The results show different approaches to occupational radiation protection by cardiologists in the three centres (the use of an automatic contrast medium in-jector, shielding placed on patients to absorb scatter radiation from patients) as well as different approaches by cardiologists within the same centre. The local practice in IC 1 was more dose-saving than in the other centres. The values of Hp(3)/Hp(10) were reproducible for each cardiologist, so the Hp(10) value could be used for a retrospective estimation of the eye lens dose when needed, even when the eye lens dosimeter was not worn.

Contribution ID: 1687
20. Dosimetry and Radiation Protection
20.10. Occupational dosimetry

Assessment of patient entrance skin dose (ESD) and effective dose (ED)for the most common interventional radiological exams at Mazandaran hospital

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Introduction:Nowadays we are witnessing an exponential application of interventional radiology techniques in various communities as well as Iran. Radiological technique is regarded as the 2nd contributing factor in increasing the amount of public doses in various societies. So that related radiation protection organization has recommended measuring patient doses resulted from such techniques. The aims of this study have been the measurement of skin entrance dose, effective dose and also calculating the parameters required to estimate the effective dose of interventional radiology systems to reduce patient doses during common diagnostic and therapeutic interventional examinations at Mazandaran hospital.
Materials and methods:After reviewing and analyzing interventional radiology examination data at an imaging
center of a Mazandaran hospital over a 12 month period, the five most commonly interventional radiology examinations, including cholangiography, liver chemoembolization, uterine fibroids embolization, bile duct stinting and brain embolization were selected for dosimetry calculations. For each examination, 10 patients were selected and their skin dose was measured using thermoluminescent dosimeters (TLDs). The effective doses resulting from these examinations were calculated using computational software (PCXMC) based on Monte Carlo calculations in an average human phantom.
ResultsThe average entrance skin dose measured for the patients cholangiography, liver chemoembolization, uterine fibroids embolization, bile duct stinting and brain
embolization were 52, 139, 413, 263 and 594 mGy respectively. Effective dose resulted

from the above examinations were 2.9,13, 36, 17.2 and 12 mSv respectively.
ConclusionAs expected, the patient dose in interventional radiology exams varied a lot because it depends on many factors including the type of medical imaging systems, complexity interventional examination, experience and skill of the operator, and patient weight.
Key word: Interventional radiology, Effective dose, Entrance skin dose, Mazandaran hospital

Contribution ID: 1689
20. Dosimetry and Radiation Protection
20.10. Occupational dosimetry

A four years study of personnel dose record using a direct ion storage dosimeter in radiology and dentistry department

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Background: Large percentages of X-ray facilities in Nigeria do not use radiation monitoring device; a few percentage that use them do not evaluate or carryout out assessment programs to ascertain the detriment to occupationally exposed workers. Objectives: This study was aimed at evaluating dose reports from 2013 to 2016 for personnel who operate radiation facilities and those that work within radiation field during certain X-ray procedures/examinations in the department of radiology and dentistry respectively; to ascertain if there is correlation between personnel dose and workload in both department and to determine if dose records are within acceptable limit recommended by the International Atomic Energy Agency (IAEA) safety standards. Materials and Methods: Direct Ion Storage (DIS) dosimeter was used for a total of 35 occupationally exposed personnel who work in the department of radiology and dentistry. The DIS dosimeter was read every two months and results were automatically saved on the instadoseTM platform. Results: The mean (total) dose in radiology department for the first, second, third and fourth year was 0.17± 0.08 (3.52), 0.08± 0.03 (0.77), 0.07± 0.04 (0.72) and 0.07± 0.05 (0.55)mSv and in Dentistry was 0.08± 0.02 (0.73), 0.05± 0.02 (0.42), 0.05± 0.02 (0.24) and 0.07± 0.04 (0.34)mSv respectively. There was significant difference in mean personnel dose from 2013-2016 in Radiology (P = 0.028) and in Dentistry Department (P = 0.004). Correlation of workload and personnel dose in Radiology (P = 0.240) and Dentistry Department (P = 0.765) wasn’t significant. There was no correlation in mean dose between both department (P = 0.256). Conclusion: Overall mean dose in both department for occupationally exposed personnel were below 20mSv IAEA dose limit per year. Dose reports of personnel in both department reduced as the year progressed due to radiation safety awareness.

Contribution ID: 1787
20. Dosimetry and Radiation Protection
20.10. Occupational dosimetry

Nursing staff radiation exposure in purpose built radio-iodine therapy treatment rooms

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Patients undergoing radioiodine therapy become sources of radiation for staff members within the hospital environment. In dedicated iodine therapy rooms, the staff members most exposed are the nurses, who are required to have constant interaction with the patient.

This study aims to quantify the radiation exposure as well as associated risks. Radiation exposure was audited from nursing staff records. The radiation exposure was measured using personal monitors in uSv. The results showed that on average a nurse received less than 1 uSv per patient. Patient groups that exposed the nurses to the most radiation exposure were pediatrics and elderly patients. However, in a year the contribution to individual radiation exposure was well below the occupational dose constraints. Radiation risk to nursing staff from radioiodine patients is negligible if basic radiation safety principles are followed, such as limiting the time spent with the patient and increasing the distance from the patient.

Contribution ID: 474
20. Dosimetry and Radiation Protection
20.12. Other

Development of laser safety glasses for laser alignment using a 3D printer

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Laser is highly intensive light so its safety procedure is an important during work of laser alignment for radiation therapy. We develop of laser safety glasses using a 3D printer. We developed a safety glasses to protect safety of operator’s eyes from a laser light that is need to position a patient for radiation therapy. The two Polaroid filters can be controlled an intensity of laser light so safety glasses of laser using the filters could be controlled the intensity of laser light. The frame of glasses was made by a high resolution 3D DLP (Digital Light Processing) printer. It is designed to be used regardless of glasses wearing. We transformed our 2D drawings into three dimensional models optimized for 3D printing. Polaroid filters are made of a special material that is capable of blocking one of the two planes of vibration of an electromagnetic wave so we observed change of intensity of laser light according as a geometrical orientation of the laser light. The intensity of laser light is changed periodically depending on filter’s angles. We have developed laser safety glasses using a 3D printer and the glasses can be controlled the intensity of laser light depending on operator’s purpose. The glasses can be a useful and safety tool for laser alignment and protection of operator’s eyes.

Contribution ID: 533
20. Dosimetry and Radiation Protection
20.12. Other

Hyaluronic acid nanoparticles in protection against ionizing radiation

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Current advances in nanotechnology have led to the development of the new field of nanomedicine. This area includes many applications of nanomaterials for diagnostic and therapeutic purposes. In particular, new approaches to site-specific drug targeting using nanoparticle drug carrier systems have been developed. Nanoparticle-based molecular imaging techniques have been introduced as improved treatment of patients. In recent years, hyaluronic acid (HA) has emerged as a promising candidate for biomedical applications such as tissue

engineering and drug delivery systems. HA-based nanoparticles have shown promising potential as the drug carrier for cancer therapy, due to specifically bind to CD44 which is over-expressed on various cancer cells. Already, a number of drug delivery systems such as drug-conjugates, nanocomplexes, and nanoparticles, using HA as the primary constituent have been widely investigated. Hyaluronic acid is a linear polysaccharide endowed with some exceptional physicochemical properties such as high biocompatibility and biodegradability, strong hydration and viscoelasticity that depend on the size of the molecule. It plays a variety of important physiological roles in tissue hydration and mechanical protection and is also involved in inflammation, leukocyte migration and extracellular matrix remodeling. For these reasons, HA appear to be a very interesting option that could contribute to the mitigation or even complete elimination of radiation damage. Our goal is to determine the radioprotective effect of hyaluronic acid nanoparticles (HA NPs). We are investigating in vitro effect of HA NPs with focus on toxicity assays relative to nanoscale as well as effect on irradiated cell lines and specific surface receptors in response to ionizing radiation. Also, HA NPs are applied to in vivo model (C57Bl/6J mice) before total body or partial thorax irradiation. This part of our research is targeting on effect of exogenous HA on the development and / or mitigating acute radiation syndrome and radiation induced lung injuries.

Contribution ID: 587
20. Dosimetry and Radiation Protection
20.12. Other

Usage of electrochemical methods in biodosimetry

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Advances and modernization of laboratory methods and increasing demands on retrospective biodosimetry force us to search for new approaches for accurate and fast quantification of absorbed dose in cases of accidental exposure to ionizing radiation. Electrochemical detection with sensors finds use in many areas of science and studies of various types of substances. This method is fast, cheap and very sensitive, which could find its utilization as a good biodosimetric tool for studying radiation-induced damage at the molecular level. Electrochemical methods offer a wide range of detection modes. Electrodes from various materials have emerged on the market in recent years, allowing the user to detect almost anything . To study and analyze the effects of ionizing radiation on nucleic acids, the most appropriate voltametric detection mode appears to be in conjunction with screen printed carbon sensors (SPE electrodes). This approach allows the absorption of DNA, enzymes and antibodies on the electrode surface, forming a biosensor to study changes in DNA structure or to detect metabolites of DNA damage. One of the first reactions in response to ionizing radiation includes the disruption of sugar–phosphate DNA backbone and the oxidation of bases. The most oxidative-prone site in DNA structure is carbon C8 on guanine. The product of this process is 8-hydroxyguanine, which is considered a stable and specific indicator of DNA damage and can be detected from the blood and urine in irradiated individual. The use of voltammetry to detect 8-hydroxyguanine in DNA isolated from peripheral blood lymphocytes of irradiated individuals could be a unique method of biodosimetry.

Contribution ID: 597
20. Dosimetry and Radiation Protection
20.12. Other

Incidence of burnout among medical dosimetrists in Portugal

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Burnout is a pathologic response to chronic occupational stress resulting on the lack of coping strategies that assist the individual to comply with the working demands. Burnout causes serious consequences for both the individual and the organization.
Given the lack of studies on the incidence of this disease in medical dosimetrists in Portugal, this study aims to compensate for this gap.
The method used for data collection was a survey divided into three parts. The first part was designed to evaluate the sociodemographic and professional conditions of the sample. The second part of the survey was based on the Copenhagen Burnout Inventory (CBI) and the third part was based on the Malash Burnout Inventory (MBI). The survey was distributed to all medical dosimetrists working in a public or private institution in Portugal, which gave the authorization to carry out the study.
In this study, we evaluated 17 medical dosimetrists (physicists and radiation therapists), engaged in six Portuguese public and private institutions.
Our results reveal an incidence of burnout among medical dosimetrists, between 35.3% (CBI) and 88.2% (MBI), manifesting more worrying results on the sub-scales of personal burnout, work-related burnout, emotional exhaustion and personal accomplishment.
For future studies it is recommended validate the questionnaires used in this study, ensuring their adaptation to the Portuguese clinical dosimetrists population.

Contribution ID: 1083
20. Dosimetry and Radiation Protection
20.12. Other

Conceptual design of reference radiation field simulating secondary neutrons during carbon-ion radiotherapy

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The risk of radiation-induced secondary cancer is of great concern to long-term cancer survivors who received radiotherapy and people involved in radiotherapy, because normal tissues around the treatment target are potentially exposed to undesired doses.
Estimations of the risk for conventional radiotherapy with high-energy x-ray and electrons have been reported based on epidemiologic studies including dose estimations. On the other hand, for ion-beam radiotherapy (IBRT) such as proton and carbon-ion radiotherapies, the risk estimation derived from epidemiologic studies is difficult yet because it is more modern radiotherapy modality. In addition, since many radiation species such as secondary charged particles and neutrons are produced by primary beam through interactions with irradiation devices and patient body during IBRT compared to conventional radiotherapy, dose-response relationships depending on radiation quality has to be investigated. In particular, secondary neutrons are a high-LET radiation which leads to high relative biological effectiveness (RBE) and provide whole-body exposure, though the neutron dose in IBRT is low according to published dosimetric studies. So it is very important to clarify the dose-response relationship for neutron exposures following IBRT. However, the epidemiologic approach is not realistic yet as mentioned before, biological experiments with cells and animals have still a key role.
The goal of this study is a development of reference neutron field for simulating secondary neutrons during carbon ion radiotherapy (CIRT) with the broad beam method. As is well known,

there is the dependence on neutron energy in RBE, so it is ideal to perform experiments in the real treatment room. But, such experiments should be limited considering constraints of time and biological hazard. It is, therefore, required for the reference field to simulate well the neutron energy spectrum in the treatment room. Here, conceptual design of the reference neutron field using Monte Carlo code, PHITS is shown.

Contribution ID: 1825
20. Dosimetry and Radiation Protection
20.12. Other

A method to automatically detect the high gradient profile region despite of beam quality and modifiers

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Quality Assurance of Treatment Planning System (TPS QA) is required, and in some countries obligatory, prior to first clinical use. During TPS QA one has to compare TPS calculations with measurements for different beam qualities and modifiers. According to ESTRO and IAEA recommendations for TPS QA the output factors, profiles and depth doses should be compared. For profile comparison the recommended tolerance levels depend on regions of dose profile (low dose area, penumbra, high dose area). Therefore it is important to have indisputable way of determination of these regions. Historically penumbra was defined as a part of profile between 20% and 80% of dose. This definition can be applied only for open beams. Alternatively we propose to use 3rd derivative in order to detect high gradient regions of profile. This method is based on the idea proposed by Fogliata et al. to specify the inflection point of FFF beams profile. The 3rd derivative used simultaneously with the 2nd derivative allows to divide profiles into different regions required in TPS QA analysis. In our project we examined how proposed method corresponds to previous penumbra definition. We analyzed profiles for 5x5, 10x10 and 40x40 open fields for depth of: 1.5cm, 5cm, 10cm, 20cm and 30cm. All profiles were normalized to the axis despite depth. We compared the boundaries of penumbra region defined according to the 20%-80% method and our proposal in terms of percentage of dose. It could be seen that starting point of penumbra increased with depth and field size, while ending point decreased. The effect was more significant for open flattened beams (WFF) then for FFF or wedged beams.
The proposed method allows fast and automatic detection of high gradient regions for open WFF and FFF beams, WFF beams with wedges, WFF beams shaped with MLC (like “U” shape fields).

Contribution ID: 594
21. Advanced Technologies in Cancer Research and Treatment
21.01. Adaptive radiation therapy (ART)

Is the outcome of deformable registration dependent on the extent of rigid registration matching in head and neck auto-segmentation?

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Aim: To study the role of rigid registration matching on the outcome of deformable image registration in the auto-segmentation of contours in head and neck radiotherapy.
Methods and materials: Two sets of five patients each, one with extended neck position and other with neutral position were chosen. Only patients without distorted anatomy were included. Inter patient registrations were done within and between the sets by using rigid registration of bony anatomy initially followed by deformable registration. A total of 90 registrations were done. The registration process was evaluated both qualitatively and quantitatively. Quantitative evaluation of deformable registration was done using dice similarity index (DSI). The deformed contours using auto-segmentation for each patient were then compared with the oncologist's contour and DSI was determined for brainstem, mandible, parotids, spinal cord and trachea. The relation between DSI and the rigid registration matching was analyzed. Paired student t-test was used for statistical analysis and p value less than 0.5 is considered as statistically excellent.
Results: The rigid registration of bony anatomy was good in the intra-set patients whereas inter-set rigid registration was poor because of difference in head positioning and mismatch of non-rigid bony structures. In the intra-set group, the mean DSI scores between the deformed contours and oncologist contours were 0.81 for brainstem, 0.73 for mandible, 0.79 for parotids, 0.83 for spinal cord and 0.87 for trachea respectively. For the inter-set deformable registration, the mean DSI scores were 0.72 for brainstem, 0.43 for mandible, 0.56 for parotids, 0.59 for spinal cord and 0.75 for trachea respectively.
Conclusion: For effective deformable registration, it is desirable to have a perfect rigid registration. Proper alignment is essential and indispensable in the auto-segmentation of contours using deformable registration. Improper rigid matching resulted in poor deformation evident from the DSI scores in the study.

Contribution ID: 1447
21. Advanced Technologies in Cancer Research and Treatment
21.01. Adaptive radiation therapy (ART)

Feasibility study a clinically significant anatomical change detection in HN IMRT using transit EPID images and organ-of-interest gamma analysis

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The major factors of radiotherapy for head and neck (HN) cancers include patient's anatomical changes and tumour shrinkage. These changes can significantly affect the planned dose distribution that causes the treatment plan deterioration. A transit EPID-based dosimetry has been clinically implemented to verify the dose accuracy as part of adaptive radiotherapy protocol. However, a gamma analysis dose insensitive to the critical organ changes as only entire treatment field is compared.
The objective of this feasibility study is to evaluate the dosimetric response to patient anatomical changes during the treatment course in HN IMRT using a novel organ-of-interest gamma analysis method. This provides more sensitive to specific organ change detection. Random replanned 5 HN IMRT patients with causes of tumour shrinkage and patient weight loss were selected and evaluated its transit dosimetry. A comprehensive physics-based model was used to generate a series of predicted transit EPID images for each gantry angle from original CT and replanned CT datasets. The patient structures (left and right parotid, spinal cord, and PTV56) were projected to

the EPID level. The agreement between the transit images generated from original CT and replanned CT was quantified using 3%,3mm gamma criteria. Only gamma pass-rate was calculated within each projected structure.
The gamma pass-rate in right parotid and PTV56 between predicted transit of original CT and replan CT were 42.8%(±17.2%) and 54.7%(±21.5%). The gamma pass-rate for other projected organs were greater than 80%. Additionally, the results of organ-of-interest gamma analysis were compared with 3D-CBCT and the rational of replan by radiation oncologists. It showed that using only registration of 3D-CBCT to original CT does not provide the dosimetric impact of anatomical changes. Using transit EPID images with organ-of-interest gamma analysis can provide additional information for treatment plan suitability assessment.

Contribution ID: 910
21. Advanced Technologies in Cancer Research and Treatment
21.02. Image–guided radiation therapy (IGRT)

A Pre-Clinical Image Guidance Technique for Synchrotron Radiotherapy

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Several pre-clinical radiotherapy techniques that employ third-generation synchrotron sources are currently being explored around the world, and as these pre-clinical techniques mature, so must the technology surrounding them. A synchrotron is primarily a research environment and meets few, if any, clinical standards. With the goal of realising some of these pre-clinical techniques as a viable treatment options for humans, the topic of patient positioning and image guidance has yet to be satisfactorily addressed.
We present a patient positioning protocol, complete with a user-interface for end-to-end image-guided radiotherapy on Imaging and Medical Beamline (IMBL) at the Australian Synchrotron. Our protocol is capable of interfacing with current medical imaging and treatment planning protocols, and using hardware available on IMBL (such as robotic patient positioning arms or small-animal stages) to perform highly accurate patient positioning for treatment. It is also ready to extend to both the dosimetry and conformal treatment aspects of radiotherapy.
We have successfully delivered our alignment protocol on IMBL using clinical datasets and treatment plans. A head-phantom with fiducial markers and 3D dose tracking capabilities was treated with sub-millimetre precision.
This work ensures that IMBL is ready for in-depth studies for patient positioning, immobilisation and treatment, now that it has a bridge to the clinical workflow. The next steps are to look at accuracies in patient immobilisation for different tumour sites and comment on what sites are viable to treat.

Contribution ID: 1049
21. Advanced Technologies in Cancer Research and Treatment
21.02. Image–guided radiation therapy (IGRT)

Four-dimensional digital tomosynthesis acquisition based on respiratory guidance

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Patient breathing-related sorting method of projections in 4D digital tomosythesis (DTS) can be suffered from severe artifacts due to non-uniform angle distribution of projections and noncoplanar reconstructed images for each phase. In this study, we propose a method for optimally acquiring projection images in 4D DTS. Depending on scan parameters such as the number of acquisition points per cycle, total scan angle and projections per acquisition amplitude, acquisition sequence is pre-determined. A simulation study for feasibility test was performed. To mimic actual situation closely, a group of volunteers were recruited and breathing data were acquired both with/without biofeedback. Then, x-ray projections for a humanoid phantom were virtually performed following (1) the breathing data from volunteers without guide, (2) the breathing data with guide and (3) the planned breathing data (i.e., ideal situation). Images from all of 3 scenarios were compared. Scenario #2 showed significant artifact reduction compared to #1 while did minimal increase from the ideal situation (i.e., scenario #3). We verified the performance of the method with regard to the degree of inaccuracy during respiratory guiding. Also, the scan angle dependence-related differences in the DTS images could reduce between using the proposed method and the established patient breathing-related sorting method. Through the proposed 4D DTS method, it is possible to improve the accuracy of image guidance between intra/inter fractions with relatively low imaging dose.

Contribution ID: 1060

21. Advanced Technologies in Cancer Research and Treatment
21.02. Image–guided radiation therapy (IGRT)

A novel Linac gantry-based on-board imager for CBCT, spectral CT and SPECT online imaging

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Purpose: To investigate the feasibility of a novel Linac gantry-based On-Board Imager (OBI) for routine CBCT, multiple-energy spectral CT, and SPECT online imaging through outfitting an MV-beam Linac with a single kV-beam source and a single photon-counting detector panel sharing the same coordinate system and isocenter of the MV beam in the Linac.
Methods: A kV-beam source and a pixelated CZT detector panel, positioning orthogonally to the MV beam axis, were mounted to a Linac in the treatment room. The system was designed using GATE Monte Carlo software and evaluated by several phantoms. The concurrent differentiated imaging performance from the triple modalities was mainly tested by a phantom with the gadolinium (Gd), gold (Au), calcium (Ca), and radioactive ^{99m}Tc inserts. The dual-isotope SPECT imaging was also examined by a phantom with ^{99m}Tc and ¹²³I inserts. The K-edge imaging and the optimal image-based weighting imaging, as well as an image-based material decomposition method, were used to differentiate and decompose contrast elements in multiple-energy spectral CT.
Results: The spatial resolutions of SPECT and CBCT imaging of the system were estimated to be 4.8 mm and 0.66 mm, respectively. In the SPECT/spectral-CT image of the phantom, the Gd, Au, Ca, and ^{99m}Tc inserts were differentiated and decomposed well from each other, and the reconstructed distribution of radiation activity of ^{99m}Tc agreed well with the CBCT image of the phantom. Moreover, the reconstructed distributions of two isotopes of ^{99m}Tc and ¹²³I can be separated clearly based on their different photon peaks of emitted gamma photons.
Conclusion: This study demonstrated the feasibility of a new OBI architecture by integrating triple modalities, CBCT, spectral CT and SPECT into Linacs. With the added functional and molecular information acquired from this OBI, further improvement for the accurate IGRT process could be achieved, especially for adaptive RT.

Contribution ID: 643
21. Advanced Technologies in Cancer Research and Treatment
21.03. Real time IGRT

Evaluation of the dosimetric benefit of using Cyberknife for stereotactic radiotherapy (SBRT) of prostate treatment

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Objective: SBRT is gaining prominence as an excellent treatment option for men with favorable risk prostate cancer. Because of the high doses per fraction, advanced treatment delivery techniques to correct for target motion thus reducing planning target volume (PTV) margins is important. The purpose of this work is to quantify the dosimetric advantage of using CyberKnife for prostate SBRT treatment over linac-based VMAT.
Methods: We consecutively selected 10 patients in this study. All of the patients had been treated with CK for 36.25-Gy in 5 fractions. As our previous study has demonstrated that a 3 mm margin is adequate for creating the PTV in the CK treatment planning, due to the fact that CyberKnife inTempo Adaptive Imaging System is equipped with a time-based motion tracking technology used to compensate for intrafraction motion of the target, we have adopted this margin in our clinical practice. For the linac-based treatment planning, our clinical guideline is to use 5 mm margin for the PTV, as imaging guidance associated with a linac doesn’t offer time-based motion tracking and compensation. Treatment planning comparison is performed on Multiplan and Eclipse planning system, respectively, using the constraints suggested in the RTOG-938 protocol.
Results: Our preliminary results show that, comparing to linac-based VMAT plans, the maximum doses received by 1-cc and 3-cc of the rectum in the CK plans are reduced by 5.9% and 6.2%, respectively. The reduction in the maximum dose received by the 1-cc of bladder is moderate (2%). The doses to the 90% of the bladder and the rectum are generally comparable or reduced with linac-based VMAT. The difference in the maximum dose received by the urethra is not clinical significant (1%).
Conclusions: An SBRT platform that tracks and corrects for prostate motion in real time has definitely advantage over other platform for prostate SBRT.

Contribution ID: 166
21. Advanced Technologies in Cancer Research and Treatment
21.04. High intensity focused ultrasound (HIFU) therapy

MR guided pulsed focused ultrasound for prostate cancer therapy: a histology study

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Purpose: Significant tumor growth delay has been demonstrated in mice treated with pulsed high intensity focused ultrasound (pFUS). This study aims to understand the cell killing mechanisms of pFUS.
Methods: Prostate cancer cells (LNCaP) were grown orthotopically in nude mice, which were subsequently treated using pFUS with an acoustic power of 25W, pulse width 100msec and 300 pulses in one sonication under MR guidance. Mutiple sonications were used to cover the entire tumor volume. Temperature (less than 40 degree centigrade in the focal spot) was monitored using MR thermometry. Animals were euthanized at pre-determined time points (n=2) after treatment: 0 hours; 6 hours; 24 hours; 48 hours; 4 days and 7 days. Two tumor-bearing mice were used as control. Three tumor-bearing mice were treated with radiation (RT, 2 Gy) using 6 MV photon beams. RT treated mice were euthanized at 0 hr, 6 hrs and 24 hrs. The tumors were processed for

immunohistochemical (IHC) staining for PARP (a surrogate of apoptosis). A multispectral imaging analysis system was used to quantify the expression of PARP staining. Cell apoptosis was calculated based on the PARP expression level, which is the intensity of the DAB reaction.
Results: The IHC results showed that PARP related apoptosis peaked at 48 hrs and 7 days in pFUS treated mice, which is comparable to that for the RT group at 24 hrs. The preliminary results from this study were consistent with our previous studies on tumor growth delay using pFUS.
Conclusions: Non-thermal pFUS increased apoptotic tumor cell death through the PARP related pathway. MR guided pFUS may have a great potential as a safe, noninvasive treatment modality for cancer therapy, either be used alone or combined with thermal HIFU or other therapies. This treatment modality might be able to synergize with PARP inhibitors for better therapeutic results.

Contribution ID: 116
21. Advanced Technologies in Cancer Research and Treatment
21.05. Target ablation by using microwave, radiofrequency, cryotherapy, etc.

An in vitro phantom study to quantify the efficacy of multi-tine electrode in attaining large size coagulation volume during RFA

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Radiofrequency ablation (RFA) is one of the most extensively studied and widely applied minimally invasive thermal ablative technique for treating various tumors located in liver, lung, kidney, bone, prostate and breast. The potential advantages of RFA include low cost, minimal scarring, less pain, increased preservation of surrounding tissue, improved cosmesis, shorter hospitalization time and lower morbidity. However, the major limitation of RFA is the poor efficacy in treating large size tumors, i.e., ≥ 3 cm in diameter. To overcome this deficiency, present in vitro study is focused on evaluating the efficacy of commercially available RITA's StarBurst® XL multi-tine electrode in achieving large size coagulation volumes. The study has been conducted utilizing different active lengths of nine tine electrode, viz., 2 cm, 3 cm, 4 cm and 5 cm. The power supply to the electrode is delivered by a commercial electrosurgical radiofrequency generator (RITA 1500X, AngioDynamics Inc., Latham, NY) that is capable of delivering RF power up to 250 W at a frequency of 460±5 kHz. The in vitro studies have been conducted on the cylindrical shaped polyacrylamide based tissue-mimicking phantom gels. Importantly, the developed phantom gels are transparent and turns into ivory white at a coagulation temperature above 50 degrees Celsius. The maximal longitudinal and maximal transverse dimensions of the dissected phantom gels post RFA procedure have been measured macroscopically from which the derived coagulation volume has been computed. The variation in the power supply, temperature distribution and the size of coagulation volume has been reported for different active lengths of the electrode. The effect of deploying the active length of electrode from one level to next level during a real-time RFA procedure has also been studied. Further, simplified novel statistical correlations between the coagulation volume and active length of the electrode have been developed.

Contribution ID: 1604
21. Advanced Technologies in Cancer Research and Treatment
21.05. Target ablation by using microwave, radiofrequency, cryotherapy, etc.

Paclitaxel loaded Nano-micelles for Enhanced penetration and Suppression of Peritoneal Carcinomatosis

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Peritoneal carcinomatosis (PC) is a fatal condition arising in gastrointestinal tract characterized by poor prognosis and poor understanding of the disease. PC patients administered drugs locally in the tumor region such as intraperitoneal chemotherapy, often suffer from low drug retention time and tumor penetration. Herein, we synthesized Lithocholic acid (LCA)-conjugated disulfide-linked polyethyleneimine (ssPEI) micelle nanoconstruct by covalently conjugating ssPEI and LCA, thereby forming nano-micellar structures which loaded with paclitaxel (LAPMi-PTX) drug for IPCh. Incorporation of positive surface charge aided in prolonged peritoneal retention presumably by ascites fluid-induced protein corona formation and the subsequent size expansion caused resistance against crossing the lymphatic openings for the undesired clearance. Furthermore, preferential tumor penetration by LAPMi-PTX is attributable to the permeation enhancing properties of LCA, and subsequent tumor activatable drug release was induced by the presence of the disulfide linkages. By integrating these properties, LAPMi exhibited prolonged peritoneal residence time, enhanced tumor permeation and chemotherapeutic effect clearly evidenced by in vitro tumor spheroid and in vivo studies. Importantly, our strategy enabled significant PC inhibition and the overall survival rate of tumor-bearing mice. In conclusion, we provided a new paradigm of intractable PC treatment by enabling the prolonged residence time of nanoconstruct and thereby enhancing tumor penetration and anti-tumor therapy.
Acknowledgements :
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Contribution ID: 73
21. Advanced Technologies in Cancer Research and Treatment
21.06. Nanotechnology in radiation therapy and imaging

Gold nanoparticles as a cancer theranostic agent

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Introduction: The application of nanotechnology to medicine that known as nanomedicine, focuses on the use of nanomaterials to develop novel therapeutic and diagnostic modalities. Because of unique physiochemical and optical properties of gold nanoparticle (GNP) such as good biocompability, nontoxic nature, surface properties, comparative Stability and etc., it have been widely studied in medicine, especially as a cancer theranostic agent.
Areas covered: This review focus on recent progress in the field of gold nanomaterials in cancer therapy and diagnosis. For cancer detection, several studies indicated that GNPs can be used for X-ray, MR and optical imaging. In the aspect of cancer treatment, more studies investigated the effect of GNPs in different treatment modalities like photothermal therapy, photodynamic therapy, sonodynamic therapy, drug delivery, and radiotherapy. Moreover, concern about the toxicity of different features of GNP and uptake method by cells or organs is addressed in in-vitro and in-vivo studies.
We have especially reviewed the role of GNP in improving radiotherapy efficiency as radiosensitizers. For optimization of the parameters influencing on the radiosensitisation of GNP, many studies have been performed in different scientific routes. We categorized them to 3 fields; monte carlo simulation, cellular and animal studies. Finally, according to the reported finding by different researchers, the Physical and biological mechanism of GNPs in providing the radiosensitizing effect have been discussed.

Contribution ID: 168
21. Advanced Technologies in Cancer Research and Treatment
21.06. Nanotechnology in radiation therapy and imaging

Synthesis and evaluation of C595 mAb-conjugated SPIONs nanoprob for specific detection of prostate cancer

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Introduction: Carcinoma of the prostate is the most frequent diagnosed malignant tumor in men and is the second leading cause of cancer-related death in this group. Early detection of prostate cancer is key to designing effective treatment strategies. However, in its early stages, PC rarely causes symptoms and new detection methods are needed for prostate cancer. The objective of the present study is to locate primary tumors or distant metastases using MRI with contrast agents targeted specifically to cancer cells. We take advantage of the fact that many types of prostate cancer cells express high levels of mucin 1 (MUC1) oncoprotein on their cell surface. The imaging strategy is to use super paramagnetic iron oxide nanoparticles (SPIONs), attached to an antibody that directly target MUC1, to specifically enhance the contrast of MUC1-expressing prostate cancer cells.
Methods: Conjugation of Mab C595 (anti MUC1) to SPIONs was achieved by using a heterobifunctional linker, sulfo-SMCC . Two type of prostate cancer cell lines were chosen for experiments: LNCaP (muc1-) and DU145 (muc1+). After determination of physical and biological characteristics of synthesized nanoprob, in vitro and in vivo imaging was performed in a 7 T MRI system (Bruker, Karlsruhe, Germany).
Results: The results of Prussian blue staining and measurement of iron uptake by cells, showed high targeting and specificity of C595-SPIO to MUC1 positive prostate cancer cells. In addition, MRI imaging of prostate cancer cells demonstrated that synthesized nanoprob with high stability and sensitivity have potential to be used as an MR contrast agent for the detection of MUC1 positive prostate cancer cells.
Conclusions: Results of this study showed that with development of this and similar imaging specific vehicles, targeted MR imaging of prostate cancer cells with more effective and detailed diagnosis through high concentrations of SPIONs at the tumors site is achievable.

Contribution ID: 288
21. Advanced Technologies in Cancer Research and Treatment
21.06. Nanotechnology in radiation therapy and imaging

Investigation of ROS enhancement in water due to gold nano-sheets for proton irradiation

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Introduction: Dose enhancement effects of gold nanoparticles (GNPs) in x-ray beams have been well documented. While GNPs were not expected to be effective enhancers in proton beams due to the low Z dependence of proton stopping powers, experimental measurements have shown radiosensitisation effects and indications that production of reactive oxygen species (ROS) plays a large role. As such, ROS production may need to be incorporated into radiosensitisation modelling

to account for the combined effects of direct and indirect damage. In this work, the ROS yield enhancement in water beyond a gold nano-sheet irradiated with protons was calculated using Geant4 as an initial step in the development of a complex cellular model studying radiation damage in the presence of GNPs for proton radiotherapy.
Method: Geant4-DNA chemistry models were used to simulate the ROS production in water beyond a 50 nm gold nano-sheet. The sheet was irradiated with protons of various energies and the tracking of the primary particle ceased once it passed through the sheet. The ROS yields over time were measured for a gold nano-sheet and compared with a water nano-sheet to find the enhancement.
Results: An enhancement in initial yields of ROS by a factor of 1.5-3.5 was observed due to the gold nano-sheet. It was found that the ROS enhancement decreased with increased time after physical interactions. Additionally, the enhancement peaked for protons in the energy range of 5-10 MeV.
Conclusion: The reduction in ROS enhancement over time is likely due to increased recombination at the higher concentrations beyond the gold nano-sheet. The greater enhancement effect for 5-10 MeV protons is beneficial as these are present in the spread-out Bragg peak conformed to the tumour. This study allows subsequent modelling of the ROS production and radial yield enhancement for gold nanoparticles in water irradiated with protons.

Contribution ID: 1000
21. Advanced Technologies in Cancer Research and Treatment
21.06. Nanotechnology in radiation therapy and imaging

Radiotherapy synergistic therapy of treating deep-seated use 2-Deoxy-D-Glucose Coated graphene quantum dot

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Heavy metal Quantum dots (QDs) have been proposed by many people as potential PDT agents, however, they have high biological toxicity. In contrast, graphene thin quantum dots are thought to have few side effects, low systemic toxicity and minimize the risk of cells developing drug resistance. Photoluminescence properties also make it a suitable candidate for biomedical applications.
Glioblastoma, the most common primary brain tumor in adults, also relies heavily on glucose metabolism to survive and proliferate. The current standard treatment of glioblastoma is surgical resection, radiation therapy and drug therapy, but there is a high recurrence of tumors. It is also difficult to eradicate tumors with the current traditional surgical resection. A number of radiation therapy co-therapy strategies such as chemotherapy, photodynamic therapy and photothermal therapy are used to inhibit and / or kill cells. However, these methods still have many limitations such as carrier specificity and the limited depth of penetration of UV and NIR light. To overcome these limitations, we achieved highly specific synergistic and highly accurate synergistic radiotherapeutic treatments by using a strategic design of deoxyglucose-bonded graphite QDs as a targeted vector delivery system. Graphene quantum dots (GQDs) which are multifunctional vectors, were coupled with deoxyglucose (2DG), a glucose analogue, to generate new 2DG-GQDs complexes.
Delivery of 2DG-GQDs complexes to brain cancer cells via blood-borne vectors using the blood-brain barrier transport mechanism allows nanocarriers to significantly increase accumulation in tumor cells.
Use of radiation-enhancing nanocarriers followed by irradiation with 6MV X-rays proved to be more effective at eliminating tumors.
Preliminary results simply GQD plus 6MV X-ray had 20% radiation-enhancing.

Contribution ID: 1062
21. Advanced Technologies in Cancer Research and Treatment
21.06. Nanotechnology in radiation therapy and imaging

Preferential sensitization of S-phase cells with gold nanoparticles

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Cancer heterogeneity from the cellular to inter-individual level greatly impacts treatment, prognosis and probability of tumour control. While nanoparticles have been shown to significantly improve the effects of radiotherapy, little is known regarding their mechanistic effects and the impact of highly heterogeneous distribution in tumours. In our work, we utilise synchrotron X-Ray Fluorescence (XRF) to quantify nanoparticles in individual cells cross-correlated with confocal microscopy images of DNA breaks after irradiation with clinical radiotherapy sources. Nanoparticle uptake histograms provide Probability Density and Cumulative Density Functions that describe heterogeneity in nanoparticle uptake and provide statistical comparison between cell lines and time points. The individual cell data on nanoparticle uptake are correlated with biological markers, such as DNA breaks, in radiosensitization studies to enable elucidation of fundamental mechanisms and probabilistic effects for stochastic radiobiological models.
The ability to study discrete sub-populations of cells enables discrimination of cell variables and heterogeneity in response to internalization of nanoparticles and effects of irradiation. These data have revealed mechanistic phenomena. Low numbers of nanoparticles in cells leads to a radio-protective effect and different correlations on the degree of sensitization with nanoparticle uptake are found between different cell phases. Cells in the S-phase are known for being radioresistant. Numbers of cells in the S-phase in tumours can be a negative prognostic factor, contributing to tumour recurrence and treatment failure. We identify that these cells are sensitized to a greater extent with the inclusion of nanoparticles compared to cells in other phases and could contribute to macro-scale effects observed. The statistical, probabilistic data are further useful for stochastic Monte Carlo models in the design of optimised fractionation schedules.

Contribution ID: 1250
21. Advanced Technologies in Cancer Research and Treatment
21.06. Nanotechnology in radiation therapy and imaging

Radiosensitization of breast cancer cells using AS1411 aptamer-conjugated gold nanoparticles

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A main choice for cancer treatment is radiotherapy. But, the radiotherapy disadvantage is damages caused by radiation given to normal tissues/organs surrounding cancer. One way to avoid this is via increasing radiosensitization of cancer cells. Gold nanoparticles (GNPs) have shown sensitizing effect on cancer cells by enhancing their absorbed dose. Unlike earlier delivery

techniques developed for nanotherapeutics, active targeting can achieve specific effect and higher uptake of GNPs in tumors while leave healthy cells untouched and consequently improve the therapeutic index. To achieve active targeting, GNPs should be equipped with functional ligands which can recognize and adhere to the receptors of cancer cells. Aptamers are small DNA-molecule/RNA-fragments with high specificity and affinity towards target molecules. AS1411 aptamer can specifically bind to over-expressed nucleolin on the membrane of tumor cells including breast cancer. This aptamer is capable to enter cancer cells through specific ligand–receptor interaction. Greater uptake of GNPs by cells may induce increased radiation effects. Cancer stem cells are a small population of cells within a tumor capable for self-renewal and differentiation into various cell types. We hypothesized that conjugation of GNPs with AS1411 (AS1411/GNPs) could increase GNPs-mediated radiosensitization in breast cancer cells. We hypothesized that AS1411/GNPs would radiosensitize breast cancer stem/progenitor cells grown to three-dimensional (3D) mammospheres. Cytotoxicity studies of the GNPs and AS1411/GNPs were done on two different cancer cell lines of MCF-7 and MDA-MB-231 with MTT assay. Atomic absorption spectroscopy (AAS) confirmed the cellular uptake of particles. Radiosensitizing effect of GNPs and AS1411/GNPs on MDA-MB 231 and MCF- 7 cells assessed by clonogenic assay. Clonogenic survival data revealed that AS1411/GNPs at 12.5 mg/L results in radiosensitization of breast cancer cells. Mammosphere of MCF-7 was more resistant than their monolayer counterparts.
Keywords: Goldnanoparticles, Radiosensitivity, breast cancer cell, aptamer, AS1411, mammosphere.

Contribution ID: 647
21. Advanced Technologies in Cancer Research and Treatment
21.07. Small animal research technologies

Intelligent platform for stereotactic body radiation therapy in head and neck cancers: Small animal model

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Purpose: Novel stereotactic body radiation therapy (SBRT) for human lung and liver cancers has been widely discussed. However, SBRT for human head and neck cancers is not yet well-established. Traditional translation focuses on studies from animal models to human diseases. Veterinary medicine includes nature occurring animal disease that may be similar with human disease. Translating medicine from human to veterinary oncology and back is developing. In this study, we aim to establish an intelligent platform of Taiwan Small Animal Radiological Sciences (TSARS) to share advanced radiological equipment including CT, MRI, PET/CT, and SBRT in head and neck cancers for veterinary oncology.
Material and Methods: We developed a picture archiving and communication system (PACS) in cloud archive for veterinary medicine in Taiwan. Services and processes workflow were as follows: This system implemented the Digital Imaging and Communications in Medicine (DICOM) Storage Service that allowed any imaging equipment to directly send acquired images to the centralized

cloud archive. The workstations in hospitals and research institutes could search and transfer images through the cloud archive. The encrypted keys were transmitted through the DICOM Bridge Router and the images were transmitted over the public cloud providers in a ciphered manner. In our platform, we could gather DICOM diagnostic imaging, radiotherapy planning, radiobiological effects and clinical outcomes of SBRT in head and neck cancers for veterinary medicine. .
Results: In the platform, we translated basic and clinical results of human medicine to veterinary medicine and back. We connected academic departments/hospitals in the human and veterinary oncology. We further integrated diagnostic CT, MRI, PET imaging and radiotherapy planning system.
Conclusion: We establish an intelligence platform to share advanced radiological equipment for small animal radiological sciences in Taiwan. Basic researches, preclinical studies, and clinical results of human medicine and veterinary medicine can be translated to and fro.

Contribution ID: 1057
21. Advanced Technologies in Cancer Research and Treatment
21.07. Small animal research technologies

Triple on-board imaging in a small-animal radiation therapy platform

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Purpose: To investigate the feasibility of using a single pixelated semiconductor imager to realize triple on-board imaging including regular CBCT, multiple-energy spectral CT and SPECT in a small-animal radiation therapy (SART) platform.
Methods: The SART platform with the capability of on-board triple-modality image guidance was designed using Gate Monte Carlo code. A single energy x-ray tube was used both for imaging at a low tube current and for radiation therapy purpose at a high tube current. A single photon-counting CZT imager was used to detect both x-ray photons and gamma photons for reconstruction of spectral-CT/CBCT and SPECT images of small animals, respectively. The imaging performance of the system was evaluated with several phantoms, mainly including a PMMA phantom with the iodine (I), gadolinium (Gd), and isotope ^{99m}Tc inserts. The K-edge imaging and the optimal image-based weighting imaging, as well as an image-based material decomposition method, were used to differentiate and decompose contrast elements in the multiple-energy spectral CT imaging reconstruction.
Results: The intrinsic spatial resolution of the pixelated CZT imager was measured to be 8.6 lp/mm at 10% modulation transfer function (MTF). The spatial resolution of CBCT and SPECT imaging of the system was estimated to be 4.5 lp/mm at 10% MTF and 1.2 mm, respectively. In the SPECT/spectral-CT image of the phantom, the I, Gd, and ^{99m}Tc inserts were differentiated and decomposed well from each other, and the reconstructed radioactivity distribution of the ^{99m}Tc agrees well with the actual inserts, which can also be seen from the SPECT/CBCT image of the phantom.
Conclusion: This study demonstrated a novel SART platform with high-quality on-board SPECT/spectral-CT/CBCT imaging of small animals, which provides comprehensive anatomical, functional and molecular image guidance for radiation beam delivery. This architecture could also shed lights on the clinical procedure of RT, especially for adaptive RT.

Contribution ID: 1814
21. Advanced Technologies in Cancer Research and Treatment
21.07. Small animal research technologies

Intelligent platform for stereotactic body radiation therapy in head and neck cancers: Small animal model

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Purpose: Novel stereotactic body radiation therapy (SBRT) for human lung and liver cancers has been widely discussed. However, SBRT for human head and neck cancers is not yet well-established. Traditional translation focuses on studies from animal models to human diseases. Veterinary medicine includes nature occurring animal disease that may be similar with human disease. Translating medicine from human to veterinary oncology and back is developing. In this study, we aim to establish an intelligent platform of Taiwan Small Animal Radiological Sciences (TSARS) to share advanced radiological equipment including CT, MRI, PET/CT, and SBRT in head and neck cancers for veterinary oncology.
Material and Methods: We developed a picture archiving and communication system (PACS) in cloud archive for veterinary medicine in Taiwan. Services and processes workflow were as follows: This system implemented the Digital Imaging and Communications in Medicine (DICOM) Storage Service that allowed any imaging equipment to directly send acquired images to the centralized cloud archive. The workstations in hospitals and research institutes could search and transfer images through the cloud archive. The encrypted keys were transmitted through the DICOM Bridge Router and the images were transmitted over the public cloud providers in a ciphered manner. In our platform, we could gather DICOM diagnostic imaging, radiotherapy planning, radiobiological effects and clinical outcomes of SBRT in head and neck cancers for veterinary medicine.
Results: In the platform, we translated basic and clinical results of human medicine to veterinary medicine and back. We connected academic departments/hospitals in the human and veterinary oncology. We further integrated diagnostic CT, MRI, PET imaging and radiotherapy planning system.
Conclusion: We establish an intelligent platform to share advanced radiological equipment for small animal radiological sciences in Taiwan. Basic researches, preclinical studies, and clinical results of human medicine and veterinary medicine can be translated to and fro.

Contribution ID: 1826
21. Advanced Technologies in Cancer Research and Treatment
21.07. Small animal research technologies

Simulation of novel stereotactic body radiation therapy for canine nasal tumors

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Purpose: Novel stereotactic body radiation therapy (SBRT) for human lung and liver cancers has been widely adopted. While SBRT for human head and neck cancers is not yet well established, curative-intent SBRT using evolving technology for veterinary oncology is developing. This study

was designed to simulate novel dynamic arc SBRT for canine nasal tumors and investigate the dosimetric and radiobiologic effects on tumors and organs at risk (OAR).
Material and Methods: We simulated a canine nasal tumor model treated by dynamic arc SBRT in the radiotherapy treatment planning system. The dosimetric index of the tumor and OAR, dose distribution, and dose-volume histogram were analyzed to evaluate the treatment planning quality. Different radiobiologic effects including biologically effective dose (BED), α/β, and equivalent dose in 2Gy fractions (EQD2) were also evaluated.
Results: In the canine nasal tumor models, the radiation dose ranged from 12~14 Gy x 3~5 fractions. The dosimetric index, BED (α/β=10, range 84.4 ~ 100.8 Gy10), and EQD2 were acceptable and within the constraint limits.
Conclusion: SBRT is feasible for canine nasal tumor models. It is worthy of further basic researches and preclinical trials which human oncology and veterinary oncology can be translated to and back in the future.

Contribution ID: 334
21. Advanced Technologies in Cancer Research and Treatment
21.08. Hyperthermia therapy

Combined therapeutic ultrasound and metformin for the treatment of cancer tumors

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Specific Aim: Metformin is a drug for type-2 diabetes and it has anti-cancer properties and selectively targets cancer stem cells. Therapeutic ultrasound can produce both thermal and mechanical effects to destroy tumor microenvironment, kill cancer cells and enhance the efficacy of anti-cancer drugs. In this study, we investigated cancer treatment by combination of metformin and ultrasound.
Materials and Methods: In in-vitro study, CT-26 cancer cells were cultivated in 96-well dishes. There were four groups: Control, Met (metformin alone, 1 mM), pUH (pulsed-wave ultrasound hyperthermia alone, 42℃, 0.94-MHz, 0.1-mW and 10% duty cycle for 15-min), and pUH+Met. In in-vivo study, BALB/c male mice were used and the mice were injected subcutaneously with CT-26 Luc colon cancer cells in the right flank. Treatments were started when the tumors grew up to 50 mm3. The mice were randomly divided into four group: Control, Met (25 mg/kg by oral gavage), pUH (1.0 MHz, 2.7 W and 50% duty cycle ultrasound for 15 min) and Met+pUH. The treatment was taken every 3 or 4 days with a total of 4 times. Tumors were measured every two days and IVIS imaging was taken every week. H&E staining was used to study the effects of metformin and pUH on the tumors.
Results: The in-vitro study showed that Met+pUH decreased the cell viability significantly than the other groups either Met or pUH alone for a single treatment. The in-vivo animal experimental results showed that Met+pUH could effectively suppressed the tumor growth, and the effect was significantly better as compared to Metformin alone or pUH alone after a sequential treatment. Lymphocyte infiltration, inflammation and tissue rupture could be observed on the H&E staining for both pUH and Met+pUH groups.
Conclusion: The effective treatment of cancer cells and cancer tumors by pulsed-wave ultrasound hyperthermia can be markedly enhanced by metformin.

Contribution ID: 347
21. Advanced Technologies in Cancer Research and Treatment
21.08. Hyperthermia therapy

Equivalent radiation dose escalation for lung cancer cell line with 13.56 MHz radiofrequency hyperthermia

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The enhancement of radiosensitivity by hyperthermia depends on the targeted temperature and type of cancer cell lines. We investigated the effects of hyperthermia on lung cancer cell lines by calculating the parameters of cell survival curves and equivalent radiation dose escalation in mouse xenograft models. Lung cancer cell lines A549 and H226 were used for in-vitro cell experiments and mouse heterotopic xenograft models were made for in-vivo experiments. The local ethical committee for animal experiments approved the experimental protocol used in this study (IACUC No. 17-0110-S1A1). A 13.56 MHz radiofrequency hyperthermia system was used for heating the cancer cells and mouse tumor models to a temperature of 42°C. To investigate the radiosensitizing effect of hyperthermia, hyperthermia was applied following radiation therapy of 10 Gy. To quantify the effect of combined radiation and hyperthermia therapy, numerical simulations were performed on a CT mouse model to calculate the equivalent radiation dose escalation with modulated radiosensitivity parameters. Lung cancer cells and tumors could be heated to 42°C selectively compared to surrounding medium or tissue. Thermal enhancement of radiosensitivity was found for the parameters of the cell survival curves. Temperature-depended equivalent radiation dose escalation was determined and an escalation of over 2 Gy was found in the mouse tumor model. Overall, hyperthermia enhanced the radiosensitivity of the lung cancer cell lines and escalated the equivalent radiation dose to the mouse tumor model. The present study would contribute to effective clinical thermoradiotherapy planning.

Contribution ID: 1408
21. Advanced Technologies in Cancer Research and Treatment
21.08. Hyperthermia therapy

Development of a spherical ultrasound transducer for transcranial low-dose ultrasound hyperthermia used in brain tumor nanodrug delivery

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Previous studies showed that low-dose focused ultrasound hyperthermia (UH) could enhance the delivery and therapeutic efficacy of nanodrug for brain metastasis of breast cancer. In this study, our purpose is to design an ultrasound transducer that can be used for clinical application for brain tumor nanodrug delivery. Computer simulation has been used to calculate the pressure field, temperature distribution and thermal dose in the brain for different parameters of a spherical array ultrasound transducer. An ultrasound transducer with 112 disc elements (1 MHz, 2 cm in diameter) was constructed and its heating ability was characterized using a skull phantom filled with hydrogel. The simulation results showed that the position of peak pressure was slightly offset when the transducer was mechanically moved 3 cm away from the center point in all directions. There was no significant side-lobe developed when the transducer was moved away from the center 2 cm. Temperature distribution showed that the heating zone was an ellipsoid with temperature

higher than 42℃ for a maximum intensity of 119 W/cm2. Phantom experiment showed that the 42℃ color-changeable hydrogel would turn to be white at the focal point when the transducer was moved 2 cm in all directions with an electrical power 55 W. A spherical ultrasound phased array was developed and characterized. This ultrasound transducer has the potential used in transcranial short-time ultrasound hyperthermia for brain tumor nanodrug delivery.

Contribution ID: 1610
21. Advanced Technologies in Cancer Research and Treatment
21.08. Hyperthermia therapy

Radiothermotherapy for glioblastoma multiforme: A preliminary study

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Background and aim: Glioblastoma multiforme (GBM) is a highly radioresistant cancer with low survival rate. Current therapy approaches have failed to treat GBM. The aim of this study was to assess how GBM tumors respond to combination of hyperthermia and radiotherapy.
Material and methods: In this study, 38 GBM patients were included. 19 patients were treated with 60 Gy radiations in 30 fractions and 19 patients received 60 Gy radiation and 10-12 hyperthermia seasons. Hyperthermia was done using 13.56 MHz radiofrequency radiation, with capacity electrodes. All hyperthermia regimens were delivered one hour before radiotherapy. For all patients, Karnofsky Performance Status (KPS) and tumor volumes were assessed before and 3 months after treatment.
Result: Our results showed that KPS was improved in hyperthermia group rather than radiotherapy group. In regard to tumor volume changes, 2 and 3 patients had more than 50% and 20-50% decrease in tumor volume post radiotherapy respectively and 7 patients had no change. Also, 2 and 5 radiotherapy patients had more than 50% and 20-50% increase in tumor volume respectively. In hyperthermia groups 8 and 4 patients had more than 50% and 20-50% decrease in tumor volume respectively and 5 patients had no changes. In addition, 2 patients had 20-50% increase in tumor volume.
Conclusion: Our results identified that combination of hyperthermia and radiation is a feasible approach to treat GBM patients and patient’s quality of life.

Contribution ID: 1679
21. Advanced Technologies in Cancer Research and Treatment
21.08. Hyperthermia therapy

Gold nanoparticle-induced sonosensitization enhances the antitumor activity of ultrasound against colon tumor–bearing mice

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Light-driven cancer therapy strategies (e.g., photodynamic therapy and photothermal therapy) have undergone remarkable progress in recent years, but they suffers from the serious drawbacks of the limited penetration depth of light in tissue. As a non-invasive and nonionizing radiation, ultrasound can be remotely focused and transfer energy to any depth inside the body, thereby addressing the penetration depth barrier of light. The effectiveness of ultrasound for cancer therapy can be considerably improved by utilizing nanomaterials exhibiting sonosensitizing properties, which are so-called nanosonosensitizers. Gold nanoparticle (AuNP) has been recently presented as a potent nanosonosensitizer with the potential to simultaneously enhance both the thermal and

mechanical interactions of ultrasound with tissue. Accordingly, this paper attempts to evaluate the in vivo antitumor efficiency of ultrasound in combination with AuNP.
Balb/c mice bearing CT26 colorectal tumor model were intraperitoneally injected with AuNPs and then subjected to ultrasound irradiation (1 MHz; 2 W/cm2; 10 min) for three sessions. The tumors were thoroughly eradicated and the mice appeared healthy over 21 days of study span without the evidence of relapse. Furthermore, [18F]FDG (2-deoxy-2-[18F]fluoro-D-glucose)-positron emission tomography (PET) imaging was performed and radiomic features form different feature categorizes were extracted to quantify tumors' phenotype. The animals treated with AuNP plus ultrasound exhibited an obvious decline in tumor metabolic parameters such as standard uptake value (SUV), total lesion glycolysis (TLG) and metabolic tumor volume (MTV) compared to other treatment groups.
These findings strictly propose AuNP as a potent sonosensitizing agent with the potential to focus the thermal and mechanical damages of acoustic waves on the tumor, resulting in strong antitumor efficacy.

Contribution ID: 1684
21. Advanced Technologies in Cancer Research and Treatment
21.09. Laser therapy

Iron-gold (Fe2O3@Au) core-shell nano-theranostic for magnetically targeted photothermal therapy under magnetic resonance imaging guidance

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Photothermal therapy (PTT) is a nanotechnology-assisted cancer hyperthermia approach in which the interaction between laser light and plasmonic nanoparticles generates a localized heating for thermoablation of the tumor. Recent efforts in the area of PTT follow two important aims: (i) exploitation of targeting strategies for preferential accumulation of plasmonic nanoparticles within the tumor and (ii) enabling real-time guidance of PTT operation through employing multimodal imaging modalities.
In the present study, we utilized a multifunctional theranostic nanoplatform constructed from a magnetic core and Au shell (Fe2O3@Au) in order to fulfill these aims. The Au shell exhibits surface plasmon resonance, a property that is exploited to realize PTT. The magnetic core enables Fe2O3@Au to be used as magnetic resonance imaging (MRI) contrast agent. Furthermore, the magnetic core can also be used to achieve a magnetic drug targeting strategy through which Fe2O3@Au would be concentrated in the tumor site by means of magnetic field.
Balb/c mice bearing CT26 colorectal tumor model were intraperitoneally injected with Fe2O3@Au. Immediately after injection, a magnet (magnetic field strength of 0.4 Tesla) was placed on the tumor site for 6 hours in order to concentrate Fe2O3@Au, and thereafter the tumors were irradiated with the near infrared (NIR) laser source (808 nm; 2 W/cm2; 3 min). This experiment was conducted for three sessions. MRI confirmed the accumulation of nanoparticles within the tumor due to T2 enhancement capability of Fe2O3@Au. The temperature of the tumors without magnetic targeting was increased by ~7°C after NIR irradiation, whereas the tumors in magnetic targeting group showed a temperature rise of ~12°C. The in vivo antitumor assessment revealed that intraperitoneal injection of Fe2O3@Au nanoparticles and their targeting via magnetic field toward the tumor followed by NIR irradiation remarkably inhibited tumor growth and induced extensive necrosis. Therefore, Fe2O3@Au can establish a targeted MRI-guided PTT strategy.

Contribution ID: 1001
21. Advanced Technologies in Cancer Research and Treatment
21.10. New particle accelerators for radiation therapy

Study on the effect of Au@SiO2 nanoparticles for the glioblastoma

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Glioblastoma multiforme (GBM) is a grade IV glioblastoma and the most common primary brain tumor in adults. Radiation therapy (RT) is one of the main treatment modalities used for glioblastoma multiforme, often used in combination with surgery and chemotherapy, however, prognosis remains poor. Glioblastoma multiforme usually spreads quickly because glioblastomas have finger-like tentacles, thus complete surgical removal is difficult. Radiation and chemotherapy may be used to slow the growth of tumors that cannot be removed with surgery. However, these therapies have low cure rates. On the contrary, immunotherapy has shown promise for treatment of glioblastoma multiforme and could work synergistically with radiation. Radiation has been shown to increase antigen presentation and promote a proinflammatory tumor microenvironment. Programmed death-ligand 1 (PD-L1) is a surface receptor expressed on activated and exhausted cancer cells, which mediate cancer cell inhibition upon binding with its ligand PD-1, expressed on T cells. Studies have shown that single-session high dose radiation is effective in combination with PD-1 against intracranial tumors.
Gold is an excellent absorber of X-rays that has potential to enhance radiation effects in tumors. This study hypothesized that SiO2 coated Au nanoparticles(Au@SiO2) excited by low dose radiation could recall T cells to kill glioblastoma multiforme binding PD-L1. Preliminary results indicated that there was a significant reduction in cell viability by 40% between the experimental groups compared with the control group. Experiments on flow cytometry showed high-level nuclear NF-kappa B of expression through a combination of immunotherapy with carriers and radiotherapy.
Keywords: Glioblastoma multiforme (GBM), Radiation therapy, immunotherapy

Contribution ID: 114
21. Advanced Technologies in Cancer Research and Treatment
21.11. Light ion radiotherapy

Estimation of linear energy transfer distribution for broad-beam carbon-ion radiotherapy at the National Institute of Radiological Sciences, Japan

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Carbon-ion radiotherapy (CIRT) is generally evaluated with the dose weighted by relative biological effectiveness (RBE), while the radiation quality varying in the body of each patient is ignored for lack of such distribution. In this study, we have developed a method to estimate linear energy transfer (LET) for a treatment planning system that only handled physical and RBE-weighted doses. The LET taken from a database of clinical broad beams was related to the RBE per energy with two polyline fitting functions for spread-out Bragg peak (SOBP) and for entrance depths, to be differentiated by RBE per energy per modulation. The LET estimation was consistent with the original calculation typically within a few keV/μm except for the overkill at the distal end of SOBP. The CIRT treatments can thus be related to the knowledge obtained in radiobiology experiments that used LET to represent radiation quality.

Contribution ID: 117
21. Advanced Technologies in Cancer Research and Treatment
21.11. Light ion radiotherapy

Bragg-peak degradation of a carbon-ion beam penetrating a patient immobilization device with microscopic fine structures

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In carbon-ion radiotherapy, therapeutic carbon-ion beams occasionally penetrate an immobilization device of patients. The microscopic fine structures of the device may enlarge the Bragg-peak width of the beam as compared to the non-porous solid materials with the same water-equivalent thickness. In this study, we investigate this Bragg-peak degradation effect on patient dose distributions in scanned carbon-ion radiotherapy. The depth-dose curves of a pristine carbon-ion beam were measured behind the immobilization device of different thicknesses. A material parameter, namely a modulation power, was deduced from the measured depth-dose curves. The modulation power was defined as the square of the Gaussian sigma describing enlarged Bragg peak width divided by the mean water-equivalent thickness of the immobilization device penetrated by the carbon-ion beam. The modulation power was then used in a mathematical model for dose calculations of degraded carbon-ion beams. The effect of Bragg-peak degradation on patient dose distributions was investigated for a bone and soft tissue sarcoma case, in which the therapeutic carbon-ion beam penetrates the immobilization device of thickness up to ≈15 cm. The Bragg-peak was degraded by the immobilization device. The modulation power was 9.8 ± 0.9 mg cm-2. In the patient case, however, the oblique incidence of the carbon-ion beam at the surface of the patient significantly enlarged the Bragg peak, and the Bragg-peak degradation by the immobilization device was non-dominant. Therefore, the immobilization device caused neither severe underdose to the target nor overdose to the normal tissues in the example clinical case.

Contribution ID: 410
21. Advanced Technologies in Cancer Research and Treatment
21.11. Light ion radiotherapy

Spectroscopy measurements of proton-induced radioactivity in human tissue equivalent media

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The particle therapy is the most sophisticated and advanced tumour treatment method. The reasons of its complexity are: interactions between beam and matter, unclear radiobiology, difficult dosimetry, complicated ion beam delivery systems and treatment planning.
Phantoms used for dosimetric measurements in proton therapy are made of water or PMMA and mostly created radioisotopes are short-lived beta+ emitters like C-11, O-15 or F-18. But the human body is not only composed of hydrogen, carbon, nitrogen and oxygen but also of heavier nuclides like magnesium which activated can have an influence on treatment effects. For this project, we focus our attention on radioactive isotope production during therapy in the human body as a result of interactions between energetic particles and tissue matter.
The proton beam accelerated to 60 MeV was passed through the samples made of pig liver or beef bone. The tissues have been irradiated with dose in the range from 30 Gy to 500 Gy. Induced radioactivity was measured using LaBr3 or HPGe detectors.

In out analysis based on spectroscopy methods a large number of various isotopes (which emits not only beta+ particles) have been identified. Part of produced radioisotopes have half-life time longer than a day hence it can be crucial for high-dose treatments or in a case of massive tumour.

Contribution ID: 460
21. Advanced Technologies in Cancer Research and Treatment
21.11. Light ion radiotherapy

Plastic-scintillator based PET detector for proton beam therapy range monitoring: a feasibility study

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Proton beam therapy (PBT) is an emerging radiotherapy technique. Due to the interactions of proton beams with tissue, secondary radiation is emitted from the patient during or just after the treatment such as PET-gammas, prompt-gammas, charged secondary particles. The distribution of beta+ emitters induced by a proton beam can be detected by means of Positron Emission Tomography (PET) and related to the range of primary proton beam.
In this contribution, we report the preliminary results of a study aiming to exploit a novel, plastic-scintillator based strip-PET technique (Moskal et al., PMB 2016) for range monitoring application in PBT. A prototype of a diagnostic strip-based whole body PET scanner has been built and tested at the Jagiellonian University in Krakow. A single detection module of the strip-PET scanner is constructed out of five long scintillator strips. The light pulses produced in a strip are propagated to its edges and converted into electric signals by silicon photomultipliers. They are read-out by fast on-board front-end electronics allowing excellent overall coincidence resolving time (CRT) of about 300 ps, which shows a significant improvement compared to the standard LSO-based PET scanners. The system is composed of several modules for PET-gamma signal detection and provides data for 3D image reconstruction. We will show the results of Monte Carlo simulations of secondary radiation induced by a proton beam impinging on a PMMA target and read out by module-based strip-PET detector test system. In addition, we report the expected resolution of proton beam range estimation with the strip-PET detector technique. We will present the next steps of the project that include simulation studies on in-room PET range monitoring approaches (in-spill, inter-spill, and off-beam) as well as experimental verification of detector response. We will also present our plans of pre-clinical tests of strip-PET range monitoring detector system.

Contribution ID: 724
21. Advanced Technologies in Cancer Research and Treatment
21.11. Light ion radiotherapy

Secondary charged fragments tracking detector for on-line Bragg peak monitoring in Particle Therapy

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In Particle Therapy (PT) treatments secondary particles are produced, whose emission point is correlated to the dose released in the crossed tissues. The detection of the secondary charged fragments component could represent a valid technique to monitor the Bragg Peak position during the PT treatments, especially when Carbon ions are used.
In this contribution a detector, named Dose Profiler (DP), is presented. It is specifically planned to monitor on-line the beam range exploiting the secondary charged particles produced in a PT Carbon ions treatment. The DP will allow an in-treatment tracking of the secondary fragments (mainly protons) emitted at large angles with respect to the beam direction, with the aim to reconstruct the spatial coordinates of the fragment emission point extrapolating the track towards the beam axis. The DP has been developed within the INSIDE collaboration (Innovative Solutions for In-beam Dosimetry in hadrontherapy). The tracker is made by six layers (20x20 cm2) of BCF-12 square scintillating fibres (500 µm) coupled to Silicon Photo-Multipliers, followed by two plastic scintillator layers of 6 mm thickness. A system of front-end boards based on FPGAs arranged around the detector implements the data acquisition.
After a data taking campaign with protons that took place in Trento Proton Therapy Center, the detector has been tested under clinical conditions (Carbon ion beams with therapeutic intensities and energies) on an anthropomorphic phantom at CNAO Center in Pavia. In this contribution, the DP layout and the preliminary results of the analysis of its performances (obtained with the anthropomorphic phantom as well as other targets) will be presented in the context of a possible application to Carbon therapy treatments monitoring in the CNAO center.

Contribution ID: 1134
21. Advanced Technologies in Cancer Research and Treatment
21.11. Light ion radiotherapy

Track-etched detectors measurements and Geant4 Monte Carlo simulations of the LET distributions behind dental implants irradiated with therapeutic proton beam

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The goal of this work was to study the absorbed dose and Linear Energy Transfer (LET) distributions of a scanning proton pencil beam applied to plastic phantoms containing metallic dental implants.
The irradiation of phantoms has been realized in the Proton Therapy Center Czech, Prague, Czech Republic.
Inside two rectangular plastic phantoms the 2, 5, 10, and 15 mm of grade-2 and grade-5 Titanium were inserted. To simulate possible clinical cases of head and neck cancer treatments, we have chosen two experimental setups:
(a) the phantoms were irradiated with very high proton energy, 226 MeV, so the LET spectra of charged particles were recorded in the entrance region of the Bragg curve and

(b) the range of the proton beam at 80-100% maximum dose was set to coincide with the detector's back side behind 10 mm implant.
Track-etched detectors (TEDs) were used to collect the data. The experimental results were compared with Monte Carlo simulations using the Geant4 toolkit to identify the contribution of each type of particles to the LET spectra and estimate the LET above the TED's detection threshold.
In the experimental setup (a), the results showed negligible differences in the LET spectra for increasing thicknesses of each alloy. This has been proven by comparing the experimental data with simulations, where a good agreement was found. On the other hand, in case of the experimental setup (b) a conglomeration of tracks was detected at the border between 15 mm implant and plastic material caused by scattered particles inside the titanium. This leads to dose enhancement of up to a factor of 13 in the case of grade-2 Ti, and more than 12 in the case of grade-5 Ti irradiations. The effect of metallic implants on LET and dose distributions will be discussed.

Contribution ID: 1264
21. Advanced Technologies in Cancer Research and Treatment
21.11. Light ion radiotherapy

Monte-Carlo model development for evaluation of efficacy of proton boron fusion therapy for gliobastomas

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Introduction: Glioblastoma (GBM) tumours are notorious for their extensive diffusion and high fatality rate. Proton Boron Fusion Therapy (PBFT) is binary charged particle modality and is still at conceptual stage. PBFT is based on proton fusion reaction by labeled 11B in the tumour (Boron Uptake Region (BUR)). The reaction results in a compound nucleus 12C which splits into three α-particles. Primary advantages of PBFT are: 1) emission of three high LET α-particles, achieving good therapeutic outcome with a smaller beam flux; 2) proton energy loss in matter is described by the Bragg-peak offering superior normal tissue sparing. The purpose of this work is to extend the previously-developed GBM model to incorporate PBFT to investigate its efficacy in terms of GBM cell survival fraction (SF).
Materials & Methods: The GEANT4 GBM-PBFT model was designed as a water phantom with 16cm diameter and 6cm height and irradiated with 80MeV proton beam at 50cm distance from water surface. Percentage depth dose curves (PDDs) were calculated with and without BUR to examine the displacement of Bragg-peak depending on the location of the BUR. Also, PDDs were calculated for 80-100 MeV proton beams to evaluate increased proton maximum dose level in BUR. The results were compared with published data. The integrated GBM modelling platform, developed previously, was re-designed for PBFT. It consisted of three main components: 1) simulation of a GBM tumour with different microscopic infiltrations 2) irradiation of the GBM model using the Geant4 MC toolkit; and 3) cell survival calculation.
Results & Conclusion: Good agreement was achieved between the calculated and published proton beam PDDs. The resulting Bragg-peaks showed a significant increase in the maximum dose level, located within BUR, and was maintained for different proton energies. Ongoing work is focusing on determination of tumour SF following PBFT.

Contribution ID: 1475
21. Advanced Technologies in Cancer Research and Treatment

21.11. Light ion radiotherapy

Low-dose carbon-ion transmission radiography and tomography for improving ion beam therapy

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The rationale of ion-beam therapy relies on its ability to confine a highly biologically-effective dose to the tumor while sparing healthy tissues. Achieving this aim is impeded by range uncertainties, demanding innovative imaging solutions to monitor the relative stopping power(RSP). Main range uncertainties arise during treatment planning and due to anatomical or positioning variations during treatment delivery. To overcome the former major uncertainty stemming from the X-ray-based calibration of Hounsfield-units into RSP, imaging methods using the same radiation as for treatment would be greatly beneficial for direct RSP assessment.
In this work, carbon-ion transmission imaging was performed with actively scanned beams synchronized with an integration-mode detector. The detector consists of 61 parallel-plate ionization chambers, interleaved with 3mm-thickness PMMA slabs. Ion-radiography(iRAD) enables pre-treatment verification of the integral RSP and patient positioning, while ion-computed-tomography(iCT) directly retrieves the RSP-3D-distributions for treatment planning purposes.
We present experimental radiographies and tomographies of complex phantoms of different tissue-equivalent composition imaged at two dose levels. A dedicated Monte-Carlo post-processing method was applied to improve the water equivalent thickness(WET) spatial and depth resolution for iRADs, and RSP for iCTs. A quantitative comparison between the iRADs and iCTs with ground-truths was made in terms of accuracy [%relative error(RE)] of the WET and RSP, respectively. iRADs were produced with 0.5 to 1mGy imaging dose, yielding an absolute mean WET-RE within 1.5%. Experimental tomographies of two heterogeneous phantoms were acquired using a high-dose of 4Gy, resulting in an RSP-RE below 1%. Post-processed individual low-dose iRADs indicated a possible dose reduction down to 0.2Gy for iCTs. Moreover, by improving the readout system, we demonstrated that the dose exposure can be decreased further by about one order of magnitude down to ~0.03Gy.
Ion-based transmission imaging can potentially generate accurate low-dose iRADs and iCTs at the treatment site, offering improved accuracy for ion-beam therapy.

Contribution ID: 317
21. Advanced Technologies in Cancer Research and Treatment
21.12. Robotics and mechatronics in cancer diagnostics and therapeutics

Development of a robotic motion platform for quality assurance of 4D radiotherapy

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Objectives: The purpose of this work is to develop a robotic motion platform for the quality assurance of four dimensional (4D) radiotherapy treatments and validate the performance of the phantom in clinical environment.
Material and methods: A 3D moving phantom was designed to enable quality assurance of 4D imaging as well as treatment deliveries. The major part of the phantom is a dynamic platform over which any dosimetric or imaging QA devices can be placed and this dynamic platform can be used to mimic 3D tumor motion by using three independent stepper-motor systems (Bipolar 48mm Stepper). Each of three independent stepper motors was connected to respective micro-controllers (1067 – Phidget Stepper Bipolar controller) using USB cables. Each of the three stepper motors was coupled to a lead-ball screw (25mm Ball screw) in a slide assembly, thereby creating one dimension motion of a stage and the axes are named x (right-left), y (inferior-superior) and z (anterior-posterior). The x, y, and z axes are connected orthogonally in order to move a stage in three dimensions. A computer interface program was developed using Matlab (version 8.5) and this program was able to move the three axes independently for arbitrary breathing period and amplitude. The phantom reproducibility and accuracy was evaluated using Real-time position management (RPM) system (Varian Medical Systems, Palo Alto, CA) for various breathing patterns.
Results: Cross correlation coefficient between the phantom motions and RPM recorded motions was calculated. The correlation coefficients were 0.979, 0.989 and 0.955 respectively for sinusoidal, regular breathing and realistic respiratory waves.
Conclusions: A robotic motion platform was developed in-house and the performance was evaluated using RPM system. Initial results were promising and the limitations will be addressed in the full fledged phantom which is under development.
Acknowledgement: Department of Science & Technology, Grant No: DST/TSG/AMT/2015/326

Contribution ID: 124
21. Advanced Technologies in Cancer Research and Treatment
21.13. Other

Inverse optimization of kilovoltage arc therapy treatment for breast, lung and prostate patients

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Purpose: The goal of this work is to assess the feasibility of our novel cost-effective kilovoltage x-ray arc therapy (KVAT) system to treat breast, lung, and prostate cancer.
Methods: The EGSnrc/BEAMnrc and DOSXYZnrc Monte Carlo (MC) codes were used to calculate phase space files and dose delivered by our KVAT source to three virtual patients at energies ranging from 200 – 225 kV. The size of the irradiated planning treatment volume (PTV) in the breast and lung patient was 3 cm in diameter while the PTV of the prostate patient had a diameter of 4 cm. Inverse optimization of KVAT plans was performed by an optimization framework from McGill University (McO). All KVAT plans were compared to MC calculated MV VMAT plans using a model of a TrueBeam linac. Dose constraints on organs-at-risk (OARs) were derived from relevant RTOG protocols. The prescribed dose per fraction for the breast, lung and prostate patient was 385, 200, and 180 cGy, respectively.

Results: All KVAT OARs were within dose constraints for all three cases. The KVAT treatment times per fraction were calculated to be 2.3, 1.7 and 7.2 minutes for the breast, lung and prostate patient, respectively. Generally, the KVAT plans delivered higher, but clinically acceptable doses to OARs due to the lower penetration of the kV photons. MV VMAT dose distributions were more homogenous than KVAT. Of particular note is the KVAT lung plan which is of comparable quality to the VMAT plan with the exception of increased rib dose.
Conclusion: The KVAT dose distributions calculated in this work demonstrated the ability of our low-cost KVAT system to deliver conformal dose to deep-seated lesions with PTV sizes ranging from 3 – 4 cm with clinically practical treatment times.

Contribution ID: 215
21. Advanced Technologies in Cancer Research and Treatment
21.13. Other

Hadron minibeam radiation therapy (MBRT): first experimental proof of concept

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Despite recent advancements in radiotherapy, significant limitations remain. Although charged particle therapy, being in clinical use for more than 15 years, has shown remarkable effectiveness, it still could benefit from a lower impact on non-targeted tissues to allow its administration at higher doses. This is the reason why we propose a new approach called hadron minibeam radiation therapy (hadron MBRT). The technique is based on the well-established tissue-sparing effect of arrays of parallel, thin or small beams, observed in studies performed with synchrotron radiation. This novel strategy might widen the therapeutic window for radio-resistant tumors. Within this context, the main goal of this study was to perform the first in-depth dosimetry study to evaluate this innovative approach from a dosimetric point of view and to verify its technical feasibility for pre-clinical studies.
Carbon and oxygen minibeams were generated by means of a multi-slit collimator with line apertures of 700 μm separated by 3500 μm. Scanned particle fields were used to cover the desired irradiation field size over a spread-out Bragg peak (SOBP) region of 50 mm at 80 mm-depth in water. Due to the challenging measurement conditions, both a microDiamond detector (PTW) and radiochromic films (EBT3) were used for dose assessment.
The measured lateral dose profiles consisted in a pattern of peaks and valleys, which prove the technical feasibility of this approach. The two detectors were in good agreement. Very high peak-to-valley dose ratios (PVDR) of around 60 were obtained at the entrance region. Then, PVDRs progressively decrease down to around 10 at 80 mm-depth. PVDRs in healthy tissues are higher than the ones obtained in x-rays MBRT, for which biological effectiveness has already been proven. Additionally, hadron MBRT might provide an additional benefit in terms of biological effectiveness in the tumor.
Reference: Martínez-Rovira et al., Med. Phys. 44 (2017).

Contribution ID: 477
21. Advanced Technologies in Cancer Research and Treatment
21.13. Other

Development and evaluation for correction of deformed image according to change of reflector angle of video-based electronic portal imaging device

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Purpose : A small detector using a semiconductor device is used to identify the radiation filed in therapeutic radiation. However, these equipment are expensive. In this paper want to develop and evaluate small EPID equipment which is cheap by using similar parts of existing EPID device.
Method & material : The experiment was performed in a CO-60 irradiation room. We used parts similar to existing electronic portal imaging device such as reflector, fluorescent paper, and digital camera. The specifications of the EPID device are 90 mm high, 425 mm wide and 300 mm high. The angle of the reflector was set at 9 degrees. However, adjusting the angle of the reflector caused the deformation of the image. In this paper developed and used a correction program that uses the intersection of two straight lines to correct the image.
Result : For images of all sizes, the lower line was the most deformed with an averageof change of 87.5%. The average change of the upper line and height was 13.6% and 14.9%. Even when the deformed image was corrected, the correction was the highest at the lower line. The error of the average correction of the lower line is 1.04%. The error of the average correction of the upper line and the height was 0.1% and 0.4%. The error between the original image and the corrected image was not large. In addition, the correction error for the width of the original image and the corrected image was insignificant. For the largest image width, the correction error was about 0.2%, and the smallest image width was about 0.1% error.
Conclusion : If we can improve the correction rate on the image, we expect to be able to use it as an actual detector.

Contribution ID: 539
21. Advanced Technologies in Cancer Research and Treatment
21.13. Other

Investigation of prompt gamma ray imaging using LaBr3(Ce) scintillator with high energy resolution for Boron Neutron Capture Therapy

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In order to improve the quality of treatment of boron neutron capture therapy (BNCT), it is necessary to perform the detection of boron concentration during the BNCT irradiation. Prompt gamma ray analysis and the induced coupled plasma are not able to obtain the information of the boron concentration during the irradiation. We have the proposal to measure boron concentration in real-time by using prompt gamma ray with the energy of 478 keV emitted by the reaction between boron-10 and thermal neutron. However, there are 511 keV annihilation gamma rays in BNCT irradiation fields as back-ground; it is required to discriminate between prompt gamma ray of 478 keV and annihilation gamma ray. We have developed a prompt gamma ray imaging detector consisting of LaBr3(Ce) scintillator, which is divided into 8 x 8 arrays, 8 x 8 channels MPPC, 64 channels amplifies and ADCs.
The size of a LaBr3(Ce) scintillator, which is divided into 8 x 8 arrays, was 50 mm x 50 mm x 10 mm. The scintillator arrays were set at the front of 8 x 8 MPPC. The output of 64 MPPC channels were fed to amplifier unit. The 64 analog outputs were digitalized by ADC. These digital signals were stored in PC. The energy resolution of less than 6.5 % FWHM at 511 keV was needed in order to discriminate 511 keV gamma ray from 478 keV prompt gamma rays. The irradiation test using Na-22 gamma-ray was performed.

The irradiation test was performed using Na-22 gamma ray source. The measured energy resolution was less than 6.5 % FWHM.
It was confirmed that our developed system was able to detect 478 keV prompt gamma rays in the existence of 511 keV annihilation gamma rays. Our developed system will be applied to clinical studies in the future.

Contribution ID: 629
21. Advanced Technologies in Cancer Research and Treatment
21.13. Other

Rapid optimization of lung dose using novel volume-based algorithm in dynamic arc-based radiotherapy for esophageal cancer

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Purpose: Novel dynamic arc-based radiotherapy with rotating gantry/arcs including volumetric modulated arc therapy (VMAT) and tomotherapy provides highly-conformal dose distribution. However, VMAT and tomotherapy may result in extensive low-dose distribution in lungs. It is time-consuming to perform the traditional inverse-plannings by repeated trial-and-error tests. In this study, we aim to optimize rotating gantry arcs by a novel automatic volume-based algorithm (VBA) and to reduce lung dose preceding the inverse-planning in the dynamic arc-based radiotherapy for esophageal cancer (EC).
Material and Methods: This study included 236 treatment plannings (TPs) (tomotherapy n=146; VMAT n=90) of EC patients who received radiotherapy at our institute from January 2007 to June 2017. The prescription radiation dose of planning target volumes (PTV) was normalized to 50 Gy in 25 fractions. Prior to inverse-planning, we developed a VBA which can automatically calculate the arc angles, related restricted angles, predicted lung_V5 in TPs. The restricted angles were designed in both lungs to avoid primary radiation beams. The partial arc/gantry angles, related restricted angles/volumes, dosimetric parameters for organs at risk and homogeneous index of PTV were analyzed.
Results: Tomotherapy and VMAT TPs using arc angles/restricted angles by VBA significantly reduced the mean lung dose (24.62%, p=0.002), lung_V5 (39.78%, p<0.001) and lung_V10 (46.35%, p<0.001) as compared with non-restricted arc inverse plans. There was a trend toward reduced mean lung dose and increased mean heart dose when the restricted angle increased. The restricted angles/volumes showed strong correlation with mean lung dose (r= -0.998) and lung_V5 (r= -0.988). The predicted lung_V5 using VBA in each TPs was achieved accurately and rapidly within 20 iterations by 5 minutes.
Conclusion: This novel VBA provides optimal arc/gantry angles to achieve expected lung_V5 and significantly reduces lung dose in VMAT and tomotherapy. The VBA predicts lung_V5 accurately and rapidly preceding the traditional time-consuming inverse-plannings.

Contribution ID: 656
21. Advanced Technologies in Cancer Research and Treatment
21.13. Other

Intraoperative rapid quantifications of iron accumulating in lymph nodes in swine model for breast cancer patients

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Sentinel lymph node biopsy (SLNB) using magnetic nanoparticles and magnetic instruments is a promising technique as an alternative radioisotope technique in the treatment of breast cancer that evaluates the presence of metastasis in sentinel lymph nodes (SLNs). The selection of the first SLN that contains the largest amount of iron of magnetic nanoparticles in some resected nodes can help investigate the metastasis because cancer most likely metastasizes to that node. To select the first SLN for breast cancer patients, we developed the novel device for intraoperative quantifying iron amount without node-size/iron-distribution dependency. In this paper, we demonstrated the feasibility of the intraoperative rapid quantifying iron contents in resected lymph nodes in swine model.
Magnetic nanoparticles (28 mg of iron) that were injected into the 3rd subareolar accumulates in the popliteal lymph node (as SLN) in swine model. The nodes were detected by a handheld magnetometer and resected nodes can be performed the quantification of iron using the developed device immediately; the measurement time is about a few seconds per a node, indicating that the quantification can complete intraoperatively in situ measurements. We revealed that the iron contents in the nodes is about 0.77 mg (2.5% of injection amount), which are comparable to the value obtained from the SQUID magnetometry (0.71 mg). Furthermore, the correlation factor of the relationship between values measured by these devices is approximately 0.98, suggesting the presence of a good correlation. By contrast, the correlation factor of the relationship between the values measured by the handheld magnetometer and SQUID magnetometry is approximately 0.65. These results indicate that we succeeded in the accurate quantification using the developed device. In the near future, we will perform the intraoperative quantifications of iron contents for breast cancer patients in clinical trials.

Contribution ID: 759
21. Advanced Technologies in Cancer Research and Treatment
21.13. Other

Intraoperative molecular imaging investigation using a CZT detector

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Aim: In molecular imaging, the spatial and energy resolutions are important to be optimized as well as other camera calibration parameters. To investigate the effectiveness of using a handheld gamma camera as a major aid in intraoperative molecular imaging surgery, the sensitivity of the device should also be a top priority.
Method: Using a commercial handheld cadmium zinc telluride (CZT) solid state gamma detector (CrystalCam), the sensitivity, spatial and energy resolutions were investigated under different conditions but same collimation (LEHS Tungsten).

Sensitivity data were acquired from 50 to 350mm source-detector-distance (steps: 50mm) by using a Co-57 point source in air (activity: 610.88 kBq, energy window: 122.1 keV ± 10 %), acquisition duration of 90s. The spatial resolution was investigated using an in-house mini-parallel bar phantom of ca. 2mm thick. The investigation of the image resolution was by point spread function measurements from 50 to 150mm (steps: 50mm), acquisition duration of 120s. Acquisitions were exported using the manufacturer's software (Crystal-Imager) and further processed with ImageJ.
Data plots and analysis was performed on spreadsheets. Adequate count statistics (error below 1%) were achieved in all measurements; and no significant dead-time corrections.
Results: The sensitivity versus source-detector-distance response showed an estimated 3.23 cps/MBq/mm loss with increasing point source distance. Interestingly, the 2mm spatial resolution was achieved when using the correct homogeneity correction matrix. The PSF expressed the image resolution of 3.23%, 4.62% and 6.62% at 50, 100, and 150mm SDD respectively, corresponding to count rates of 700, 640 and 480cps.
Conclusion: The investigations show that the CrystalCam can effectively localize "small" lesions up to about 2mm apart and within a relatively small time scale. The high sensitivity and very good spatial resolution in combination with its light-weight, fast processing and precise performance, make the CrystalCam very suitable for intraoperative molecular imaging-guided cancer surgery.

Contribution ID: 836
21. Advanced Technologies in Cancer Research and Treatment
21.13. Other

Quantitative analysis of prompt gamma ray imaging during proton boron fusion therapy according to boron concentration

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The purpose of this study is to evaluate the prompt gamma ray imaging technique according to the clinical boron concentration range during proton boron fusion therapy (PBFT). To acquire a prompt gamma ray image from 32 projections, we simulated four head single photon emission computed tomography and a proton beam nozzle using a Monte Carlo simulation. We used modified ordered subset expectation maximization reconstruction algorithm with a graphic processing unit for fast image acquisition. Boron concentration was set as 20 to 100 µg at intervals of 20 µg. For quantitative analysis of the prompt gamma ray image, we acquired an image profile drawn through two boron uptake regions (BURs) and calculated the contrast value, signal-to-noise ratio (SNR), and difference between the physical target volume and volume of the prompt gamma ray image. The relative counts of prompt gamma rays were noticeably increased with increasing boron concentration. Although the intensities on the image profiles showed a similar tendency according to the boron concentration, the SNR and contrast value were improved with increasing boron concentration. This study suggests that a tumor monitoring technique using prompt gamma ray detection can be clinically applicable even if the boron concentration is relatively low.

Contribution ID: 890
21. Advanced Technologies in Cancer Research and Treatment
21.13. Other

Can the therapeutic benefits of microbeam radiation therapy be achieved using a linear accelerator?

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High definition multileaf collimators (HDMLCs) with 2.5mm leaves provide an opportunity for the biological response to 'grid' therapy to approach that of Microbeam Radiation Therapy (MRT). We have shown that a high frequency modulated 6MV beam can be 30% more cytotoxic than a 6MV uniform beam delivering the same average dose (Peng 2017). However, the prescription of periodic spatial dose modulation across the target volume runs counter to current clinical practice. Our aim is to first determine how a treatment planning system can be used to design MRT treatment fields for linac delivery, the subsequent dose and response confirmation. Second, to gain a better understanding of cell dose responses to such treatments.
A range of treatment plans were calculated on the VarianTM Eclipse v13.6 treatment planning system to deliver a prescribed average dose to the target volume. The dose distribution was planned to be either uniform across the target volume or to have high spatial frequency modulation of 2.5mm. The plans were then delivered on a Varian NovalisTx TM to treat three surrogate 'patients' (in vitro) one normal cell line and two cancer cell lines. The survival fractions for each plan and each cell line were compared. Radiation field modulation did not affect the survival of normal cells, but for the same average dose, cancer cell survival was significantly lower for 2.5mm stripe-modulation.
A mathematical model was developed to incorporate the dose gradients of the spatial modulation into the standard linear quadratic model. Our new extended bystander LQ model assumes spatial gradients drive the diffusion of soluble factors that influence survival through bystander effects and successfully predicts the experimental results that show an increased therapeutic ratio.
Our results challenge conventional radiotherapy practice and predict that additional gain could be realized by prescribing spatially modulated treatments to harness the bystander effect.

Contribution ID: 1113
21. Advanced Technologies in Cancer Research and Treatment
21.13. Other

Temperature-induced modulation of voltage-gated ion channels in human lung cancer cell line A549 using automated patch clamp technology

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In cancer cells specific ion channels exhibit altered channel expression, which can drive malignant and metastatic cell behavior. Hence, therapeutic strategies modulating ion channels prove to be promising in cancer therapeutics. Alterations in temperature, even small deviations from normothermia, may cause changes in electrophysiological processes, since activation and conductivity of various ion channels are temperature-dependent.
In this pilot study, we focus on a basic understanding of the effects of temperature-alterations on voltage-gated ion channels of A549 cells using an in-house adapted automated patch-clamp system. The measurements were carried out in whole-cell voltage-clamped configuration applying a pulse-protocol starting with an initial- and re-pulse of -80mV and test pulses between −60mV and 60mV (800ms, increment 10mV). For positive voltages the ion-current curves showed an instantaneously activating conductance, mainly driven by fast K+ channels, followed by a slow current increase provoked by later activating voltage-gated ion channels. We observed a further increase in current with longer pulse durations. It was found that the registered current amplitudes at the end of an 800ms test pulse correspond to about 60% of the maximum current measured at a pulse length of 60s (13 cells, n=55 single measurements), indicating the time-delayed response of additional channels. To investigate the temperature-dependent electrophysiological behavior, three

cells (passages 7-10, n=6) were examined at room temperature (21.2-24.3°C) and normal body temperature (37-38.5°C). Compared to normothermia, reduced temperatures revealed a higher whole-cell current at negative voltages (63.4%(+/-18.5), -60mV) and lower currents (52.6%(+/-27.3), +60mV) at positive voltages, indicating a hyperthermia-induced modulation of voltage-gated channels in lung cancer cell line A549.
In a next step we will also investigate possible effects of hyperthermia on ion channel acitivity and its impact on the resting potential. These findings will serve as an input for a model-description of temperature-induced alterations in ion-channel activation in non-excitable cancer cells.

Contribution ID: 1212
21. Advanced Technologies in Cancer Research and Treatment
21.13. Other

Effect of the slow stroke back massage (SSBM) on anxiety among older woman with breast cancer undergoing chemotherapy

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Background and Aims: Anxiety is the most prevalent psychological side effect of breast cancer and chemotherapy treatment. This study aimed to determine the effect of slow stroke back massage (SSBM) on anxiety among older patients with breast cancer undergoing chemotherapy.
Matterial and Methods: In this non-randomized clinical trial study, 80 older women with breast cancer undergoing chemotherapy were enrolled by continuous sampling method and divided in two experimental and control groups. The experimental group received three 15-miniutes sessions of slow stroke back massage (SSBM) for three consecutive day. The data collection instrument as Geriatric Anxiety Scale (GAS) was used to measure the anxiety of the subjects. Descriptive and inferential statistics were used to analyze the data with 95% of confidence in SPSS V.21.
Results: There was no significant statistical differences between the two groups in terms of demographic data ($p<0.001$) and anxiety ($p=0.220$) pre-intervention. The mean score of anxiety level has reduced significantly from 40.97 before intervention to 30.47 after the intervention in the experimental group compared to the control group and the results were statistically significant ($p<0.001$). Furthermore, no significant reduction was found in the anxiety levels of control group at pre-post intervention ($p=0.457$). There was also a significant difference between the mean score of anxiety levels of the two groups after intervention ($p < 0.001$).
Conclusion: Due to the significant reduction of anxiety in the experimental group by using SSBM, this method can be an easy, accessible and affordable to apply to the older women with breast cancer and undergoing chemotherapy. Therefore, it is recommended that SSBM to be used by the health care professionals working with this group of women.
Keywords: Breast cancer, chemotherapy, massage therapy

Contribution ID: 1700
21. Advanced Technologies in Cancer Research and Treatment
21.13. Other

Application assessment of novel hybrid pixel detector PHpix in relative dosimetry

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Currently, the field of clinical imaging in radiotherapy is mostly relying on flat panel detectors based upon CsI/GOS/aSi or aSe technology. These types of detectors have an excellent detection efficiency and a great spatial resolution, on the other hand they are also characterized by a low radiation hardness, usually in range of a few kGy. The low radiation hardness of these detectors limits their application for continuous on-line dose monitoring during irradiation treatment. Presented novel hybrid pixel detector (PHpix) is designed directly for spatial on-line continuous dose monitoring. It provides a great radiation hardness and acceptable price at lower spatial resolution which is not as decisive as for diagnostic medical imaging. Moreover, this technology is expected to be used also for daily QA therefore for relative dosimetry. This work is focused on properties particularly important for such applications and deals with the assessment of its potential in relative dosimetry.

Contribution ID: 1926
22. Biological Effects of Ionizing Radiation
22.12. Keynote lecture

KEYNOTE LECTURE: DNA double strand break repair: the choices and limitations

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A DNA double strand break (DSB) can be a lethal lesion if unrepaired but, as importantly, can lead to carcinogenesis if misrepaired. Our cells are equipped with two major DSB repair pathways as well as a signalling response that can impact upon the repair of DSBs in multiple ways. In human cells the major DSB repair pathway is DNA non-homologous end-joining (NHEJ), a simple process which allows end-processing to couple with end ligation. Homologous recombination is a more complex and elegant process that functions only in late S/G2 phase since it uses a sister chromatid as a template for repair. In human cells, the upstream components of NHEJ (the DNA-PK complex, involving Ku and DNA-PKcs) are highly abundant and have exquisite end-binding capacity. Hence, Ku is usually the first protein to bind to DNA ends and NHEJ is the favoured pathway. Even after high doses, NHEJ is highly efficient in its capacity to rejoin DSBs. An important issue, however, is the fidelity with which the DSBs are rejoined. Indeed, evidence suggests that misrepaired DSBs rather than unrepaired IR-induced DSBs are a major cause of cell death. If the DSB is complex involving sequence loss from both DNA strands then the lost sequences cannot be regained during NHEJ, and deletions at the junction will arise. Current evidence also suggests that a component of NHEJ involves resection of the DNA ends, which also has the potential to cause small deletions at the junctions. Additionally, and importantly in the context of radiotherapy, NHEJ has the capacity to rejoin the incorrect DNA ends, leading to the formation of translocations. This appears to arise at a frequency that increases exponentially with dose. The signalling response to DSBs involving the ATM kinase serves to restrict incorrect end-joining, thereby promoting accurate rejoining. I will discuss the processes of DSB rejoining, focusing on the two distinct components of NHEJ and its interface with the signalling response. I will discuss the limitations of NHEJ underlying incorrect end-joining and the mechanism by which ATM-dependent signalling helps to counteract these weaknesses inherent to NHEJ.

Contribution ID: 579

22. Biological Effects of Ionizing Radiation
22.01. DNA damage and repair in cells and tissues

Plasmid DNA sensitization by organometallic compounds to damage caused by secondary electrons

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Synergistic effect of cisplatin (CDDP) with ionizing radiation to DNA damage is a known issue, but the mechanism is not yet known. One of the most promising explanations for this phenomena is that covalent bond of CDDP molecule to DNA causes conformation changes which may increase the reactivity of DNA with radicals or secondary electrons generated by irradiation. Other explanation could be that low energy electrons can enhance the dissociation of CDDP which can then follow up radical reactions with DNA, but our results don't support this explanation so far. Some authors propose other explanation, that the presence of CDDP can enhance the production of low energy electrons (LEE) in the close vicinity of Pt-DNA adducts, which can then cause a damage to DNA.
To distinguish between the effects of secondary electrons on DNA damage from the effect of ·OH radicals, which is dominant, we evaluated our experiments with different scavenging capacity of ·OH radicals. At first, we tested the CDDP molecule for synergy with ionizing radiation on DNA damage. The results were positive, in the agreement with the previous studies. Then we applied the same methodology to test other organometallic compounds based on ruthenium (RAPTA-C) and titanium (*Cp2TiCl2, *Cp2TiF2) for the same synergistic effect. To be able to see if the LET of ionizing radiation has some effect on described phenomena, we used both low and high LET radiation, γ and protons.
We acknowledge the support from the GACR grant no 16-10995Y

Contribution ID: 762
22. Biological Effects of Ionizing Radiation
22.01. DNA damage and repair in cells and tissues

Combined effects of 528 Hz sound and X-ray in peripheral blood lymphocytes

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Radiotherapy is still one of the main options for cancer treatment but it is in association with damage to normal cells as well as the tumor cells. To reduce the injury in normal cells we have evaluated the effect of 528 hertz sound after X irradiation in peripheral blood lymphocytes. In this study, peripheral blood were obtained from 25 healthy volunteers and blood lymphocytes were separated and divided into 4 groups: I) Control group, П) Radiation group, Ш) Radiation + Sound group IV) Sound group. To measure radiation effect on DNA, nuclear (DNA) damage rate was evaluated in all groups by the use of the comet assay. The obtained data revealed that DNA damage rate in radiation group (190±45) is significantly higher than control (137±32), Sound (152±29). But, the difference of DNA damage in control with sound and also radiation+sound groups was not statistically significant. The results indicating that 528 hertz sound could induce radiation damage but when it will be combined with X radiation, the DNA damages of X-rays in peripheral blood lymphocytes is not significantly different with control groups which indicate modulation of DNA damages and addresses the needs for further studies.
Keywords: 528 Hz sound; DNA damage; Comet assay

Contribution ID: 731
22. Biological Effects of Ionizing Radiation
22.03. Tumour heterogeneity and response to radiation

A Volumentric delta TCP tool to quantify treatment outcome effectiveness based on biological parameters and different dose distributions

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Intra-tumour variability of oxygenation and clonogenic cell density causes tumor non-uniform spatial response to radiation. Strategies like dose redistribution/boosting, whose impact should be quantified in terms of tumor-control-probability (TCP), have been proposed to improve treatment outcome.
In 1999, Sánchez-Nieto et al. developed a tool to evaluate the impact of dose distribution inhomogeneities, compared to a reference homogeneous dose distribution, in terms of TCP. DVH data was used to calculate the so-called ΔTCP, defined as the contribution to TCP differences arising from dose variations in individual DVH-bins.
In this work, we develop a tool to calculate volumetric ΔTCP to evaluate the impact on TCP of: i) Spatial variations in dose distribution with respect to the reference dose; ii) Spatial radiosensitivity variations; iii) Simultaneous variation in dose distribution and radiosensitivity. ΔTCP calculations can be evaluated voxel-by-voxel, or in a user defined subvolume basis.
Subvolume control probabilities (VCP) are calculated for the reference and tested conditions and TCP is calculated as the product of VCPs. With this tool, ΔTCP distribution maps can be generated to evaluate the impact of two different dose distribution and radiosensitivity inhomogeneities.
The tool capabilities will be shown in this work with 3 examples of H&N RT treatments and molecular imaging data providing information about tumor oxygenation status. All ΔTCP calculations are performed under voxel-by-voxel and subvolume modalities. The impact of our model parameter values on ΔTCP will be also provided.
For brevity, only the most representative case is presented here, with ΔTCP values computed for a homogenous dose distribution vs a redistributed dose delivered to a tumor with 3 oxygenation levels (vascular fractions) and 3 cell density values (10^4, 10^6 and 10^7 cells/mm^3, respectively). Voxel-by-voxel values are small but useful when presented as map distributions. For the subvolumes, ΔTCP5%VascularFraction =0.26%, ΔTCP3%VascularFraction =0.15% and ΔTCP2,5%VascularFraction =2.51%, were calculated.

Contribution ID: 190
22. Biological Effects of Ionizing Radiation
22.04. Cell radiosensitivity/radioresistance and its targeted manipulations

The combination of A-966492 and Topotecan for effective radiosensitization on glioblastoma spheroids

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Radiotherapy is one of the modalities in the treatment of glioblastoma patients, but glioma tumors are resistant to radiation and also chemotherapy drugs. Thus, researchers are investigating drugs which have radiosensitization capabilities in order to improve radiotherapy. PARP enzymes and topoisomerase I enzymes have a critical role in repairing DNA damage in tumor cells. Thus, inhibiting activity of these enzymes helps stop DNA damage repair and increase DSB lethal damages. In the current study, we investigated the combination of TPT as a topoisomerase I inhibitor, and A-966492 as a novel PARP inhibitor for further radiosensitization. U87MG cells (a human glioblastoma cell line) were cultured in Poly-Hema coated flasks to reach 300μm-diameter spheroids. Treatments were accomplished by using non-toxic concentrations of A-966492 and Topotecan. The surviving fraction of treated cells was determined by clonogenic assay after treatment with drugs and 6MV X-ray. The γ-H2AX expression was measured by an immunofluorescence staining method to examine the influence of A-966492, TPT and radiation on the induction of double stranded DNA breaks. Treatments using the A-966492 drug were conducted in concentration of 1μM. Combining A-966492 and TPT with radiation yielded enhanced cell killing, as demonstrated by a sensitizer enhancement ratio at 50% survival (SER50) 1.39 and 1.16 respectively. Radio- and chemo-sensitization was further enhanced when A-966492 was combined with both X-ray and TPT, with SER50 of 1.53. Also γ-H2AX expression was higher in the group treated with a combination of drugs and radiation.
A-966492 is an effective PARP inhibitor and has significant radio-sensitivity on U87MG spheroids. By accumulating cells in the S phase and by inhibiting the DNA damage repair, TPT enhanced radio-sensitivity. A-966492 combined with TPT as a topoisomerase I inhibitor had additive radio-sensitizing effects. As a result, applying PARP and topoisomerase I inhibitors can be a suitable strategy for improving radiotherapy .

Contribution ID: 206
22. Biological Effects of Ionizing Radiation
22.04. Cell radiosensitivity/radioresistance and its targeted manipulations

Pig as an experimental model for in vivo studies of radiosensitivity of lymphocytes

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Introduction: Lymphocyte differ in their susceptibility to ionizing radiation. B cells are more radiosensitive than major T cell. Most data come either from experiments in vitro or examinations upon accidental irradiation with ill-defined doses. In vivo models include laboratory rodents and a large animal model is missing. Here we show that pigs represent a convenient model for vivo studies of radiosensitivity of B lymphocytes subsets with possible implications in biodosimetry.
Methods: Doses of 1-10 Gy were used for whole body irradiation of one-month-old boars. Heparinized blood was collected before irradiation, immediately after irradiation and after selected time intervals. Samples were analyzed immediately after collection by multicolor flow cytometry.
Results: Total leukocytes counts decreased with a dose. Similar to humans and rodents, B cells represented the most sensitive lymphocyte population. In the T cell compartment, CD4+CD8- cells are more radioresistant than their CD4-CD8+ counterparts. Among CD4+ T cell subsets, the double positive (CD4+CD8+) population and cells with surface CD25 expression belong to the most radioresistant ones. Importantly, while the CD8+ NK population (CD3-CD8+ lymphocytes) rapidly disappears after irradiation , such cells re-appeared circulation as soon as 24 hr after irradiation with lower doses.
Conclusions: Short term cultivation of full blood collected from irradiated individuals represents a convenient and reliable approach for in vivo studies on ionizing radiation induced apoptosis of lymphocyte subsets in vivo. B and NK subsets have been proved as useful biomarkers of the

received dose. Different radiosensitivity of NK cells is suggested as the reason of formerly published discrepancies in NK cells radiosensitivity.

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Contribution ID: 265

22. Biological Effects of Ionizing Radiation

22.04. Cell radiosensitivity/radioresistance and its targeted manipulations

Effect of the combination of 6 MeV radiotherapy with hyperthermia and gold nanoparticles on the MCF-7 breast cancer cells

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Combining radiotherapy as one of the main modalities used for cancer treatment with other modalities such as hyperthermia has recently played a special role in reducing side effects and improving treatment outcomes. In addition, Gold nanoparticles (GNPs) have also attracted attention as suitable clinical agents for enhancing the effect of radiotherapy in treating various cancers. The purpose of this study was to investigate the effect of combination of radiotherapy with both of the hyperthermia and GNPs for the treatment of MCF-7 breast cancer cells. We evaluated the cell death of MCF-7 breast cancer cells when treated with 6 MeV radiation therapy and 13.56 MHz capacitive radiofrequency hyperthermia in the presence of 20 nm GNPs with the lowest toxicity concentration. Initially, the cells were incubated with 20 mg/L GNPs for 24 hours. Then, they were exposed to RF hyperthermia with a power of 200 W for 15 min. Afterward, they were exposed to 6 MeV electron beam produced by a linear accelerator with a dose of 2Gy. Our primary results showed that the presence of GNPs in the cancer cells and also thermal sensitizations provided by hyperthermia increases the rate of the MCF7 cancerous cell death and also the therapeutic efficiency. Hence, the combination of the two sensitizing modalities, i.e. radiofrequency hyperthermia and GNPs could be regarded for better delivery of the highest dose to the target while maintaining the lowest dose to adjustments normal organs/tissues as risk in the future. However this would require more in vivo animal studies as well as clinical human investigations.

Keywords: 6 MeV radiotherapy, Hyperthermia, Gold nanopaticles, Radiosensitization, MCF7 cancer cell

Contribution ID: 309

22. Biological Effects of Ionizing Radiation

22.04. Cell radiosensitivity/radioresistance and its targeted manipulations

Differences of Radiosensitivity Based on Temperament (Mizaj)

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Background and objectives: Radiosensitivity is a cellular response to dangerous effects of radiation. It is shown that identical dose for treatment of cancer patients produce different reactions such as acute and low responses that may be due to their biological system. Some reports indicate that disorders such as diabetes and hypertension in warm Mizaj persons are more common. The aim of the present study is to compare of radiosensitivity in warm and cold Mizaj persons by the cytogenetic assay.
Methods: Peripheral blood sample (2ml) of 30 healthy volunteers (10 cold, 11 moderate and 9 warm Mizaj) were taken and divided into two identical parts. One part is exposed to 4 Gy Gamma rays and the second part is regarded as control. DNA damage rate was evaluated in all groups by neutral comet assay.
Results: The results showed that the mean percentage of damaged cells, in the irradiated samples for all of the groups including A (warm), B (moderate) and C (cold) was significantly higher than the controls ($P<0.001$). Also, DNA damage rate in warm Mizaj group was higher than cold and moderate groups after exposure to gamma rays.
Conclusions: It seems that warm Mizaj persons are more radiosensitive compare to other groups, although extensive studies are necessary.
Keywords: Radiosensitivity, Temperament (Mizaj), Comet assay

Contribution ID: 589
22. Biological Effects of Ionizing Radiation
22.04. Cell radiosensitivity/radioresistance and its targeted manipulations

Radiosensibilization of cancer cells: Importance of autophagy modulation

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Autophagy is believed to be a radioprotective mechanism in cancer cells, thus its inhibition should increase efficiency of radiotherapy. The presented paper shows effect of two autophagic inhibitors on cancer cells. Spautin-1 causes degradation of PI3K complex and recently developed Lys05 accumulates in a lysosome and thereby impairs its function more effectively compared to hydroxychloroquine (HCQ)1.
We employed a human non-small cell lung carcinoma cells (H1299, p53-negative) and examined its response to IR and to combination of IR with both specific autophagy inhibitors. Prior irradiation (2, 4, 8 Gy), the cells were treated by various concentrations of both inhibitors (2, 5, 10 μM) and cell proliferation was measured real-time by xCELLigence system. ELISA method was used for determination of p62 level as a marker of autophagic degradation after treatment by IR (2 Gy) and Lys05 (2 μM). The data from the xCELLigence showed dose-dependent decrease of cell proliferation. The combination of IR and inhibitors led to even more accelerated decline of proliferation. Surprisingly, level of p62 increased in H1299 after radiation alone (2 Gy), suggesting that in our experimental model IR inhibits autophagy. After the combination of IR (2 Gy) and Lys05 pretreatment (2 μM) we observed significantly increased level of p62 compared to the solely irradiated group. Taken together, our data confirmed the autophagy inhibitors can be used as an effective tool for radio-sensibilization and might provide a promising platform for anti-cancer therapeutic strategy.

Contribution ID: 765
22. Biological Effects of Ionizing Radiation
22.04. Cell radiosensitivity/radioresistance and its targeted manipulations

Differences of radiosensitivity based on temperament (Mizaj)

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Background and objectives: Radiosensitivity is a cellular response to dangerous effects of radiation. It is shown that identical dose for treatment of cancer patients produce different reactions such as acute and low responses that may be due to their biological system. Some reports indicate that disorders such as diabetes and hypertension in warm Mizaj persons are more common. The aim of the present study is to compare of radiosensitivity in warm and cold Mizaj persons by the cytogenetic assay.
Methods: Peripheral blood sample (2ml) of 30 healthy volunteers (10 cold, 11 moderate and 9 warm Mizaj) were taken and divided into two identical parts. One part is exposed to 4 Gy Gamma rays and the second part is regarded as control. DNA damage rate was evaluated in all groups by neutral comet assay.
Results: The results showed that the mean percentage of damaged cells, in the irradiated samples for all of the groups including A (warm), B (moderate) and C (cold) was significantly higher than the controls ($P<0.001$). Also, DNA damage rate in warm Mizaj group was higher than cold and moderate groups after exposure to gamma rays.
Conclusions: It seems that warm Mizaj persons are more radiosensitive compare to other groups, although extensive studies are necessary.
Keywords: Radiosensitivity, Temperament (Mizaj), Comet assay

Contribution ID: 1730
22. Biological Effects of Ionizing Radiation
22.04. Cell radiosensitivity/radioresistance and its targeted manipulations

Proton-Boron fusion reaction increases proton radiobiology effectiveness

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Protontherapy is hadrontherapy's fastest-growing modality and a pillar in the battle against cancer. Hadrontherapy's superiority lies in its inverted depth-dose profile, hence tumour-confined irradiation. Protons, however, seem to lack distinct radiobiological advantages over photons or electrons and the possibility to increase their biological effects would be of enormous clinical impact. The higher Relative Biological Effectiveness (RBE) of 12C-ions can overcome cancer radioresistance. Thus, enhancing proton RBE is desirable. To this end, we exploited the 11B(p,α)2α nuclear fusion reaction to generate high-LET alpha particles with a clinical proton beam. To maximize the reaction rate, we used sodium borocaptate (BSH) with natural boron content. Boron-treated cells were irradiated at mid-SOBP (Spread Out Bragg Peak) depth and assayed for clonogenic survival and DNA damage induction We recorded significantly increased

cellular lethality and occurrence of chromosome aberrations. Specifically, we proved that, if human cells are irradiated with a given amount of 11B the interaction with protons results in an increase of almost a factor 2 in cell killing compared to boron-free irradiated controls.The findings suggest that the effect is due to the generation of low-energy, high LET alpha particles since we measured a marked increase in the complexity of DNA damage. The alphas produced have, in fact, a sufficient range to come to a halt and release almost their entire energy in the cell nucleus by which severe damage is induced to the DNA, thereby enhancing the biological efficacy of the proton beam. An added value to such a therapeutic approach is related to the gamma prompt emitted in the proton-Boron interactions that can also be used for diagnostic purposes. Last results on the radiobiological effects of the p-B will be presented and a plan for the future activities dedicated to the complete and accurate investigation of the observed effects will be also discussed.

Contribution ID: 1778
22. Biological Effects of Ionizing Radiation
22.05. Dose hypofractionation and hyperfractionation

IMRT vs SBRT in the treatment of locally advanced adenocarcinoma of the pancreas - a literature review

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Introduction: Most pancreatic cancer patients are diagnosed with advanced disease. These cases are therefore associated with poor survival outcomes. For unresectable pancreatic cancer, modern Radiation Therapy (RT) techniques delivered concomitantly with chemotherapy may be an alternative treatment for advanced disease. In this study, Intensity Modulated RT (IMRT) and Stereotactic Body RT (SBRT) for locally advanced pancreatic adenocarcinoma was compared using the data reported in the scientific literature.
Methods and Materials: A systematic review of the literature was made, searching papers from the databases PubMed and ScienceDirect, using the keywords: Radiotherapy, Pancreas, Survival and Local control. From the 72 papers initially found, 17 papers published between 2004 and 2017 met the inclusion criteria: locally advanced adenocarcinoma, unresectable and no metastasis. The biological effective dose for each study was determined using an alfabeta value of 10 and potential doubling time of 42 days.
Results: For IMRT and SBRT median disease free survival was between 5.9-7.6 months and 6.8-15.0 months, respectively, and median overall survival ranged between 8.5-14.8 months and 8.0-20.0 months, respectively. Overall survival rates one year after IMRT and SBRT were between 15%-69% and 39%-65%, respectively. Locoregional control 12 months after IMRT ranged from 64%-82%, for prescription doses between 45-60 Gy delivered with 1.8-2.5 Gy dose per fraction (BED ~33-45 Gy). Local control for SBRT, using prescription doses of 15-45 Gy delivered in 1-5 fractions (BED ~33.6- 87.5 Gy), was between 40%-94 %, respectively.
Conclusions: SBRT demonstrated slightly superior results than IMRT. For patients treated with SBRT, a tumour dose-response effect was obtained. Treatment strategies that may allow a dose escalation in pancreatic cancer should therefore be investigated.

Contribution ID: 75
22. Biological Effects of Ionizing Radiation
22.06. Protons and high-LET radiations: implications for cancer treatment

Glioma tumor control effectiveness after proton minibeam radiation therapy

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The morbidity of normal tissues continues to be the main limitation in radiotherapy. To overcome it, we proposed a novel concept: proton minibeam radiation therapy (pMBRT) [1]. It allies the physical advantages of protons with the normal tissue preservation observed when irradiated with submillimetric spatially fractionated beams [2]. We have recently implemented this technique [3] at a clinical center (Proton therapy center in Orsay) and demonstrated that pMBRT leads to a significant increase of normal tissue tolerances [4] with respect to standard proton therapy. The goal of this work was to show that this gain allows using higher and potentially curative doses in the cases of radioresistant tumors, like gliomas. With that aim two groups (n=10) of 7 weeks old male Fischer 344 rats were implanted with 5000 RG2 rat glioma cells intracranially. Half of the animals received a whole brain irradiation (pMBRT), 9 days after tumor inoculation. A clinically relevant proton beam energy (100 MeV) was used. The dose distributions were completely inhomogeneous, with areas of very high doses in the minibeam paths (70 Gy in one fraction). The controls presented a mean survival time of 20.8 ±0.4. The group receiving pMBRT showed a substantial increase of mean survival time (as today, a factor 6 gain with respect to the controls), indicating tumor sterilization. These results suggest that pMBRT widens the therapeutic window for gliomas and might offer a curative option. The fact that a significant tumor control is achieved with inhomogeneous dose distributions contradicts the classical paradigm of standard radiotherapy and points at the participation of distinct radiobiological mechanisms.

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Contribution ID: 153
22. Biological Effects of Ionizing Radiation
22.06. Protons and high-LET radiations: implications for cancer treatment

Model evaluation of normal tissue response by mini-beam radiotherapy with ion beams

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Bragg peak characteristics of ion beams makes ion-beam radiotherapy advantageous over conventional X-ray. The localized dose delivery to the Bragg peak enables to control deep-seated tumor cells while sparing surrounding benign tissues. The Bragg peak gets shaper for heavier ions; additionally, the biological effectiveness of carbon and its vicinity also increases gradually in accordance with increasing energy loss. Idea of the mini-beam radiation therapy (MBRT) was initially studied with X-ray as a method to spare proximal normal tissues by irradiating through submillimeter slit collimator. Recent studies try to apply the MBRT concept for proton beam by interlacing multiple sparse heterogeneous fields. The combination of the MBRT with ion-beam RT may lead further reduction of normal tissue toxicities.

This study aims at assessing the efficacy of the MBRT with ion beams with commonly-used normal-tissue complication probability (NTCP) consideration.
A Monte Carlo code PHITS was used to simulate the spatial dose distribution of carbon 276 MeV/n and proton 145 MeV pencil beams in water. Incident energy was selected to reach 15 cm depth. The beam was aligned in parallel at interval of the full width at half maximum at the Bragg peak layer. Accordingly, Equivalent Uniform Dose (EUD) widely used in common NTCP models was assessed from dose deposited proximal to the Bragg peak layer by changing the organ-structure parameter. The result revealed that carbon-ion beam is advantageous over protons in reducing EUD to the proximal normal tissues, however, the advantage of the mini-beam delivery was found only in case the normal tissue has extremely parallel-like structure therefore sensitive to minimum dose within the volume. The result is compared with the other NTCP models.

Contribution ID: 12
22. Biological Effects of Ionizing Radiation
22.07. Low dose effects

Hesperidin modulate radiation- induced injury in the liver of rats

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Objective: In this article, we investigated the modulation effects of hesperidin on radiation- induced lesions in the liver of Sprague Dawley rats.
Materials and methods: 48 male Sprague Dawely rats were divided into 8 groups: control, HES (100mg/kg b.w, orally, seven consecutive days, orally), total body (TB) gamma irradiation with 2 and 8 Gy, pre-administrated with 50 and 100 mg/kg b.w of hesperidin for seven consecutive before irradiation with 2 and 8Gy. The rats in the irradiated groups were irradiated by TB gamma radiation doses of 2 and 8 Gy using a 60Co source at a focus of 80 cm away from the skin. Histopathological evaluation was done 24 h after radiation.
Results: Pathological damages of radiation were dilation of central vein, accumulation of inflammatory mononuclear cells in portal space and capillarization of sinusoids. The results showed HES administration (100 mg/kg b.w, seven consecutive days, orally) before exposure to 2 Gy gamma radiation led to remove inflammatory mononuclear cells in the portal space and central vein dilation and observed with normal liver structure. Microscopic findings in the groups receiving two doses of hesperidin (50 and 100 mg/kg b.w, orally, 7 days) before 8 Gy of gamma radiation was similar, in a way that extreme dilation of central veins to be seen but there was no capillarization of sonusoids.
Conclusion:Based on the finding in this study, it shows that Hesperidin would ameliorate the radiation-induced damage. Therefore, HES may be offered as a suitable radio-protector in radiotherapy patients, radiation workers and public.

Contribution ID: 911
22. Biological Effects of Ionizing Radiation
22.07. Low dose effects

Continuous low-dose-rate irradiation promotes growth of silkworms

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In various organisms including mammalians, insects, and plants, beneficial effects of low-dose irradiation have been reported. Among such effects, growth promotion by low-dose (< 200 mGy) irradiation is attracting attention. The purpose of the present study was to investigate the influence of continuous low-dose-rate irradiation on the growth of silkworms, Bombyx mori. A total of 200 eggs of silkworms were randomly divided into two groups, and were grown on either low-dose-radiation-emitting sheets or control sheets. On the radiation-emitting sheets, the dose rate was measured as 66.0 +/- 4.3 μSv/h (mean +/- SD) by a Geiger-Mueller counter for α, β, and γ rays, and 3.8 +/- 0.3 μSv/h by a survey meter for γ rays. From the γ-ray spectra, the radiation-emitting sheet was considered to contain Ac-228 and Br-77. The control sheets had similar color and physical characteristics but no radioisotopes. After about 14 days, the eggs hatched and young silkworms emerged, with no apparent differences in the sizes of the silkworms between the low-dose radiation and control groups. The silkworms grown on the radiation-emitting sheets became larger than those of the control groups on day 39 and thereafter (P < 0.001). On day 42, the mean body weight was 2.5 +/- 0.2 (standard deviation) g for the radiation-sheet group and 2.0 +/- 0.2 g for the control group (P < 0.001). On day 49, they were 4.5 +/- 0.5 and 3.6 +/- 0.4 g, respectively (P < 0.001). Further experiments are ongoing to determine the optimal dose rate to promote growth. Continuous low-dose-rate irradiation promoted the growth of silkworms. It should be further investigated whether this phenomenon could be utilized by the silk industry.

Contribution ID: 999
22. Biological Effects of Ionizing Radiation
22.07. Low dose effects

Preparation of dental implants using in Calcium fluoride as an antimicrobial agent by radiation

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Dental composite materials have been used for more than fifty years. They cause less safety problems than dental amalgams and provide improved aesthetics. Over the years, the mechanical properties of commercial resin-filled composites have increased significantly, thus reducing failures due to breakage and wear.
However, persisting problems such as polymeric shrinkage causing micro-gaps during recovery followed by bacterial microleakage due to a lack of antibacterial activity may result in further infection and dentin mineralization.
Calcium fluoride is widely use in many biomedical applications especially dental materials. This is because it has good biocompatibility and antibacterial properties.
In this study, it was expected that low dose X-ray irradiation of calcium fluoride nanoparticles to produce significant amounts of Reactive oxygen species (ROS) on the cell membrane and cell wall would achieve the effect of antimicrobial root canal therapy.
For material characterization, firstly, size distribution analysis by dynamic scattering, showed that the particle size was 40 ~ 60 nm with 0.10 pdi. Secondly, it was shown that the material emitted red fluorescence under a hand-held UV lamp at 325nm. Finally , cytotoxicity assessment showed no toxicity by cell culture. Hence based on our preliminary results, calcium fluoride showed fluorescent properties with excellent biocompatibility thus confirming the feasiblity of calcium fluoride in radiation and antibacterial treaments.

Contribution ID: 1268
22. Biological Effects of Ionizing Radiation
22.08. Radiomics and systems radiobiology

An infrastructure for efficient voxel based dose-effect relationships mining

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Modern precision radiotherapy allows small safety margins and dose escalation. Therefore, biological uncertainties become more important such as CTV delineation and organ at risk tolerance. The aim of this work is to setup an efficient infrastructure to explore voxel-based dose-response relationships. Data is read directly from the clinical plan archive. Planning CTs are deformably registered to a reference CT using open-source algorithms, e.g. Niftyreg, Ants or Elastix. Depending on the application certain anatomical elements are suppressed, e.g., bone or anatomy outside the pelvis. Registration is assessed visually using animation to remove outliers. Registration uncertainties are quantified using organ-at risk contours or anatomical landmarks, dose distributions are smoothed according to the uncertainties and then mapped onto the reference patient. Next outcome measures are correlated voxel by voxel with the dose distributions. The resulting correlation maps are tested for significance using a test statistic, e.g. largest correlation cluster size, using randomization to test for significance. We have applied this methodology in several tumour sites and it has allowed discovery of sensitive substructures of organs. For example, in lung cancer we demonstrated a relationship of heart base dose with early mortality (~1100 patients); while in head and neck cancer, masseter dose correlated most with post treatment trismus. In prostate cancer, obturator dose relates to PSA control. One of the issues that we are investigating is the impact of confounding variables on data mining; in particular tumour size as it drives incidental patient dose as well as outcome. Furthermore the method shows inherent correlations in voxel-wise dose distributions that are related to planning techniques that are often ignored in dose-volume based analyses. We conclude that voxel-based dose response relationships can be discovered efficiently using deformable registration and novel statistical techniques and that these complement traditional dose-volume analyses.

Contribution ID: 214
22. Biological Effects of Ionizing Radiation
22.09. Biodosimetry

DNA damage in leukocytes after internal ex-vivo irradiation of blood with radionuclides frequently used in Nuclear Medicine

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Introduction: We extended our previous work on DNA damage in blood leukocytes induced by internal irradiation with I-131 and Lu-177 (Eberlein et al., PLoSOne 10, 2015) to Ga-68, Y-90, Tc-99m and Ra-223 which are the most frequently used radionuclides in Nuclear Medicine today. The aim was to correlate the DNA damage to the absorbed dose to the blood (ADBlood) and to investigate differences relating to radiation quality.
Methods: 16 blood samples (Ga-68: 6; Ra-223: 6; Tc-99m: 1; Y-90: 3) from volunteers were split into aliquots and mixed with radioactive solution, followed by 1h incubation at 37°C. Each sample's activity was determined with a calibrated germanium detector. Furthermore, non-irradiated baseline samples were prepared. After leukocyte separation and fixation, cells were immunofluorescently stained for γ-H2AX+53BP1. Co-localizing γ-H2AX+53BP1 foci and DNA damage tracks were counted manually in 100 cells per sample using an epifluorescence microscope. For the β-/γ-emitters, the calculation of ADBlood was based on a simulation of energy

deposition by Hänscheid et al. (PMB 59, 2014). For Ra-223, ADBlood was calculated assuming local energy deposition of all non-penetrating particles for Ra-223 and all progeny.
Results: While the cells irradiated with β-/γ-emitters show randomly distributed small γ-H2AX+53BP1 foci (Ø≤1.1µm) likely representing simple DNA double-strand breaks, Ra-223-irradiated cells additionally display α-induced DNA damage tracks and large foci (Ø>1.1µm) harboring complex DNA damage. For Ga-68/Tc-99m/Y-90-irradiated samples, the number of radiation-induced foci (#RIF) was proportional to ADBlood ranging from 0 to 108mGy, being in agreement with our previous results. For the Ra-223-irradiated samples, a linear relationship between the number of α-tracks (#αT) and ADBlood (range: 0 to 142mGy) was observed.
Conclusion: While #RIF is proportional to ADBlood for β-/γ-emitters, #αT proves to be a suitable parameter for describing the dose-response relationship for α-emitters. Potential differences between different β-/γ-emitters need to be further investigated.

Contribution ID: 1652
22. Biological Effects of Ionizing Radiation
22.09. Biodosimetry

Calculation of dose- response curves for in vitro biodosimetry using a linear accelerator either in FF or FFF modes

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The dose response for dicentric chromosomes plus centric rings and total unstable chromosome-type aberrations was studied in the first mitoses of cultured human peripheral blood lymphocytes were irradiated in vitro with photon beams of a Varian TrueBeam linear accelerator. Samples were irradiated either with different energy levels or with different dose rates with flattening filter (FF) or flattening filter free mode (FFF), then linear (α) and quadratic (β) components of the curves were calculated and compared.
Venous blood samples from 19 healthy volunteers were irradiated with different dose rates with 6, 10, 18 MV FF and 6, 10 MV FFF photon beams at doses between 0.5 and 8 Gy at room temperature. Metaphases from lymphocyte cultures were prepared by standard cytogenetic techniques and chromosome analysis was performed. Dose –response calibration curves were constructed with the CABAS Software version 2.0 and with OriginPro 8.
Factors like the employed energy, and dose rate influenced directly the values of α and β. In our work the value of β was higher at 6 MV FF and 6 MV FFF (0.038-0.040 Gy^{-2}) than at 10 MV FF and 10 MV FFF (0.029-0.035 Gy^{-2}). The α coefficient of dose-response curves was small (0.001-0.026 Gy-1), the β quadratic values dominated (0.029-0.041 Gy-2). We calcultated the α and β values obtained when fitting from 0-3 Gy or 0-6 Gy or 0-8 Gy at the same curves and it was found that the value of α decreased as the dose range was increased, the value of β increased parallel with the function of the dose range.
Biological dosimetry provides useful information on the potential hazardous effects of ionizing radiation in exposed individuals and helps to estimate therapeutical success and late adverse events.

Contribution ID: 145
22. Biological Effects of Ionizing Radiation
22.10. Clinical radiobiology

Radiobiological and clinical investigation of pulsed low dose rate radiotherapy for recurrent cancers

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Purpose: In this work we performed pulsed low dose rate radiation therapy (PLDR) treatments of tumor-bearing mice to investigate the treatment efficacy of PLDR and developed treatment planning strategies for the clinical implementation of a phase-I dose-escalation trial for PLDR treatment of recurrent cancers utilizing IMRT and VMAT.
Materials and Methods: Mice were implanted with various tumors and treated with PLDR or regular RT. Tumor growth delay was measured using MRI. The PLDR trial escalated the prescription dose from 40 to 60 Gy and the daily 2Gy dose was delivered in 10x0.2Gy sub-fractions (pulses) with a 3min interval. Planning strategies/guidelines were developed for PLDR including beam number selection, beam angle optimization, target dose constraints and the use of reference structures.
Results: Similar tumor growth rate was observed between PLDR and regular RT for LNCaP tumors but up to 30% more tumor growth delay was observed with PLDR for other tumors (PC3, A549, FaDu. Histopathological results showed that normal tissue toxicities were much reduced with PLDR compared to regular RT. IMRT and VMAT could further improve the target dose conformality and normal tissue sparing, which is essential for treating recurrent cancers. All PLDR plans using IMRT and VMAT met the dosimetry requirements of the PLDR protocol. The mean dose was 0.20±0.01 Gy and the maximum dose < 0.4 Gy. Mo re than 14 patients were treated on the PLDR protocol with no ≥ grade 4 acute or ≥ grade 3 late effect/adverse events reported.
Conclusions: The results of our in-vivo experiments demonstrated the effectiveness of PLDR for tumor control. Both IMRT and VMAT can be used for PLDR treatment of recurrent cancers with superior target dose conformity and critical structure sparing. The planning strategies/guidelines developed in this work are practical for IMRT/VMAT treatment planning for the clinical implementation of PLDR.

Contribution ID: 685
22. Biological Effects of Ionizing Radiation
22.10. Clinical radiobiology

Comparison of HDR, seed brachytherapy and teletherapy in the perspective of chromosomal damage and radiogen toxicities

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Personal radiosensitivity of patients is one of the most perplexing challenge of radiotherapy of malignancies, the another is the biological dose comparison of different radiotherapeutic modalities.
We aimed to compare consequences of teletherapy and high (HDR) and low dose rate (seed) brachytherapy in prostate cancer patients by biological dosimetry and with patient follow-up

regarding toxicities. Probable correlation between chromosome aberrations and patient complaints was also monitored.
Patients with prostate adenocarcinoma at low or medium risk were recruited, venous blood samples were collected right before and after radiotherapy , than 3, 6, 9, 12 months later and yearly afterwards. Adverse events were registered using RTOG-EORTC grades, and the internationally accepted IPSS and QoL questionnaires at the same timepoints. The chromosomal aberration was measured in lymphocytes, and aneuploid cells, gaps, exchanges, chromatid and chromosome breaks, translocations, dicentric and ring chromosomes were recorded.
The number of dicentric and ring chromosomes, total aberrations and aberrant cells were significantly higher in teletherapy patients' blood compared to brachyherapy patients right after and 3, 6 months after radiotherapy. (For example 3 months after radiotherapy the value of total aberrations are: 4.5 ± 3.2 in HDR, 6.0 ± 3.9 in seed therapy and 11.7 ± 8.0 in teletherapy patients). The least chromosome aberrations and geniutourinary side effects as well were seen in HDR brachyterapy patients. Gastrointestinal side effects were detected in a very few patients, and all together only one grade 3 was found in 86 patients. Furthermore, significant correlations were found between chromosome aberrations and toxicities.
In conclusion, HDR therapy is the most beneficial for low and medium risk prostate cancer patients (provided that individual anatomy allows this), as it is indicated in our prospective clinical study with 2-year follow-up.

Contribution ID: 797
22. Biological Effects of Ionizing Radiation
22.10. Clinical radiobiology

Acute esophagitis and swallowing dysfunction in head-and-neck radiotherapy: Evaluation of dose-response and NTCP model parameters

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Introduction: Swallowing dysfunction is an important side effect of radiotherapy (RT) for head-and-neck cancer (HNC) and esophagitis is one of its main causes. Little is known on dose-response for esophagitis in the cervical esophagus (CE). Moreover, parameters for the Lyman-Kutcher-Burman (LKB) normal-tissue complication probability (NTCP) model for it are lacking. This study aimed to investigate dose-response for acute esophagitis in HNC patients undergoing non-intensity-modulated RT and the ability of the LKB NTCP model parameters available for middle-and-lower esophagus to predict this endpoint in the CE. Methods: This prospective study included 50 HNC patients. Grade ≥ 2 acute esophagitis (CTCAE v.4 scoring criteria) within 9 weeks after the start of RT was assessed using the EORTC QLQ-H&N-35 questionnaire. Dose-volume parameters were analyzed for CE, superior, middle and inferior pharyngeal constrictor muscles (SPCM, MPCM and IPCM, respectively), esophagus inlet muscle (EIM), supraglottic larynx (SGL), base of tongue (BT), glottic larynx and cricopharyngeal muscle. The ability of four sets of LKB model parameters available for the NTCP of this endpoint in the middle and lower esophagus was evaluated using Biosuite software based on the mean CE dose. Results: Forty three patients (86%) experienced grades 2-3 acute esophagitis (no grades 4 or 5). The SPCM V30, MPCM V30-V40, EIM V50, CE V40-V55, BT V60, SGL V20-V40, and the mean doses of these six structures correlated with swallowing dysfunction. The mean dose to the CE was the most significant parameter. None of the current LKB model parameters fitted the observed NTCPs closely. Conclusions: The mean dose and V40-V55 to the CE are significantly associated with swallowing dysfunction. This study adds evidence to the necessity of modern techniques to reduce esophagitis in HNC RT and provides dose-response data for a wide dose range. LKB model parameters for swallowing dysfunction specifically for CE dose are also required.

Contribution ID: 870
22. Biological Effects of Ionizing Radiation
22.10. Clinical radiobiology

Enhancement of radiation effect by cetuximab on colon cancer cell lines

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Objective: In case of colorectal cancer radiotherapy, it is difficult to increase administered dose even though IMRT. Chemoradiotherapy is considered as an enhanced effective therapy on colon cancers. It has already been reported improved outcome by combination of cetuximab, a molecular EGFR-targeted drug, and radiotherapy which has synergistic effect in head and neck cancers. Therefore, we hypothesized that combination of cetuximab and radiotherapy on colon cancers would be an effective therapy.
Materials and methods: First, radiation sensitivities of 8 human colon cancer cell lines were examined by clonogenic assay. Next, radiosensitizing effect of cetuximab on each cell lines were examined by clonogenic assay.
Results: Radiosensitizing effect of cetuximab was observed in 3 of the 8 cell lines. No correlation was found with regard to the expression level of EGFR and radiosensitivity. The association with genetic mutation such as k-Ras, b-Raf was not clear.
Discussions: Cetuximab has potential to enhance radiation effect in colon cancer cell lines. We will continued further studies and are going to investigate the mechanism why cetuximab has enhanced the radiation effect.

Contribution ID: 1716
22. Biological Effects of Ionizing Radiation
22.10. Clinical radiobiology

The evaluation of radiobiological effect of Leksell gamma knife treatment

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The main purpose of the study is to evaluate the radiobiological effect of the dose rate changes in Leksell Gamma Knife (LGK) clinical conditions. In principle there are two reasons why dose rate on LGK is reduced during patient irradiation: 1) Co-60 sources decay with a half-life of 5.26 years and 2) using multiple isocenters and conformal treatment plans. This pilot study is an experimental work performed in vitro with medulloblastoma DAOY cells.
A number of repeated experiments were performed with medulloblastoma DAOY cells irradiated on LGK Perfexion by various dose rates (0.37 – 3.05 Gy/min). The irradiation was performed in a spherical Elekta ABS plastic phantom with the special insert for the Eppendorf tube containing cells. The approach was to cultivate cells as an adherent culture in suspension. The control of the different dose rates of LGK was achieved by sector blocking of the LGK collimator. To ensure homogenous irradiation of the cells 16 mm collimator was used. Plating efficiency and surviving fraction were determined for each experimental cell sample. Various different doses in the range 0 – 6 Gy were used to have enough experimental points to obtain cell survival curve. The linear quadratic model was used to fit experimental data. Survival curves for different dose rates were plotted and compared, as well as obtained α and β parameters.
Based on data obtained so far, higher cell survival for dose rates lower than 0.40 Gy/min compared to higher dose rates over 0.75 Gy/min has been observed. Currently, further experiments are performed in order to enlarge interval of studied dose rates and to take into account more biological endpoints of the irradiation.
This study was supported by the Ministry of Health, Czech Republic - conceptual development of research organization (Nemocnice Na Homolce - NNH, project n. 00024883).

Contribution ID: 76
22. Biological Effects of Ionizing Radiation
22.11. Other

Transfer of minibeam radiation therapy into a small animal irradiator

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Minibeam radiation therapy (MBRT) is an innovative synchrotron radiotherapy technique able to shift the normal tissue tolerances to very high doses [1]. MBRT seems to involve different biological mechanisms from those in standard RT. However, its exploration was hindered due to the limited and expensive beamtime at synchrotrons. The aim of this work was to evaluate the feasibility of the implementation of MBRT into cost-effective equipment. This would permit the realization of systematic radiobiological studies. For that purpose, a series of modifications of a small animal irradiator (Small Animal Radiation Research Platform-XSTRAHL Ltd.) were performed. An adapted collimator was designed by means of Monte Carlo simulations (Geant4). Peak to valley dose ratio (PVDR) values and full width half at maximum (FWHM) similar to those ones at the European synchrotron radiation facility (ESRF) [2] were obtained. As a proof of concept, two groups of animals were irradiated: a first group (series 1) received conventional (broad beam) irradiations, the second series was irradiated with MBRT. The rats brain, excluding the olfactory bulb, were irradiated unilaterally. Thick minibeams (1 mm-wide beams) were employed for this study. The same average dose was deposited in both cases, 20 ± 1 Gy, which corresponds to 58 Gy peak dose in the MBRT case. The animals were followed-up for 6.5 months. The rats treated with conventional irradiation exhibited very important brain damage, including radionecrosis. In contrast, no substantial brain damage was observed in the animals of the MBRT group. This is the first time that such an evaluation is done with millimetre-sized minibeams in the brain, which opens the door for future implementations with less technically demanding and very compact systems.

[1] Prezado, Y. et al. Rad Research 184, 314–21 (2015).
[2] Prezado, Y. et al. Med. Phys. 38, 5012–5020 (2011).

Contribution ID: 91
22. Biological Effects of Ionizing Radiation
22.11. Other

Effect of X-ray minibeam radiation therapy on clonogenic survival of F98 rat glioma cells

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The main goal of this work was to assess the effectiveness of X-ray minibeam radiation therapy compared to conventional radiotherapy in inducing tumor cell (glioma) kill. With that aim, we report on the first in vitro study performed in a X-ray Small Animal Radiation Research Platform modified to make it suitable for MBRT irradiations.
Preplated F98 rat glioma cells were irradiated with either an array of minibeams or with conventional homogeneous beams (broad beam). A specially designed multislit collimator (400 μm width) was used to generate the minibeams. Before X-rays exposure, cells were plated into 48-well plates in order to obtain a nearly confluent monolayer at the time of irradiation. Cells were either replated for clonogenic assay directly (immediate plating) or 24 hours after irradiation (delayed plating) to assess the effect of potentially lethal damage repair on cell survival. Gafchromic films placed on top of the well plated were also used for irradiation quality assurance. We observed that MBRT leaded to higher surviving fractions than classical irradiations for mean doses below 20 Gy. No difference in clonogenic survival between the two irradiation methods was observed for high mean doses (20 Gy). This corresponds to 54 Gy and 4.7 Gy peak and valley doses, respectively, in MBRT. At equal mean dose the same tumor control can be obtained with standard irradiations and with completely heterogeneous dose distributions such as those in X-ray minibeam radiation therapy provided that a minimum valley dose in MBRT is attained. This finding contradicts the established paradigms of the standard RT and points at the participation of different biological mechanisms from those in conventional RT.

Contribution ID: 218
22. Biological Effects of Ionizing Radiation
22.11. Other

Infrared microspectroscopy as a bio-analytical tool to understand the biochemical effects involved in innovative radiotherapy approaches

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Radiotherapy is one of the main modalities for cancer therapeutics. However, it remains unsatisfactory for certain tumors and localizations, where the tolerance of normal tissues to radiation limits the possibility of delivering higher (potentially curative) doses to the tumor. This is

especially critical in the case of radio-resistant tumors, such as gliomas. High-grade gliomas have still a poor prognosis and most of the treatments remain palliative. In the quest for ways to improve the therapeutic index, innovative radiotherapy approaches are being explored. Within this context, we are working both on the development of spatially fractionated radiotherapy using hadron beams, and on the use of Au-nanoparticles as tumor radio-sensitizers [1-2].
Despite the potential of these two innovative approaches, the biochemical mechanisms are not yet fully understood. Within this context, we used synchrotron-based Fourier-transform infrared microspectroscopy (SFTIRM) as a bio-analytical tool to disentangle the biochemical processes inside glioma cells induced by these novel radiotherapy modalities [3]. For this purpose, the intense infrared light produced at ALBA synchrotron was used, leading to a clear advantage in spectral quality at sub-cellular level. The SFTIRM data obtained provided valuable information on cell functionality, cell cycle and cell death modes. Results showed clear treatment-induced variations in the main cell bio-molecules (Amide I and II protein bands; CH2 and CH3 lipid stretching modes; and phosphodiester DNA modes), after Principal Component Analysis (PCA).
An overview on both spatially fractionated radiotherapy and on the use of nanoparticles as tumor radio-sensitizers will be given. Then, detailed PCA results with focus on how SFTIRM contributes to understand the underlying biology of these cutting-edge radiotherapy techniques will be presented.
References: [1] Yousef et al. Analyst. 141 (2016); [2] Martínez-Rovira et al., Med. Phys. 44 (2017).

Contribution ID: 451
22. Biological Effects of Ionizing Radiation
22.11. Other

Raman spectroscopy for monitoring ionizing radiation-induced damage in cells and tissues

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Radiation is currently used in upwards to half of all cancer treatments. Despite it's ubiquity, radiation therapy remains challenging from a range of technological and radiobiological perspectives. From a clinically relevant radiobiological point of view, the monitoring of cellular and tumour tissue response post radiation treatment is an outstanding issue and hence remains a pressing and active research area. While a number of assays and imaging modalities are currently under investigation, there does not appear to be a clinically accepted and routinely utilized method for assessing tumour and patient response to radiation therapy. We herein investigate the possibility of utilizing Raman spectroscopy for the detection and monitoring or ionizing radiation-induced biological damage in irradiated cell and tumour tissues. Raman spectroscopy is a non destructive optical spectroscopic technique that allows for the multiplexed collection of a host bimolecular signatures within a cell or tissue sample. We show that Raman spectroscopy, in combination with principal component analysis, can be used in detecting radiation damage in a host of cellular and tumour tissues, and that a dependence in both radiation dose and time post-irradiation can be identified in the response. Furthermore, a number of principal components can be mapped to specific biomolecular signatures of radiation response and, when Raman spectra are acquired on irradiated murine tumour tissues, the spatial dependence of the bimolecular response can be mapped. We show that the bimolecular response is heterogeneous across the tumour sample, and that this heterogeneity can be quantified using Haralick texture analysis. The heterogeneity of tumour response to radiation is shown to be dose dependent and illustrates the spatial complexity of tumour radiation response. The sum of our investigations illustrate that Raman spectroscopy, in combination with multivariate analysis techniques, can prove to be a useful tool in understanding and monitoring tumour radiation response.

Contribution ID: 917
22. Biological Effects of Ionizing Radiation
22.11. Other

Radiation dose on the ascending aorta and the heart for mediastinal lymphoma treatment with abc technique

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Purpose: Evaluation of the radiation dose in radiotherapy treatment of mediastinal lymphomas to the heart and the ascending aorta according to RTOG protocols. Patients were treated with deep breath hold technique (DIBT) using two, the most often photon energies, 6 MV and 10 MV.
Material and methods:
The radiation treatment with deep breath hold method (DIBT) provided for 22 patients (men and women) of reproduction age with diagnosis of Hodgkin and non-Hodgkin mediastinal lymphoma. Ascending aorta was contoured by CT scans 3mm thickness, the length and diameters of the ascending aorta was calculated by MONACO treatment planning system and Excel formulas. Dose was estimated for the aorta and heart. Statistical analysis was performed including correlation analysis and coefficient of variation evaluation (STATISTICA program). The results are presented as graphics and histograms.
Results: According to RTOG 1005 and RTOG 0623 protocols the radiation dose to the heart was estimated. As a result, use of the photon energy in 6 MV is safer for critical structures, such as the heart and the ascending aorta. Different dosimetric parameters of the ascending aorta were evaluated such as the radiation dose to the aorta volume of 10%, 20%, 50% and 70%. The constraints for these parameters were found.
Conclusion: The photon energy of 6 MV is more effective in terms of cardiotoxicity in radiotherapy of mediastinal lymphomas in comparison with higher energy, like 10 MV it is showed prescribed dose to the tumor, where we found, 6 MV has less value. Contouring of the ascending aorta is an important step of the radiation treatment preparation, because aorta is closely adjacent to the target, so cardiotoxicity can emerge on aorta in the first place.

Contribution ID: 156
23. Nuclear Medicine and Molecular Imaging
23.14. Keynote lecture

KEYNOTE LECTURE: Quantitative imaging biomarkers using PET/MRI

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PET has, since its inception, established itself as the imaging modality of choice for the in vivo quantitative assessment of molecular targets in a wide range of biochemical processes underlying tumour physiology. PET image quantification enables to ascertain a direct link between the time-varying activity concentration in organs/tissues and the fundamental parameters portraying the biological processes at the cellular level being assessed. However, the quantitative potential of PET may be affected by a number of factors related to physical effects, hardware and software system specifications, tracer kinetics, motion, scan protocol design and limitations in current

image-derived PET metrics. Given the relatively large number of PET metrics reported in the literature, the selection of the best metric for fulfilling a specific task in a particular application is still a matter of debate. Quantitative PET has advanced elegantly during the last two decades and is now reaching the maturity required for clinical exploitation, particularly in oncology where it has the capability to open many avenues for clinical diagnosis, assessment of response to treatment and therapy planning. Therefore, the preservation and further enhancement of the quantitative features of PET imaging is crucial to ensure that its full clinical value is utilized in clinical oncology. The bulk of PET/MR research to date focused on the instrumentation and building MR-compatible PET detectors and readout technologies, the challenges of MRI-guided PET attenuation correction, partial volume correction and motion compensation, and also finding a niche or primary clinical use of PET/MRI. This talk reflects the tremendous increase in interest in quantitative molecular imaging using PET/MRI hybrid imaging in both clinical and research settings. Quantitative imaging biomarkers will help in charting personalized treatment plans for patients and also in exploring new therapeutic opportunities. Current and prospective future applications of quantitative molecular imaging using PET/MRI will be addressed.

Contribution ID: 997
23. Nuclear Medicine and Molecular Imaging
23.01. Nuclear medicine instrumentation – present and future designs

Evaluation the performance of a PET detector using a sparse SiPM array with reflectors

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Positron emission tomography (PET) is a functional and molecular imaging tool which plays a great role in nuclear medicine for disease diagonoses and
medical researches. PET is usually built with scintillation detectors which consist
of crystal arrays and photon sensor arrays. In recent years, silicon photomultipliers (SiPMs) are widely used in PET detectors. Although closely arranged SiPM array will achieve high performance, a sparse array can effectively reduce the cost and provide a more cost-effective system.
We have developped a sparse 8×8 SiPM array using the MicroFB-30035-SMT
form SensL Inc. The size of the array is 33.7×33.7 mm2 while the size of the SiPM chip is 3.2×3.2 mm2, thus the ratio of the gaps is 44%. Based on the sparse SiPM, a high performance depth of interaction PET detector has been built with a dual-layer offset LYSO array. The gaps between the SiPMs are dead zones which reduce the optical photon collection. In this work, the effect of pasting enhanced spectral reflector films (3M) in the gaps are studied.
The flood maps with and without reflectors are acquired using Na-22 source under room temperature. A quantitative method has been developed for the evaluation including the photopeak, energy resolution and root-mean square (RMS) of the crystal response. The results show that reflectors pasted in the gaps effectively enhance the photon collection (25.5% increase) and improve the energy resolution of the detector (from 13.47% to 12.77%). The average RMSs with and without reflectors are 4.12 and 5.24 respectively, which indicates the quality improvement of the flood map, i.e. the intrinsic spatial resolution of the PET detector is improved.

Contribution ID: 1019
23. Nuclear Medicine and Molecular Imaging
23.01. Nuclear medicine instrumentation – present and future designs

Health regulation of multimodal technologies with positrons in Cuba

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The regulation of equipment and products related to multimodal technologies has had as an essential component a greater interrelation between the health and radiological protection authorities in order to guarantee efficacy and safety in their use. In Cuba, these last 7 years a new regulatory dynamic have prevailed, which, although makes this activity complex, it is complemented with a greater focus on hospitals. The incorporation of multimodal equipment to Cuban nuclear medicine, such as PET / CT technology, has imposed the link of aspects related to good practices for the manipulation of short-lived radiopharmaceuticals and a more personalized attention to the patient, also complying with Radiation protection requirements. The concept of Suitable for Clinical Use has been implemented as a complementary strategy for authorizations that has strengthened regulatory control increasing the number of equipment that have the ability to function in effective and safe conditions, under a more perceptive technology surveillance. As a result of the strategy outlined, the national protocol for the quality control of nuclear medicine instrumentation was updated with the incorporation of these equipment, a new checklist was draw up for the quality audits that are carried out and the first equipment has been put into service in our country, using Fluor-18 and Galio-68, which is already a reference in the implementation of these concepts.

Contribution ID: 1228
23. Nuclear Medicine and Molecular Imaging
23.01. Nuclear medicine instrumentation – present and future designs

High resolution PET detector module with optimized coordinate correction

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Owing to their comparable gain to photomultiplier tubes, compact size, fast response and immunity to magnetic field, Geiger-mode silicon photomultipliers (SiPMs) have recently received considerable attention for high resolution Positron Emission Tomography (PET) applications, especially where space limitations are an issue or simultaneous acquisition with Magnetic Resonance Imaging (MRI) is needed. The goal of this work is to report on an evaluation of a small – scale PET detector prototype based on LYSO scintillation crystals, 8x8 SiPM arrays and Row/Column (R/C) signal readout with 64:16 multiplexing ratio and an optimized Truncated Centre of Gravity (TCoG) coordinate reconstruction method. A 0.25mm Na-22 point source imbedded in 1cm x 1cm x 1cm acrylic cube and 2 different phantoms were used to evaluate the detector performance. Studies demonstrate a notable advantage of using TCoG algorithm instead of basic Centre of Gravity (CoG): the Field of View (FoV) shrinkage effect is minimized and flood histogram peak to valley ratio (PVR) is increased. Application of TCoG helps to clearly resolve all crystal pixels and improves signal to noise ratio in reconstructed images of phantoms. For NEMA Micro PET phantom it is possible to resolve smallest hot rod of 1mm size and for Ultra Micro Hot Spot - as small as 1.35 mm closely positioned hot rods. Overall, our results demonstrate that TCoG positioning algorithm with multiplexing permits to effectively reduce the image shrinkage effect and non-linearity at the edges of the FoV while reducing the number of channels used. In such, it is a feasible approach for development of a high resolution and lower cost compact gamma detector.

Contribution ID: 1653
23. Nuclear Medicine and Molecular Imaging

23.01. Nuclear medicine instrumentation – present and future designs

Neutron-generating target for nuclear medicine purposes

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Nuclear-power reactors are suppliers of radioactive isotopes. The medical practice has already faced a lack of isotopes due to a stoppage in production at the primary producer's site (NRU).
As an alternative to nuclear-power reactors and spallation sources, it is suggested to use a photoneutron generation method when irradiating a target working fluid surrounded by a blanket, in which it is planned to accumulate radioactive isotopes.
The conventional components of such system include a particle accelerator and a target. However, there is a problem of heat removal from the target material. Such restrictions are lifted by using a liquid metal – natural gallium of isotopic composition as a target material, whose liquid phase covers the temperature range of 30°C to 2000°C.
The operational principle of such system is as follows. Electrons from the accelerator having the energy of 20 – 100 MeV are hindered in the gallium. The incipient deceleration gamma radiation initiates a neutron photoproduction reaction in the area of giant dipole resonance $^{69,71}Ga(\gamma, xn)$. The energy of generated neutrons is average in the area of 1 MeV, so the probability of their capture in the gallium is suppressed, and the total leakage from the target surface is virtually equal to 100%. In consequence of irradiation with a flux of high-energy neutrons in the blanket, nuclear reactions do occur. A required neutron spectrum shall be selected on the basis of blanket neutronic calculations and the intended application of the accelerator-driven system.
The project deliverable shall include a multi-functional tool for accumulating different types of isotopes and radionuclides for the medical practice.

Contribution ID: 1027
23. Nuclear Medicine and Molecular Imaging
23.03. Magnetic resonance in nuclear medicine

Planar images on a new hybrid gamma detector MRI compatible

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The author does not agree to publish the abstract

Contribution ID: 1028
23. Nuclear Medicine and Molecular Imaging
23.03. Magnetic resonance in nuclear medicine

Study of sensibility for a new gamma-MRI compatible detector using Monte Carlo simulations

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The author does not agree to publish the abstract

Contribution ID: 15
23. Nuclear Medicine and Molecular Imaging
23.04. SPECT, SPECT/CT imaging

Improvement of neuroendocrine tumor detection in In-111 pentetreotde SPECT

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In-111 pentetreotide is used as an unclear medical imaging diagnostic reagent of neuroendocrine tumor. In-111 pentetreotide is combined with somatostatin receptor onset to NET, which is known as somatostatin receptor scintigraphy. There are only a few studies in nuclear medicine using In-111 radionuclide and they do not discuss SPECT acquisition conditions or correction methods. This study examined the acquisition conditions for improving the detectability of positive signals in phantom tests and human studies. We acquired individual images from 172keV and 247keV energy peak. Then, SPECT images were added and compared with individual images. The convention of ±10.0% and ±7.5% was used as the width of the energy window. In the first phantom study, we used a cylindrical phantom with three hot spheres arranged at equal intervals on a uniform background (22kBq/ml). The diameters were 8, 10, and 15 mm, and densities of 2, 4, 8 and 16 were established. Moreover, in the second phantom study, we used a body phantom with two hot spheres arranged in the liver and spleen. In the clinical study, the activity was injected into parts of the phantom of patients with neuroendocrine tumor (N = 26). Comparison of the contrast ratios of hot rods in phantoms indicated 16.8% improvement in energy peak±7.5% than in energy peak±10.0%, and 9.2% improvement in 172keV±10.0% plus 247keV±7.5% than in energy peak±7.5%. The detectability of intrahepatic tumor also improved in the body phantom. Moreover, detection in the clinical study with a similar tendency also improved. In general, when the energy width widens, Compton scatter increases, and the image is known to deteriorate. SPECT images are particularly influenced by 247keV. However, even if 172keV widened the energy width in this study, there were increased counts and the detectability of the signal (tumor) in the SPECT image improved and stabilized.

Contribution ID: 636
23. Nuclear Medicine and Molecular Imaging
23.04. SPECT, SPECT/CT imaging

Reconstruction characteristics of the xSPECT Quant SPECT/CT reconstruction for Lu-177

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Aim: The aim of this work was to investigate the reconstruction characteristics of the recently presented xSPECT Quant reconstruction method for absolute quantitative Lu-177-based SPECT/CT imaging with regards to noise and resolution, and determine recovery coefficients.
Materials and methods: Acquisition: Siemens Intevo Bold SPECT/CT, 0.95-cm crystal, medium-energy collimator, 2×60 views, 30s/view, non-circular orbit.
Reconstruction: xSPECT Quant, 6/48/96iterations, 1subset, no/16mm-Gaussian post-filtering, CT-based attenuation correction, triple-energy-window scatter correction (208keV, 10%–20%–10%).
Resolution analysis: 6 Lu-177-filled spheres (1.31MBq/mL, diameters: 10mm-13mm-17mm-22mm-28mm-37mm) placed in water-filled NEMA/IEC body phantom. After SPECT/CT acquisition (4.2M counts), a numerical mask was extracted from a 1-mm isotropic attenuation CT. SPECT images of different resolution were simulated by convolution with a Gaussian point-spread-function and resampling to SPECT grid size. A resolution estimate was obtained by applying Gaussians of different FWHMs, and by selecting the value leading to the smallest root-mean-squared error between simulated and reconstructed SPECT images.

Recovery coefficients: The activities in CT-based spherical VOIs (exact diameter) were evaluated, and the ratio to the nominal activities calculated.
Noise analysis: SPECT/CT acquisition of Lu-177-filled Jaszczak cylinder (6.7L @ 73.5kBq/mL → 8.0M counts). The noise was calculated as ratio between standard deviation and mean value of counts within a large cylindrical VOI (2.0L).
Results: The resolution was determined as 18.4mm-10.4mm-9.0mm without filter and 24.4mm-17.3mm-16.5mm with filter (6-48-96 iterations). The recovery coefficients were 0.20-0.32-0.53-0.60-0.69-0.80 without filter and 0.06-0.11-0.22-0.31-0.43-0.59 with filter (smallest to largest sphere, 48 iterations). Lastly, the noise was determined as 0.06-0.20-0.28 without filter and 0.04-0.07-0.09 with filter (6-48-96iterations).
Discussion: With the 2 experiments performed in this study, resolution, recovery, and noise characteristics of the xSPECT Quant reconstruction can be assessed and the reconstruction parameters can be optimized with regards to the expected number of counts. As recommended by the vendor, the combination (48iterations/1subset) represents a reasonable trade-off between resolution improvement and noise increase.

Contribution ID: 1020
23. Nuclear Medicine and Molecular Imaging
23.04. SPECT, SPECT/CT imaging

Image quality performance of a dedicated cardiac Discovery NM 530c SPECT: impact of time acquisition and reconstruction parameters

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Although nuclear cardiology imaging using cadmium-zinc-telluride (CZT) detectors results in s enhancement of the count detection sensitivity, enabling shorter times or reduced activities injected to the patients, the influence of acquisition and processing parameters in image quality and lesion visibility remain unclear. The aim of this study is to evaluate the impact of acquisition time and reconstruction parameters in images produced by a dedicated cardiac Discovery NM 530c CZT SPECT scanner. Anthropomorphic torso phantom with cardiac insert and a cold lesion (Data Spectrum Corporation) filled with 99mTc using 84 kBq/ml, 62 kBq/ml and 3 kBq/ml in the myocardium, liver and background, respectively, simulated high-dose stress image acquisition. One and two half-lives later, images were acquired to simulate lower doses, using both 3 min and 5 min time acquisition. Reconstruction parameters were optimized separately per type of acquisition (low-dose, high-dose), according to the manufacturer recommendation. Image quality and cold lesion visibility were evaluated using normalized standard deviation (NSD), contrast ventricle wall-cavity (CVC), contrast-to-noise ratio (CNR), and lesion effective contrast (LEC). Variations in acquisition time did not affect quality parameters and lesion visibility for the same type of reconstruction. However, when the activity concentration values are around 48kBq/ml in myocardium, the image quality parameters are highly sensitive to the reconstruction type choice, producing statistically significant differences ($p<0.05$) in NSD, CVC, CNR and LEC. Concluding, the reconstruction parameters need to be chosen carefully, considering patient´s characteristics and administered activity, in order to produce the best relation between image quality/lesion visibility and dose.

Contribution ID: 1812
23. Nuclear Medicine and Molecular Imaging
23.04. SPECT, SPECT/CT imaging

A novel molecular breast imaging system with asymmetric detection heads for early diagnosis of small-size breast cancer

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Breast cancer is the most common cancer in women. Early diagnosis is a crucial point to achieve an efficient therapy.
In order to identify small-size tumours at the early stage, mammography is the most used technique for screening having showed to be able to decrease mortality from the breast cancer.
Nevertheless it showed reduced performance in case of dense breast.
Magnetic Resonance Imaging (MRI), Ultrasound (US) and Molecular Breast Imaging (MBI) techniques have been proposed as complementary to mammography.
The most promising among them is the MBI based on dedicated gamma camera, which provides functional, specific, information, particularly appropriated to dense breast.
It showed better sensitivity and specificity than mammography in case of dense breast.
A new compact system, consisting of a two asymmetric (different geometries and collimations) detectors, has been developed.
The two detector heads face each other in anti-parallel viewing direction, compressing, appropriately, the breast between them and allowing Limited-Angle Tomography.
The detectors provide somehow complementary planar images that shall be properly combined (fused) to get enhanced, diagnostic information with high specificity and sensitivity.
A full scale prototype based on matrices of Position Sensitive Photo-Multiplier Tube (PSPMT), coupled to segmented NaI(Tl) scintillators with parallel and pin holes optics has been constructed to test different design solutions, and evaluate the expected performances.
We will present the results of the measurements, in different modalities, including the Limited-Angle Tomography, with 99mTc on a rather complex perspex phantom simulating a woman breast with up to four spheric tumour lesions of different sizes, positions and uptakes.
First results on performance will be reported.

Contribution ID: 1420
23. Nuclear Medicine and Molecular Imaging
23.05. PET/CT imaging

Dosimetric impact of PET CT based GTV contouring over conventional CT based GTV contouring for carcinoma esophagus

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Aim: To study the dosimetric impact of PET based GTV contouring over conventional CT based contouring for carcinoma esophagus.
Methods & Materials: 15 patients of carcinoma esophagus were taken retrospectively for this study. Two sets of GTVs in CT Plain images were generated one with the help of IV and oral contrast which includes the entire lumen and the enlargement in wall thickening (GTV CT) (which in turn increases the treatment volume considerably) and the other with only by using PET uptake

(with proper SUV window levels SUVmax>2.5) incorporated with CT plain image (GTV PET). corresponding CTVs and PTVs were generated. For all patients rapidarc plans were generated with 2 complete arcs. cumulative dose volume histograms were used to evaluate the plan. critical structures doses like lung V20 % V10 % cumulative mean lung, heart mean dose and V30%, spinal cord doses were tabulated for comparison. student t test was used to find the statistical significance of the study.
Results: Mean deviation of the reduction in PTV45Gy and PTV 5.4Gy were 45.69cc and 44.15cc (P values 0.045 & 0.027) respectively. mean deviation of reduction in heart mean dose was 1.33Gy (SD=2.09 & P value of 0.034) mean deviation of reduction in left lung V10% was 3.34Gy (SD=5.26 & P value of 0.034) mean deviation of reduction in right Lung V20% and V10% were 3.18Gy and 2.82Gy respectively (SD=5.08 & 4.68, P values of 0.036 and 0.042). mean deviation of reduction in total lung mean dose was 0.95Gy (SD=1.22 & P value 0.012).
Conclusion: The effect of PET CT on the delineation of GTV was evaluated considering the PET information in addition to that of CT. P values exhibit significant reduction of PTV volume and critical structure doses in PET based contouring over CT based contouring for 95% confidence limit.

Contribution ID: 1323
23. Nuclear Medicine and Molecular Imaging
23.06. PET/MR imaging

Innovative analysis methods for preclinical evaluation of PET radiotracers for in-vivo imaging in neurological diseases

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Data analysis and interpretation of acquired data remain an important and challenging issue in preclinical studies using Positron Emission Tomography (PET). The aim of this study is the implementation of a tool which allows a semi-automated PET data analysis independently from the PET radiotracer and the imaging modality for preclinical investigations in vivo.
Data used for primarily implementation of the tool were acquired on a Siemens μPET scanner (Inveon®) and were based on the investigation of glucose metabolism in a subarachnoid hemorrhage (SAB) model in Sprague Dawley rat brains in vivo using FDG-PET. We used the software programs Matlab (version 2016a) and Fiji (Schindelin et al., 2012) for data analysis and visualization.
Following data import, data were separated into predefined time periods and artefacts were eliminated. Afterwards, a volume of interest (VOI) was defined by the threshold of the Standardized-Uptake-Value (SUV). Before masking each data set with its segmented VOI, all data sets were intensity-normalized, eliminating the full body intensity differences caused by the different amount of injected activity. After masking, data sets of the SHAM operated animals were registered on the best-orientated SHAM data set, reduced on the VOI and shifted into the center of the 3D space. By averaging all aligned SHAM data sets, we received a FDG template of a Sprague-Dawley rat brain based on 28 different data sets of seven SHAM rats. This PET data template formed the basis for the registrations of all measured data sets. Additionally, an anatomical MR-based atlas of a Sprague-Dawley rat brain (Papp et al., 2014) was co-registered on the template for a better sub-classification of the acquired data.
In the next steps, statistical tests (e.g. boxplots, QQ-Plots, T-test, ANOVA, time course) will be performed in order to determine regions with trending/significant differences in the SUV of SHAM and SAB animals.

Contribution ID: 307

23. Nuclear Medicine and Molecular Imaging
23.07. Image reconstruction and correction strategies

Comparison of image reconstruction parameters of Philips Gemini TF 64 PET/CT imaging system: phantom and clinical evaluation

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PET imaging, using CT information for attenuation correction, provides information on glucose metabolism uptake of the FDG. This may also indicate the functional status of cancer lesions. Erroneous image details such as distortion, blur, or artifact may lead to false results. Reconstruction is used to enhance the data by minimizing the noise, adjusting the contrast, and modifying the features of the image mathematically. Methods: The study used the NEMA phantom for quantitative analysis and retrospective data for clinical evaluation. An ethical clearance was obtained from the UST Ethics Board before the study was carried out. The raw phantom images and retrospective data were reconstructed using defined Time-of-Flight (ToF) protocols of varying relaxation parameter, iteration subsets and kernel width. For the phantom study, the data were analyzed to determine the percent contrast (PC), background variability (BV), and contrast-to-noise ratio (CNR) for each reconstruction protocol. Two experienced nuclear medicine physicians, who were blinded by the reconstruction methods used, evaluated the retrospective data. The reconstructed images are rated on a scale of 1-4 and scored by rank according to 6 parameters (background marrow, liver, and mediastinum; lesion detectability; noise level; and overall image quality). Results: In the quantitative analysis, the smallest radioactive sphere obtained the highest PC of 18.3% on Protocol 5, while the largest radioactive sphere had the highest value of 55.1% on Protocol 6. The BV was least at 4.37% for the smallest radioactive sphere, and at 5.55% for the largest radioactive sphere, both on Protocol 1. The CNR was highest on Protocol 1 across all sphere sizes. The clinical evaluation of the retrospective data subjectively preferred Protocol 1 and Protocol 5. Conclusion: The findings showed that lower values of image reconstruction parameters produced improved CNR and were more favored by nuclear medicine physicians.

Contribution ID: 841
23. Nuclear Medicine and Molecular Imaging
23.07. Image reconstruction and correction strategies

Application of deep learning technique to nuclear medicine imaging

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The purpose of this study is to show an application feasibility of a deep learning technique to a nuclear medicine (NM) image acquisition. For achievement of artificial intelligence (AI) technology, the learning technique and big-data skill are essential. The AI technology has many strong points to the many field, and we tried to apply this technique to the nuclear medicine. Main algorithm of the deep learning in this study was composed of input part, supervising learning process, weight decay process, and output part. In order to acquire the NM image using deep learning process in this study, only sinogram from scanner for NM, such as single photon emission computed tomography (SPECT) and positron emission tomography (PET), is used. The proposed deep learning system can learn the profiles from the deducted sinogram, and it progresses to find optimum solution through the convolution neural network (CNN). This optimum solution is deducted as the final NM image without any image reconstruction algorithms such as filtered back projection (FBP), expectation maximization (EM), etc. In addition, the performance of deep learning based NM image was evaluated by comparing with the conventional NM image using the FBP and

ordered subset EM (OSEM) reconstruction algorithm. We tried to evaluate quantitatively the image through the calculation for SNR. In conclusion, the deep learning technique can provide more powerful and more correct NM image to us. However, although we secured the accuracy of NM image, the reconstruction time is not sufficiently fast yet. In the future, we will try to reduce the reconstruction time by using graphic processing unit (GPU).

Contribution ID: 677
23. Nuclear Medicine and Molecular Imaging
23.09. Image quantification

Investigation of time-activity curve behavior in dynamic [11C]-(R)-PK11195 PET in brain cortical regions

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Background: Dynamic Positron Emission Tomography (PET) allows the quantification by relating the activity measured in time to the underlying physiological processes of the tissue or organ. Radiotracer analysis can be done using time-activity curves (TAC). Although [11C]-(R)-PK11195 PET enables labeling neuroinflammation, measuring microglial activation in brain diseases, dynamic imaging quantification is still challenging.
Aim: The aim of this study was to investigate a new method for analyzing TAC behavior from dynamic [11C]-(R)-PK11195 PET, in different brain cortical regions.
Method: Dynamic 60 min [11C]-(R)-PK11195 PET scans of 7 healthy subjects were acquired in list-mode. TAC data extraction from brain cortical regions was performed using AAL-Merged atlas of PMOD. The proposed method is based in the area under the curve (AUC) analysis of each cortical brain region, normalized by the whole brain AUC of each subject, and multiplied by the whole brain mean AUC of whole control group. A healthy population-based TAC for each cortical brain region was created from the normalized mean TAC. To evaluate the differences between a healthy brain region and an inflamed region, a cut-off value was created using Spearman correlation.
Results: The method was tested with a multiple sclerosis (MS) patient with high score (5) in Kurtzke EDSS (Expanded Disability Status Scale). Significant differences in regions of rolandic, supplementary superior area, frontal lobe, insula, parahippocampal gyrus, amygdala, calcarine, cuneus, occipital lobe, fusiform gyrus, precuneus, paracentral lobe, caudate nucleus, putamen, palladium, thalamus, heschl gyrus and cerebellum were found. Precentral, retus, lingual, postcentral, supramarginal, and angular gyrus, parietal lobe, temporal lobe and vermis showed no significant differences when compared to healthy population-based TAC.
Conclusion: The proposed method is able to identify brain cortical regions affected by neuroinflammation in [11C]-(R)-PK11195 PET scans using a healthy population-based TAC. Further studies are required to evaluate the proposed method with more MS patients.

Contribution ID: 1094
23. Nuclear Medicine and Molecular Imaging
23.09. Image quantification

A phantom–based methodology for the standardization of heart–to–mediastinum ratio in cardiac Iodine–123 metaiodobenzylguanidine sympathetic imaging

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Objectives : To overcome differences in measured myocardial activity; namely, heart–to–mediastinum ratio (HMR) from cardiac Iodine–123 metaiodobenzylguanidine sympathetic nerve imaging, a dedicated calibration phantom was created. The purpose of this study was to compare the effect of calibration factors between single-center and multi-center average conditions.
Methods: The calibration factor was calculated with the scintigraphic planar phantom image using dedicated analysis software, and camera-collimator specific conversion coefficients (CC) were defined. The CC shows an approximate range of 0.5 to 1.0, corresponding to low–energy (LE) to medium–energy collimators. We used two near–normal patient groups in Japanese hospitals A and B (n = 14 and 16, respectively), which were included in the Japanese Society of Nuclear Medicine working group normal databases. The clinical HMR were calibrated with individual camera–collimator–specific CC (CC–ind) and average CC (CC–ave) from a multicenter phantom study. The CC–ind was determined by institutional CC in each hospital. The CC–ave was calculated based on 1071 multicenter phantom images including various camera–collimator systems available in Japan.
Results: The CC–ind and CC–ave were 0.627 and 0.621 (95% range, 0.602–0.641) for hospital A (IRIX camera with LE collimator, Picker international, USA), and 0.830 and 0.838 (0.824–0.851) for hospital B (e.cam camera with low-medium energy collimator, Siemens, Japan), respectively. Although HMR without calibration were 2.43 ± 0.30 and 2.75 ± 0.43 for hospitals A and B, respectively ($p = 0.0014$), the institutional differences disappeared after calibration; 3.00 ± 0.42 and 2.83 ± 0.45 with CC–ind, and 3.03 ± 0.43 and 2.84 ± 0.45 with CC–ave (p = n. s., respectively), showing no difference between both calibration methods.
Conclusions: The characteristics of gamma camera–collimator systems could be determined by CC values. The HMR were successfully standardized using CC values in two hospitals. The phantom–based methodology exhibited comparable standardized HMRs derived from the CC–ind and CC–ave.

Contribution ID: 1410
23. Nuclear Medicine and Molecular Imaging
23.09. Image quantification

Optimization of quantification of mandibular growth

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Purpose: Excessive growth of one condyle suspected of active unilateral condylar hyperplasia (UCH) may lead to asymmetric facial deformities and malocclusion. Single photon emission computed tomography (SPECT) bone scintigraphy is becoming current global standard for diagnostic of UCH. The examination is performed after intravenous administration of radioactive technetium-labelled diphosphates (99mTc-MDP). The aim of this research is to select the most suitable method for the evaluation of asymmetry and mandibular growth in comparison with the normal values.
Methods: 17 patients were evaluated (11 represent normal values, 6 patients with UCH). No patient from normal database had a previous history of growth abnormality or pathological condition involving the maxillofacial skeleton or mandible. These patients underwent an additional mandibular SPECT to create a normal database. Except the asymmetry, mandibular growth was

also examined. The internal (clivus) and external standard (source of known activity) was used to evaluate the growth. The region and volume of interest (ROI/VOI) across each condyle and clivus were drawn by various methods. For each ROI/VOI, the total number of counts, maximum and average values in ROI/VOI and their size were recorded.
Results: The use of 99mTc-MDP SPECT appears to be a suitable quantitative method for assessing the growth activity of the mandible. The correlation analysis suggested that it is inappropriate to substitute the values obtained from different sizes of ROI for one another. The average counts in same size of ROI and usage of external standardization appears to be the most suitable method for assessing the growth activity of a condyle. Similar conclusion holds for assessing asymmetric growth. The evaluation method and criteria were determined. However, it is still necessary to monitor these parameters and criteria and adapt them according increasing database of normal values.

Contribution ID: 1434
23. Nuclear Medicine and Molecular Imaging
23.09. Image quantification

Optimization of quantitative 99mTc-MAA SPECT/CT imaging for 90Y radioembolization: a 3D-printed phantom study

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Purpose: Radioembolization (RE) with 90Y-microspheres has gained widespread acceptance as a safe and effective technique for treating liver malignancies. Accurate quantification in RE is a key step in treatment planning optimization and it is becoming a pressing issue in the light of the Directive 2013/59/EURATOM, stating that individual dose planning must be enforced in legislation by EU member states by February 2018. The aim of this study was to develop a SPECT/CT imaging protocol for quantitative imaging optimization in RE based on a novel anthropomorphic 3D-printed phantom.
Methods and materials: A Symbia IntevoTM system (Siemens, Germany) was used to assess the quantitative accuracy of 99mTc-MAA SPECT imaging for treatment planning in RE. Gamma camera calibration factors and recovery coefficients were determined performing preliminary SPECT/CT acquisitions of a homogeneous and a NEMA/IEC phantom, respectively. The quantification procedure was then validated using an anthropomorphic phantom provided with a fillable liver section and multiple inserts. Raw data reconstruction was performed using two independent software: i) the built-in xSPECT package, using both OSEM and OSCG algorithm; ii) the commercially available QSPECT software based on OSEM method. All reconstructed images were manually fused and appropriate regions of interest (ROIs) were drawn on the MIM 6.1.7 system.
Results: The measured activity concentration is consistent within 3% with the expected activity concentration values. This is in keeping with the overall accuracy (<10%) stated by the manufacturer. No substantial differences were reported between xSPECT with OSCG or OSEM in terms of relative activity. However, a 20% difference was found between ROIs extracted from images reconstructed with xSPECT and QSPECT using OSEM. Several artefacts were visible in the QSPECT reconstruction, likely due to the limited area used for attenuation and scatter corrections.
Conclusion: The investigated protocol based on the innovative xSPECT tool allows an accurate absolute quantification within 3%.

Contribution ID: 580
23. Nuclear Medicine and Molecular Imaging
23.10. Tracer kinetic modelling

Radio-guided surgery with beta- radiation: test on ex-vivo specimens

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Radio-Guided Surgery (RGS) is a surgical technique that enables the surgeon to evaluate during the surgical procedure, by the use of a radio-tracer, the completeness of the tumour lesion resection, thus minimising the amount of healthy tissue removed. To overcome the impact of the large penetration of gamma radiation it has been proposed to use beta- radiation.
As a start, the clinical cases were selected between the tumours known to express receptors to a beta- emitting radio-tracer already in use in the clinical routine: 90Y-labelled DOTATOC.
We present the results of tests on ex-vivo specimens of meningioma brain tumour and abdominal neuroendocrine tumours.
After the signature of the informed consent, the patients were enrolled according to the standard uptake value (SUV) and the expected tumour-to-non-tumour ratios (TNR) estimated from PET images after administration of 68Ga-DOTATOC.
The extracted ex-vivo specimens were examined to assess the correlation between the counting rates measured by the beta- detecting probe and the administered 90Y-DOTATOC.
All these tests validated this technique: all the lesioned excised samples (bulk and margin) showed a dependence of the counting rate both on the volume V and on the total activity of the sample. Even injecting as low as 1.4 MBq/kg of radio-tracer, tumour remnants of 0.1 ml would be detectable.
The negligible medical staff exposure was confirmed.

Contribution ID: 121
23. Nuclear Medicine and Molecular Imaging
23.11. Nuclear medicine dosimetry

Haematological toxicity in patients with somatostatin positive receptor tumours showing bone marrow involvement treated with 177Lu-DOTATATE

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Aim: Therapy with 177Lu-DOTATATE shows generally low bone marrow (BM) toxicity. Typically BM uptake is negligible and cumulative absorbed doses are < 2 Gy. A minority of patients show high bone involvement, raising doubts about tolerability. Our aim was to assess absorbed doses (AD) and toxicity in such patients.
Methods: Whole body (WB) images of patients treated with 177Lu-DOTATATE were acquired at 24 h p.i. Patients with bone uptake >5% of the total image were included in the study and ROIs were drawn around source organs. One patient underwent a complete dosimetry study (imaging at: 2, 24, 50, 170 h). Haematological toxicity (WBC, Hb, PLT) was evaluated (CTCAE-4.0).
Results: 19 neuroendocrine (NET) patients (9 gastro-entero-pancreatic NET; 8 lung, 1 thymoma, 1 unknown origin) out of 557 were included. Patients received multiple cycles with mean(SD) activity of 17(12) GBq. Mean(SD) follow-up lasted 18(13) months. Mean(SD) uptake% normalised to injected activity were: Bone: 8 (5)%; kidneys: 3 (1)%; remainder-of-body): 15 (5)%. Dosimetry analysis gave an effective half-life for bone lesions of 95 h. The mean(SD) extrapolated time-integrated activity coefficient were 0.3(0.1)h for bone and 5.2(3.1)h for trabecular and cortical bone. Estimated absorbed doses to BM were 0.10(0.04) Gy/GBq (corresponding to 2.8(1.1)Gy in 4 cycles of 7.4GBq).
Toxicity was almost always of grades G1 (WBC=42%, Hb=53%, PLT=37%) and G2 (WBC=21%; Hb=26%, PLT=5%). Only 3 patients manifested G3-G4 toxicity, and had 11% (WBC, G3), 41% (PLT,G3), and 45% (PLT, G4) of B-BM uptake at 24h. No myeloproliferative diseases (myelodysplastic syndrome, acute leukaemia) were observed.
Conclusion: Haematological toxicity in patients with high bone involvement is acceptable (G1,G2) in the majority of cases, indicating 177Lu-DOTATATE treatments as feasible. This is most probably due to the low range of 177Lu beta-particles in bone and BM and to uptake inhomogeneity.

Contribution ID: 136
23. Nuclear Medicine and Molecular Imaging
23.11. Nuclear medicine dosimetry

Absorbed dose correlates with metabolic response to radioembolization of liver metastases with resin 90Y-microspheres

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Aim: To investigate possible correlation between absorbed dose (AD) and tumour response by means of Tumour Control Probability (TCP) in liver metastases treated with radioembolization (RE) with resin 90Y-microspheres. To assess response, the analysis of parameters from FDG-PET/CT has been preferred to RECIST criteria as metabolic response has proven to anticipate morphologic response.
Methods: Patients with chemo-refractory liver metastases from solid tumours scheduled to receive RE underwent FDG-PET/CT scan before and 6 weeks after RE. 99mTc-MAA (75-111 MBq) were injected 2 weeks before RE to perform dosimetry based on SPECT fused to contrast CT. Response assessment was based on PERCIST criteria. Variation (%) of PET parameters versus basal examination were evaluated to establish Complete-Response (CR), Partial-Response (PR), Stable-Disease (SD), Progressive-Disease (PD).
Results: 22 patients with hepatic lesions from colon-rectal (11), breast (7), ovary (1), endometrial (1), parotid (1) cancer, cholangiocarcinoma (1) were suitable for analysis. All patients received a single RE treatment (median activity: 1.7 GBq; range: 0.6-2.9 GBq). Median (range) tumour AD: 100(30-443) Gy. Metabolic response rate of lesions based on PERCIST was: CR=31%; PR=28%; SD=24%; PD=17%. Two different TCP curves were obtained by probit regression when

considering: i) endpoint-1: PR or CR; ii) endpoint-2: CR only (p<0.01 in both cases). For tumour AD>=220 Gy only CR were observed. TCP of 50%, 75%, 100% were obtained at: i) 108, 120, 165 Gy; ii) 135, 160, 225 Gy.
Conclusion: Despite the variety of primary tumours, relatively low cohort of patients, and uncertainty of dosimetry with 99mTc-MAA, our preliminary data provided evidence of correlation between response based on PET/CT and AD. These encouraging results need to be confirmed with more ample dataset and, possibly, tumour type differentiation. Other PET/CT parameters such as the metabolic tumour volume, and tumour lesion glycolisis are being considered for comparison with PERCIST and possible improved correlations.

Contribution ID: 297
23. Nuclear Medicine and Molecular Imaging
23.11. Nuclear medicine dosimetry

Estimation of Effective Dose to Patients using Voxelized Mathematical Models in Nuclear Medicine Examinations

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The risk from ionizing radiation special the low-dose from nuclear medicine it’s not determined clearly, this study aimed to determine the effective dose from diagnostic nuclear medicine in Sudan, were the Data collected from three nuclear medicine department (Al-Nileen Medical Diagnostic Center, Royal Care International Hospital, and Al-Mak Nimer University Hospital), the Collected patient’s data and activity administered during diagnostic procedures and rules applied to adjust these a cording to the patient's parameters such as age, weight, and gender, were the data collected from 271 patients.
the results show’s that the Calculated effective dose and absorbed dose by OLINDA/EXM 2.0 software, calculated values compared to other calculation methods (MIRD 2.0, and DOSISRAD software). The Mean of effective dose from nuclear medicine procedures (1.310E-01, 4.74E-03, and 2.17) mSv for thyroid, (2.05E-03, 5.93E-04, and 4.13) mSv for bone, and (1.19E-02, 1.20E-03, and 1.07) mSv for renal scan using OLINDA/EXM 2.0, MIRDOSE 2.0, and DOSISRAD software’s respectively. This disparity between calculated values by using DOSISRAD software and the other calculated methods due to DOSISRAD designer according to simple spherical phantom (all body approximately as unit density), as for the OLINDA\EXM and MIRDOSE designer according to Hybrid phantom and Voxel phantom respectively. the mean effective dose calculated from all examinations for all centers found less than the threshold of international organization and some countries.

Contribution ID: 444
23. Nuclear Medicine and Molecular Imaging
23.11. Nuclear medicine dosimetry

Absorbed and effective doses evaluation in a pediatric PET/CT scan

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Positron Emission Tomography (PET) associated with Computed Tomography (CT) are becoming increasingly important imaging tools in the noninvasive evaluation and monitoring of children with known or suspected malignant diseases. These compound tomographic devices allow the overlapping of functional images obtained from the administration of radiopharmaceuticals and anatomical images generated by X-ray beam attenuation. Although the immediate benefit to the individual patient can be substantial, the relatively high radiation doses associated with PET/CT compared with conventional exams have raised health cares. This is especially concerning for children, who are more sensitive to radiation-induced carcinogenesis and have many remaining years of life for cancer to develop. In this study, the absorbed and effective doses generated by the CT scan and incorporated by the administration of the radionuclide will be evaluate in the most radiosensitive organs. To evaluate the CT dose, radiochromic filmstrips will be positioned into the pediatric body phantom builded by PMMA volumes. The CT protocol to be performed is the standard pediatric whole-body scanning. The calculation of the effective dose from the injected activity in the patient will be performed using the ICRP 106 Biokinetic model. The activity to be injected may vary according to the patient's body mass and with the sensitivity of the detector. It is expected that the PET/CT scans pediatric protocols are analyzed and if necessary, changed at the end of the study, so that the absorbed and effective dose received by the patient decreases.

Contribution ID: 1276
23. Nuclear Medicine and Molecular Imaging
23.12. Monte Carlo modelling in nuclear medicine

Matlab Graphical User Interface to Simulation with GATE Monte Carlo in Medical Physics

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GATE has been widely used to perform simulations in Medical Physics, since it has some advantages over other Monte Carlo codes, mainly in SPECT (Single Photon Emission Computed Tomography) and PET (Positron Emission Tomography) trials, and also because the output can be a volumetric map of absorbed dose or deposited energy. This volumetric map can be fused with the phantoma in three dimensions and observe the variation of dose or energy deposited in each organ. However, the calculation of the total or average dose in each organ is obtained through MATLAB. The objective of this work is to create a Graphical User Interface (GUI) interface to evaluate the simulations performed with GATE, used in Medical Physics. A program was created in MATLAB to determine the dose absorbed in Gy or the energy deposited in MeV., In addition, the program has specific tools for visualization of images or fusion of images, among other functionalities useful for researchers using GATE for simulations in the field of medical physics.

Contribution ID: 1277
23. Nuclear Medicine and Molecular Imaging
23.12. Monte Carlo modelling in nuclear medicine

Development of voxelized mouse phantom to Dosimetry in Nuclear Medicine through Monte Carlo Simulation

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Estimated internal absorbed dose distribution in the preclinical phase is an essential requirement in the research and development of new radiopharmaceuticals in Nuclear Medicine. Monte Carlo (MC) simulation combined with computational small animal models provides new tools to estimate the absorbed doses in organs or tissues of interest, predicting possible effects of the radiation use in diagnosis and treatment of diseases. The aim of this study was the development of a voxelized mouse phantom (C57BL/6 lineage) for use in Monte Carlo Simulations in Nuclear Medicine.
A voxelized mouse phantom was developed from Computed Tomography(CT) images in DICOM format. Ten organs were identified and segmented by SLICER 3D software. For each segmented organ was assigned a pixel value (ID), one same ID assigned to the left and right lung, as well as for the two testes and for both kidneys. The skin, muscles and other unsegmented regions wereincluded in "other tissues". The volume and number of voxels for each organ was calculated by the software. The results showed that the mass values of the simulator developed in this study agreed with the model proposed by literature. The phantom developed in this work was coupled with the Monte Carlo GATE code to validate the results. The simulation procedure was validated comparing the obtained S-factors for 18 F –FDG with the reported in the literature. The results were very close to the literature, with discrepancies ranging from 2 to 47%, attributed to modeling different organ masses. The simulator developed in this work was adequate and could be used in other applications.
The methodology developed in this work will help preclinical studies of biodistribution and dosimetry, fundamental to the development of newradiopharmaceuticals.

Contribution ID: 496
23. Nuclear Medicine and Molecular Imaging
23.13. Dosimetry in nuclear medicine (experiments, calculations)

Design and fabrication of a thyroid monitoring dosimeter in radioiodine therapy

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Using Iodine 131 is one of the most important methods for treatment of thyroid cancer. Dosimetry is the main process of detecting and measuring the intensity of radiation of radioactive materials that is widely used in nuclear medicine. Knowledge about the delivered dose to the target volume and adjacent normal tissues can improve the effectiveness of radioactive iodine treatments. Due to usage of radioactive materials with high activity in such treatments, using a proper dosimeter is crucial in order to monitor the target organ (thyroid) and organs at risk (red bone marrow, spinal cord, larynx) after the iodine injection to the patient. The disadvantages of common dosimeters are that they are not portable, they cannot provide online report and they have limited efficiency. Herein, the design and fabrication process of a thyroid dosimeter is explained. First, optimum characteristics of the dosimeter was investigated by Monte Carlo (MC) simulation, such as distance and position to the target organ, dimension, type and number of detectors. Then, using two CsI(Tl) scintillator crystals, two photodiodes and a suitable electronic system, the monitoring system was fabricated. Linearity of the developed system was evaluated using different activities of 131I. Also, performance of the system was tested on a head and neck phantom. Delivered dose due to a known administered activity of 131I was measured by radiochromic film and calculated using MIRD formalism to validate MC simulation of the phantom. Finally, output of the dosimeter (in Volt) during the phantom experiment was related to calculated doses of different organs based on the simulation. In conclusion, an inexpensive, light, linear and reliable thyroid monitoring system has been developed to guide the hospital staff for safe release of the iodine – administered patient and provide an insight for physicians about delivered dose to the thyroid and nearby organs.

Contribution ID: 571
23. Nuclear Medicine and Molecular Imaging
23.13. Dosimetry in nuclear medicine (experiments, calculations)

In-Vivo Biokinetics of 177Lu-OPS201 in Mice and Pigs as a Model for Predicting Human Dosimetry

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Aim: 177Lu-OPS201 is a high-affinity somatostatin receptor antagonist for PRRT in patients with neuroendocrine tumors. Here we report the first study comparing biokinetics in animals and patients. In addition, several inter-species extrapolation methods were examined to find the optimal method for dosimetry. Methods: Data on biokinetics were obtained in athymic-Nude-Foxn1nu mice, Danish-Landrace pigs, and patients with 0.19-0.27MBq (mice, 0.017µg peptide), 97-113MBq (pigs, 9µg peptide) and 850-1086MBq (patients, 55-106µg peptide) administered activities. In pigs and patients, kidney protection was applied. Multiple planar and SPECT/CT scans were performed until 250h (pigs) and 72h (patients). Blood samples were taken up to 24h (patients) and 300h (pigs). Mice were euthanized at different time points (up to 168h); the organ-specific activity contents (including blood up to 72h) were measured. Time-dependent uptake data sets were created for each species (kidneys, liver, blood). Bi-exponential fits were applied to compare the biokinetics of each species in organs and blood. Time-integrated activity coefficients (TIACs) for kidneys and liver were calculated. To determine the optimal scaling, five scaling methods were applied to the animal data. Results: A fast blood clearance was observed in the first phase (<56h) for each species. Pigs show higher liver retention than patients. Based on the same-biodistribution approach, underestimations in mice (liver: factor7, kidney:factor4) and pigs (liver: factor1.3) compared to patients were observed. Applying time-scaling and combined method on TIACs resulted in the most similar values with patients (Kidney-TIAC: Mice=3.9h, Pigs=4.8h, Patients=5.8h, Liver-TIAC: Mice=0.9h, Pigs=4.7h, Patients=5.3h). Conclusion: If the organ/mass ratios between the species are high, either time-scaling or combined method is the most adequate method for TIACs. Based on the analysis of the fit-functions and the TIACs, pigs mimic humans better than mice. For the 177Lu-labeled dosimetry studies, late follow-up time points (more than 72h) are needed to calculate TIACs appropriately.

Contribution ID: 1411
23. Nuclear Medicine and Molecular Imaging
23.13. Dosimetry in nuclear medicine (experiments, calculations)

rh-TSH stimulation vs. thyroid hormone withdrawal a surprising biogenetics differences?

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Introduction: It has been reported that there are substantial differences in radioiodine biokinetics for patients treated for thyroid carcinoma using rhTSH stimulation and thyroid hormone withdrawal. It

is generally referred that rh-TSH stimulation causes faster radioiodine elimination from the body and longer retention in the thyroid remnants comparing to the thyroid hormone withdrawal.
Materials and methods: This study aims at radioiodine biokinetics comparison in low-risk thyroid carcinoma patients T1a/T1b (16 treated with 1.1 GBq of 131I and 21 treated with 1,85 GBq of 131I, both after rh-TSH stimulation). Retention of radioiodine within the patient body was determined using Hp(10) monitoring 1 m from the patient. Activity within the thyroid remnants was monitored using calibrated gammacamera. Whole body dose was calculated based on the retention monitoring for each patient.
Results and discussion: Analyzing the data of the whole body absorbed doses per GBq showed an unexpected difference between the groups of patients treated by 1.1 GBq (32 ± 7) mGy/GBq and 1.8 GBq (44 ± 13 mGy/GBq). However; whole body residence differs only by 20 %. The residence time for thyroid remnants was nearly the same for both groups (approximately 100 hours). These results call for a detailed investigation on the radioiodine biokinetics as there seems to be lack of proportionality between the whole body absorbed dose and the administered activity.

Contribution ID: 1439
23. Nuclear Medicine and Molecular Imaging
23.13. Dosimetry in nuclear medicine (experiments, calculations)

A 3D-printed phantom study for quantitative 99mTc-MAA SPECT/CT imaging and dosimetry in 90Y radioembolization

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Purpose: Radioembolization (RE) with 90Y-microspheres is a well-established treatment modality for treating liver malignancies. At a time of increasing evidence for dose-effect relationships in RE with 90Y microspheres [1,2], the general consensus is that there is an urgent need for accurate dosimetry in patients undergoing RE treatment. This work aimed at estimating absorbed doses to lesions and normal liver in a novel anthropomorphic set-up.
Methods and materials: AbdoMan is a 3D-printed phantom provided with a fillable liver section and multiple inserts for lesion representation. A SPECT/CT Symbia Intevo provided with the proprietary xSPECT quantitative software was used. Specific regions of interest (ROIs) were drawn on MIM 6.1.7 system. A homemade tool was developed in MATLAB for image analysis and dose calculation based on two methods: I)convolution kernel and II)local deposition method. The accuracy of these dosimetric methods was evaluated by comparing dose-rate volume histograms (DrVHs). Finally, γ-index was also used to compare the dose distributions obtained by the two activity-to-dose methods.
Results: Differences calculated by the 3D γ-index are within 2%-2mm for all AbdoMan inserts. The dose-kernel results in a γ<1. The deposition method provided a poorest γ as well as several image artefacts. In particular, an apparent over-dosage (about 25%) was observed in inserts with larger diameter, most likely due to spill-in and spill-out phenomena. The DrVHs for considered ROIs are within 2%-2mm.
Conclusion: In RE planning the dose-kernel method proved to be more accurate with respect to deposition method based on full 3D dose distributions.
References:

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Contribution ID: 1696
23. Nuclear Medicine and Molecular Imaging
23.13. Dosimetry in nuclear medicine (experiments, calculations)

Assessment of Patient Effective dose in Certain Diagnostic Nuclear Medicine Procedures

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Nuclear medicine imaging has an imperative role in modern medicine due to its numerous advantages over other transmission, emission and reflection imaging procedures. However, patients are exposed to ionising radiation for different tissues and organs, which may results in cancer induction in future. Therefore, assessment of patient doses during nuclear medicine crucial for precise procedures justification and optimisation. The aims of this study are to measure effective doses for patients undergoing cardiac, thyroid and bone scan procedures. Technetium-99m was used for all procedures. A total of 130 procedures were performed (40 cardiac scan, 46 thyroid scan and 40 bone scan) were investigated using Orbiter 37 Gamma camera single head. Patients effective dose were estimated using the administered activity based on body surface area in relation to adult reference values. Regular quality control tests were performed precise activity administration. The mean and range of the administered activity (MBq) is 810.0±246 (740-1665), 177.4±16 (114.7-192) and 751.2±34 (740-925) for cardiac, thyroid and bone scan procedures, respectively. The mean effective dose (mSv) was 7.1±2 (6.7-13.2), 2.3±0.2 (1.5-2.5) and 4.3±0.2 (4.2-5.3) for cardiac, thyroid and bone scan at the same order. The radiation risk per procedure ranged between 1 x10-5 to 4 x10-4 for thyroid and cardiac scan respectively. Patient doses comparable with international atomic energy agency safety standards and international reference levels. Further patient dose reduction is recommended to reduce the radiation risks to its minimal value without affecting the image quality.

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