2<sup>nd</sup> Workshop of the Department of Physics and Mathematics of ISEC - Coimbra Institute of Engineering

April 28th 2010

# **BOOK OF ABSTRACTS**

## Part I – Biomedical Engineering

#### 09h30-09h50

## The Medical Physics Department at IPOCFG, E.P.E.

Speaker: Dr. Maria do Carmo Lopes (mclopes@ipocoimbra.min-saude.pt)

**Affiliation:** Medical Physics Department of the Portuguese Institute of Oncology in Coimbra (IPOCFG, E.P.E.), Portugal **Abstract:** The IPOCFG, E.P.E. is one of the two Portuguese institutions that have a Medical Physics Department (MPD), defined as a Supporting Service to Clinical Activities and transversal to the whole hospital. The main clinical areas supported by MPD are: Radiotherapy, Nuclear Medicine and Radiology. Concerning Radiation Protection (RP), which is a transversal subject to the whole institution, an integrated RP program supported by the hospital Administration was put into practice through an approved institutional policy. Apart from clinical supporting tasks MPD also develops research activities. The Radiotherapy Department has recently undergone a modernization and equipment replacement project managed together and technically supported by the MPD. New treatment techniques both in external radiotherapy and brachytherapy have been implemented like radiosurgery, stereotactic radiotherapy, IMRT and prostate seed implants. In Radiology a pilot national project was developed in order to assess the compliance of radiological exams doses to the EU Diagnostic Reference Levels. Another project is presently being carried out on image quality and patient dose in digital mammography. In Nuclear Medicine, apart from the routine quality control program on equipment and waste management, a project on internal dosimetry for patients undergoing iodine therapeutics has been started. MPD regularly organizes training and education initiatives like Graduation, MSc., PhD and pos-doc projects, on-job training for Medical Physicists, Physics Courses for Radiation Oncologists and Radiation Protection Courses.

**Short biography:** Maria do Carmo Lopes, PhD., Head of the Medical Physics Department of the Portuguese Institute of Oncology in Coimbra (IPOCFG, E.P.E.), with 18 years experience in Medical Physics with special interest in Radiotherapy. Her PhD. was obtained in 1991, in the Radiation Physics area. She has been deeply involved in the development of new techniques in Radiotherapy, like radiosurgery, stereotactic radiotherapy and IMRT. She has published some papers and has made numerous presentations at International Conferences. She is currently the Coordinator of the Medical Physics Division of the Portuguese Physics Society, the National Member Officer of EFOMP. She is member of the Physics Committee of ESTRO since 2005. She is also the present chair of the Education and Training Committee of IOMP.

#### 09h50-10h10

## Proton and carbon ion therapy: from the basic principles to the clinical implementation

Speaker: Prof. Dr. Katia Parodi (katia.parodi@med.uni-heidelberg.de)

Affiliation: Heidelberg Ion Beam Therapy Center, Heidelberg, Germany

**Abstract:** The application of ions to external beam radiotherapy is currently rapidly increasing worldwide. The main rationale is the favorable ionization energy-loss of swift charged ions in matter, resulting in the characteristic dose maximum at the end of the range known as Bragg-peak. Proper superimposition of several Bragg-peaks enables optimal conformation of the delivered dose to the tumor, with better sparing of surrounding healthy tissue in comparison to conventional photon and electron radiation. Ions heavier than protons can additionally offer increased biological effectiveness for treatment of tumors which are resistant to conventional radiation. This talk will review the physical and biological basic principles of ion beam therapy, as well as the main aspects of its technical and clinical implementation at the Heidelberg Ion Beam Therapy Center, which represents the worldwide first facility offering a large variety of ions (currently protons and carbon ions, later on also helium and oxygen) with completely active beam delivery.

**Short biography:** Katia Parodi received in 2004 her Ph.D. (suma cum laude) in Physics from the University of Dresden, Germany, for her work done at the Research Center of Dresden-Rossendorf. From 2004 to 2006 she held a postdoctoral fellowship at Massachusetts General Hospital and Harvard Medical School in Boston, USA. Since 2006 she is a senior researcher at the Heidelberg Ion Therapy Center, Germany. After her Habilitation in 2009 she is also an appointed lecturer for Physics at the University of Heidelberg. Her main research interests are in PET imaging and Monte Carlo modeling to promote high-precision ion beam therapy.

#### 10h10-10h30 Vital signs and telemetry

Speaker: Francisco Viana (fviana@isa.pt)

Affiliation: ISA - Intelligent Sensing Anywhere, Coimbra, Portugal

Abstract: The development of Ambient Assisted Living (AAL) solutions for customizable home care has been a recent challenge posed to the scientific and industry communities. The continuous care and vigilance of ageing people ensure a safer and cosier environment, either in their homes or in nursery houses. Systems capable of detecting possible risk situations are a helpful tool to fulfil these requirements, increasing the elderly quality of life, independence and autonomy and, at the same time, providing valuable information to the healthcare service provider, while cutting costs in the treatment of severe acute cases. In this scope, respiratory diseases are pathologies that affect the air passages, including the nasal passages, the bronchi and the lungs. Their variety can go from acute infections, such as pneumonia and bronchitis, to chronic conditions, like asthma and chronic obstructive pulmonary disease. They are one of the must significant cause of death in industrialized countries. Auscultation through the stethoscope is the most important and established non-invasive method to distinguish between normal and abnormal sounds. However, this is a subjective tool that extremely relies on medical experience and hearing capabilities. In fact, one of the basic requirements of this examination procedure is the need to maintain a doctor-patient interaction, which in the majority of situations reveals unreachable and expensive for both (patient and healthcare unit). The Look4MySounds system herein presented allows continuous monitoring of chronic diseases in home environment, over extended periods of time, avoiding constant patient displacement to healthcare unit. The evaluation of the Look4MySounds was performed using more than 378 respiratory sounds of 22 different people collected in a real environment. The system performs a sensitivity (corrected classification pathologic sounds) of 82% and a specificity (corrected classification of normal sounds) of 97%, being the overall accuracy equal to 91%. Comparing with other relevant methods for sound classification, the developed platform reports one of the highest rate of success of recent studies in automatic computer-assisted diagnose tools for respiratory sound, demonstrating its potential to become an efficient and reliable system for AAL purposes.

**Short biography:** Francisco Viana graduated at the Department of Biochemistry of the Sciences and Technology Faculty of the University of Coimbra, on the subject of resonance thromboelastography. He obtained his MSc from Lusófona University on the subject "Analysis of G-proteins in Membranous Precursors to the Nuclear Envelope of the Sea Urchin Male Pronucleus" from his work at the Amherst College Biology Department, Amherst, Massachusetts, USA. He taught biology and microbiology for two years at the Life Sciences Department of Escola Superior Agrária de Santarém, and biochemistry and microbiology for six years at the Veterinary Medicine Department of Vasco da Gama Universitary School. He joined ISA's staff on 2008 as director of the healthcare business unit. He is currently also pursuing his PhD on the subject "Characterization and production of restriction-methylation systems *Cjel* e *CjePI* of *Campylobacter jejuni*".

#### 10h30-11h00

## Targeting epileptic foci with merged EEG and nuclear medicine imaging

Speakers: Medical Doctor Francisco Sales (franciscosales@huc.min-saude.pt) MSc. Eng. Jorge Isidoro (jisidoro@huc.min-saude.pt)

Affiliation Francisco Sales: Department of Neurology, University Hospitals of Coimbra, Portugal

Affiliation Jorge Isidoro: Department of Nuclear Medicine, University Hospitals of Coimbra, Portugal

#### 11h00-11h50

COFFEE BREAK

Poster session and book publishers presented at the end of this Book of Abstracts.

#### 11h50-12h00

Master of Science in Embedded Systems for Biomedical Engineers at ISEC (Mestrado em Sistemas Embebidos para Engenheiros Biomédicos do ISEC) Speaker: Prof. Luís Marques (Imarques@isec.pt) Affiliation: ISEC – Coimbra Institute of Engineering

#### 12h00-12h10

### Master of Science in Biomechanics for Biomedical Engineers at ISEC

(Mestrado em Biomecânica para Engenheiros Biomédicos do ISEC)

Speaker: Prof. Dr. Luís Roseiro (Iroseiro@isec.pt)

Affiliation: ISEC - Coimbra Institute of Engineering

Abstract: O que é a Biomecânica? Diversas definições de biomecânica se podem encontrar na literatura. Uma das possíveis definições enquadra a biomecânica como a ciência que estuda as forças externas e internas que actuam no corpo humano e os efeitos que elas produzem. Assim, a biomecânica externa estuda as forças físicas que agem sobre os corpos enquanto a biomecânica interna estuda a mecânica e os aspectos físicos e biofísicos das articulações, dos ossos e dos tecidos histológicos do corpo. A Biomecânica inclui por isso uma vasta área de tópicos, do sistema músculo-esquelético, passando pela mecânica das próteses e das interfaces implante-tecido, pela substituição tecidular e medicina regenerativa, a mecânica da fractura e da fixação, a mecânica das próteses e das ortóteses, a análise mecânica do desempenho desportivo, etc. O Mestrado em Biomecânica, uma parceria entre o Instituto Superior de Engenharia de Coimbra e a Escola Superior de Tecnologia da Saúde de Coimbra, integra um curso com unidades curriculares de Ciências de Base, Ciências de Engenharia, Ciências da Saúde e Ciências da Saúde, e um projecto, estágio profissional ou dissertação científica. Trata-se de um ciclo de estudos que envolve fundamentalmente as áreas de Engenharia Mecânica e de Ciências da Saúde e que pretende assegurar predominantemente a aquisição pelo estudante de uma especialização de natureza profissional, com uma forte componente em Biomecânica. O Mestrado em Biomecânica, recebendo alunos licenciados em áreas da engenharia, da saúde e do desporto ou domínios afins, com a mais-valia de os

colocar a estudar em conjunto, pretende interligar estes domínios do saber, potenciando o seu conhecimento em cada uma das suas áreas profissionais. Desta forma, os intervenientes no mestrado poderão aplicar o saber adquirido em biomecânica na sua área de intervenção, quer esta esteja ligada à saúde, ao corpo, às ciências básicas ou à engenharia. *Short biography:* Luís Roseiro licenciou-se em Engenharia Mecânica na Universidade de Coimbra em 1993, tendo obtido os graus de Mestre em Engenharia Mecânica pela mesma universidade em 1997, e de Doutor em Engenharia Mecânica – Mecânica Estrutural em 2004. Ingressou no ISEC em 1993 no Departamento de Engenharia Mecânica como Professor Assistente, sendo Professor Adjunto desde 1997. É membro ou sócio dos seguintes centros ou sociedades: CEMUC – Centro de Engenharia Mecânica da Universidade de Coimbra; SPB - Sociedade Portuguesa de Biomecânica; APAET – Associação Portuguesa de Análise Experimental de Tensões; APMTAC – Associação Portuguesa de Mecânica Teórica, Aplicada e Computacional; OE – Ordem dos Engenheiros (desde 1994). No ISEC, é também Director de Curso da Licenciatura em Engenharia Mecânica, membro do Conselho Técnico Científico, membro do Conselho Pedagógico, Coordenador das Relações Internacionais do Departamento de Engenharia Mecânica, responsável pela Unidade Curricular de Projecto do 3º ano da Licenciatura em Engenharia Mecânica, responsável pela Unidade Estruturas Mecânicas do Mestrado em Equipamentos e Sistemas Mecânicos. Os seus interesses científicos incluem as áreas da biomecânica, elementos finitos, identificação e optimização estrutural, redes neuronais e algoritmos genéticos.

#### 12h10-12h30

## Hospital engineering in Portugal - new technologies for life support

Speaker: Eng. Pedro Salgado (pedro.salgado@medicinalia-cormedica.pt)

Affiliation: Medicinal-Cormédica, Coimbra, Portugal

**Abstract:** This talk will cover the following topics: Operating theatre and equipments for intensive care units (ICU); Life support systems and integration into health network systems; Ventilation in ICU – ASV mode and Cockpit concept related with minimization of medical errors; Anaesthetic systems in closed-loop ventilation.

**Short biography:** Pedro Salgado graduated in Electrical Engineering at the University of Coimbra in 1992. He worked at Siemens Medical Solutions between 1992 and 2006 as Project Manager of Integrated Services. He was responsible for project management for maintenance of hospitals in Tomar, Santarém, Ponta Delgada, Horta, Centro Hospitalar de Lisboa Ocidental. He has Technical Training in the areas of Project Management, Management, X-ray Imaging, Angiography, Equipment Life Support, and Sales. Since 2006 he is Customer Manager at Medicinal-Cormédica at the central and northern (private clients) of Portugal. The Medicinal-Cormédica is integrated in the Catalan group Werfen. In Portugal it has a turnover of 20 M€ and is the fourth largest domestic company in this area after the multinationals GE, Siemens and Philips.

#### 12h30-12h50

## The Clear-PEM breast imaging scanner

Speaker: Ricardo Bugalho (ricardo@lip.pt)

Affiliation: LIP - Laboratório de Instrumentação e Física Experimental de Partículas, Lisboa, Portugal

**Abstract:** The Clear-PEM breast imaging scanner is a dedicated PET scanner for early detection of breast cancer, aimed at providing the required higher sensitivity and spatial resolution. The scanner consists of two planardetectors mounted on a robotic gantry, allowing the distance between detectors to be adjusted for maximum sensitivity and the detectors can be rotated to achieve a good FOV coverage. Each detector consists of 64x48 LYSO:Ce crystals, each 2x2x20 mm<sup>3</sup>, which are individually read on both ends by avalanche photodiodes. The double readout scheme provides depth-of-interaction measurement, minimizing the parallax effect without reducing sensitivity. In order to cope with the 12288 APDs to be read, a custom ASIC, capable of reading 192 APDs, was developed. Sensitivity is also maximized by a data acquisition system with negligible dead-time, based on FPGAs, followed by more sophisticated event processing implemented in software. Image reconstruction and correction software had to be customized for the planar geometry of the scanner. Multi-modality will be exploited with the ongoing construction of a second prototype which combines PET with ultrasound imaging. Preclinical trials have been performed, showing the need for further image correction.

LUNCH

## Part II – Physics and Mathematics Applied to Engineering

#### 14h30-15h15

#### **Progress in time-of-flight PET scintillation detectors based on silicon photomultipliers** *Speaker:* Prof. Dr. Dennis R. Schaart (d.r.schaart@tudelft.nl)

*Affiliation:* Delft University of Technology, Mekelweg 15, NL-2629 JB Delft, The Netherlands

**Abstract:** The use of time-of-flight (TOF) information in positron emission tomography (PET) significantly improves image quality. Scintillation detectors based on silicon photomultipliers (SiPMs) are promising for TOF-PET. SiPMs are small, essentially transparent to 511 keV annihilation photons, and insensitive to magnetic fields. This enables novel detector designs aimed at e.g. compactness, high-resolution, depth-of-interaction (DOI) correction, and MRI-compatibility. We are studying the timing performance of SiPMs in combination with LYSO:Ce and LaBr<sub>3</sub>:Ce scintillators. With 3 mm × 3 mm × 5 mm LaBr<sub>3</sub>:Ce(5%) crystals coupled to a 3 mm × 3 mm Hamamatsu MPPC-S10362-33-050C SiPMs, coincidence resolving times (CRTs) of ~100 ps FWHM were achieved, while LYSO:Ce yielded a CRT of ~160 ps FWHM. At the same time, pulse height spectra with well-resolved full-energy peaks were obtained. These results indicate that SiPM-based PET detectors may perform at least as good as detectors based on conventional PMTs. In larger crystals, variations in scintillation photon transit times affect the timing resolution. A correction for this effect can be applied making use of the independently measured position of interaction. At the workshop, the prospects for SiPMs in TOF-PET will be discussed in more detail.

**Short biography:** Dennis Schaart graduated at the department of Applied Physics of Delft University of Technology (DUT) on the subject of luminescence and energy transfer processes in inorganic scintillators. After conducting a feasibility study on sealed, catheter-based beta radiation source for intravascular brachytherapy he was invited by Nucletron BV to start up a R&D project on this subject. He remained with Nucletron for more than 6 years, holding offices at Nucletron, DUT, and Oak Ridge National Laboratory (ORNL) and conducting a variety of research projects aimed at new radiotherapy devices. In his private time he wrote a PhD thesis for which he obtained a PhD degree "cum laude" in 2002. He then took on a new challenge, returning to his Alma Mater to start up a new research line on positron emission tomography (PET) detectors. At present, his main research interests include novel scintillation detectors for time-of-flight PET, for high-resolution SPECT, for multimodality imaging (e.g. PET/MRI), and for dose verification in particle therapy. Detector concepts under investigation involve, for example, new scintillation materials, solid-state light sensors such as silicon photomultipliers (SiPMs), and innovative signal processing methods. Motivated to obtain (clinically) useful breakthroughs through fundamental research, much of his research is conducted in collaboration with academic hospitals and industrial partners.

#### 15h15-16h00

## Reconstruction techniques in nuclear medicine time-of-flight PET

Speaker: Prof. Dr. Stefaan Vandenberghe (stefaan.vandenberghe@ugent.be)

Affiliation: University of Gent, Belgium

Abstract: Developments on TOF system were limited for about a decade, but started again around 2000. The combination of fast photomultipliers, scintillators with high density, modern electronics and faster computing power for image reconstruction have made it possible to introduce this principle in clinical TOF-PET systems. The development of this type of PET scanner also requires modified image reconstruction with accurate modeling and correction methods. The additional dimension introduced by the time difference motivates a shift from sinogram to listmode based reconstruction. This reconstruction is however rather slow and therefore rebinning techniques specific for TOF data have been proposed. The main motivation for TOF-PET remains the large potential for image quality improvement for a given number of counts. The gain is related to the ratio of object size and spatial extent of the TOF kernel and is therefore particularly interesting to compensate for the poor image quality observed in heavy patients. The localized nature of the TOF kernel makes it possible to limit the processing to events originating from certain regions in the FOV. This can be used for local tomography reconstruction or to separate emission from transmission data. TOF is also interesting for new applications of PET like isotopes with low abundance. The local nature also reduces the need for fine angular sampling which makes TOF interesting for limited angle situations like breast PET and online dose imaging in proton or hadron therapy.

**Short biography:** Stefaan Vandenberghe (MSc, PhD) obtained his MSc in Physics in 1996 and an additional degree in Biomedical Engineering in 1997 from KU Leuven. After working in the nuclear medicine department of the University Hospital Ghent (1997-1999) he started a Ph.D. in the MEDISIP group of the University of Ghent. His research was on the optimal configuration of gamma cameras for PET imaging and on list-mode reconstruction techniques for PET systems. He received a Ph.D. (Engineering) from this university in 2002. During his FWO postdoctoral research he worked on rotating slat systems (with solid state detectors) Monte Carlo simulations and natural pixel reconstruction. In 2004 he joined Philips Research USA (Briarcliff) to work as a Senior Scientist in the Clinical Site Program. The position was at the University of Pennsylvania (Dr. Joel Karp) in Philadelphia. During this period he worked on simulations, reconstructions and measurements for Time-Of-Flight PET systems (LaBr3 and LYSO). At the end of 2005 he returned to Belgium (return grant) in the MEDISIP group. In collaboration with different researchers in the group a variety of topics is covered: Monte Carlo simulations, rotating slat SPECT, Time-of-Flight PET and quantification for radionuclide dosimetry. He has been appointed as full time research professor (BOF-ZAP) at UGhent since October 2007. Within the Hyperimage collaboration the group's contribution is MR based attenation correction for PET and system design simulations.

#### 16h00-16h50

COFFEE BREAK

Poster session and book publishers presented at the end of this Book of Abstracts.

#### 16h50-17h10

## Towards proton therapy in The Netherlands

## Speaker: Prof. Dr. Peter Dendooven (dendooven@kvi.nl)

Affiliation: KVI – University of Groningen, Zernikelaan 25, 9747 AA Groningen, The Netherlands

**Abstract:** A few years ago, three consortia were formed with the aim to realise proton therapy facilities in the Netherlands. After an introduction on the benifit of proton therapy over traditional radiation therapy, some details of these three initiatives will be presented. The estimated number of Dutch patients that would (potentially) benifit from proton therapy will be discussed. The past and future road towards the realisation of these projects will be outlined.

**Short biography:** Dr. Peter Dendooven has a broad experience in techniques for producing and manipulating radioactive ions, ion beams and atoms and in the detection of nuclear radiation. This experience has been gained in the fields of nuclear structure, inertial confinement fusion (ICF) and molecular imaging. A study of reflection asymmetry in light actinide nuclei at the Institute for Nuclear and Radiation Physics, University of Leuven, Belgium, resulted in a PhD degree in 1992. During a subsequent 2-year post-doc appointment at Lawrence Livermore National Laboratory, U.S.A., new neutron and gamma-ray diagnostics for use in ICF were developed. The years 1994 to 2001 were spent as senior researcher at the Accelerator Laboratory of the Department of Physics, University of Jyväskylä, Finland, where the ion guide technique was further developed and nuclear spectroscopy experiments were performed, both in Jyväskylä and elsewhere. In 2001, Dr. Dendooven joined the KVI, University of Groningen, Netherlands, as a staff member. He is developing ion catcher devices based on cryogenic helium gas and superfluid helium. In recent years, attention has shifted to the development of novel time-of-flight positron emission tomography detector technology and new applications thereof (e.g. in proton therapy).

#### 17h10-17h30

## RPC-PET: a new technology for time-of-flight PET

Speaker: Prof. Miguel Couceiro (couceiro@lipc.fis.uc.pt)

Affiliation: LIP – Laboratório de Instrumentação e Física Experimental de Partículas, Coimbra, Portugal, and ISEC – Coimbra Institute of Engineering

**Abstract:** The sensitivity of a positron emission tomograph (PET) determines the acquisition time and/or patient dose needed to perform a study with a given image quality. One other factor that affects image quality, and also system sensitivity, is the use of time-of-flight (TOF) information. Without considering TOF information, sensitivity depends both on detector efficiency for a pair of 511 keV photons, and on the solid angle covered by the scanner, which can be made larger by increasing the scanner axial field-of-view (AFOV). TOF information can further improve system sensitivity by a factor given by R/(0.5\*c\*\Deltat), where R is the object size, c the speed of light, and  $\Delta t$  the time resolution of coincident events. The high cost of scintillator detectors commonly used in PET scanners, as well as the associated electronics, make them unaffordable for large AFOV systems. The resistive plate chamber (RPC) TOF-PET concept, based on the converter-plate principle, takes advantage of the naturally layered structure of RPCs, of its simple and economic construction, excellent time resolution and very good intrinsic position accuracy, which can be useful for high-sensitivity/high-resolution TOF-PET. In this talk, we will present the basic principles of an RPC-PET system with TOF information, as well as some simulation results concerning system sensitivity, and image spatial resolution.

**Short biography:** Miguel Couceiro is a Teaching Assistant at the Department of Physics and Mathematics of Coimbra Institute of Engineering. He obtained a MSc. in Biomedical Engineering in 1998, at the Faculty of Medicine of the University of Coimbra, after a degree in Physics Engineering in 1993, at the Faculty of Sciences and Technology of the University of Coimbra. He is currently working on his PhD. thesis in Technological Physics in the field of Positron Emission Tomography.

#### 17h30-17h50

## New regression equations for predicting the size of unerupted canines and premolars in the Portuguese population

Speakers: MSc. Sónia Alves (soalves1@gmail.com)

MSc. Nuno Lavado (nlavado@isec.pt) **Affiliation Sónia Alves:** FMUC – Dep. of Dentistry, Stomatology and Maxillofacial Surgery,

Faculty of Medicine, University of Coimbra, Portugal,

Affiliation Nuno Lavado: ISEC – Coimbra Institute of Engineering, and

UNIDE-Business Research & Development Unit, ISCTE Business School (IBS), Lisbon, Portugal Abstract: The prediction of unerupted canine and premolars size in children in the mixed dentition is important in early orthodontic diagnosis and treatment, in order to determine the discrepancy between available and required space in each dental arch. Mixed dentition analysis methods can be grouped into three categories: those which use regression equations, those which use radiographs, and those which use a combination of both. Among the different methods reported in the literature, the prediction methods based on the already erupted permanent teeth in early mixed dentition are the most broadly used, especially the Moyers probability tables and the Tanaka and Johnston equations. However, these two methods were developed for children of the United States and tooth and facial characteristics differ among populations of different racial or ethnic origin. In recent years several studies have been conducted in order to confirm the applicability and effectiveness of these methods in different populations. The study herein presented has been conducted using 250 patients selected from the orthodontic archives of the Faculty of Medicine, University of Coimbra (FMUC), Portugal. The combination of the sums of permanent upper central incisors, upper first molars and lower lateral incisors was the best predictor in this sample, by contrast with reports from papers from other nations. The proposed model also included sex and arch as additional predictor variables. The multivariate regression model (MRM) determination coefficient was 50% with a standard error of 0.86 mm. Validation of the proposed MRM was done through the evaluation of its prediction capability for the sum of mesiodistal tooth width of permanent canine and premolars (SPCP) on the four hemiarches in the validation sample (28 female and 22 male). Absolute deviations from the actual SPCP did not exceed 1 mm in 71,5% of the validation sample (143 from the 200 predictions obtained - in each subject deviations from actual SPCP were measured at the four hemiarches). This new model underestimate and overestimate by more than 1 mm the real SPCP in 17% (34) and 12% (23) from the 200 cases evaluated, respectively. The proposed MRM allows better overall accuracy within the Portuguese population by using a different combination of predictive teeth.

**Short biography Sónia Alves:** Sónia Alves graduated in Dentistry, becoming a specialist in orthodontics for the Order of Dental Practitioners in 2002 after postgraduate studies on that subject at the Faculty of Medicine, University of Coimbra (FMUC), Portugal, where she also received the MSc degree in orthodontics in 2004. She is a teaching assistant of orthodontics at FMUC. She is working toward the PhD degree in orthodontics at FMUC. She also works at her private clinic. She is a member of the European Federation of Orthodontics Specialists Association (EFOSA) since 2003 and she has made some conferences in congress during her academic career.

**Short biography Nuno Lavado:** Nuno Lavado received a degree in Mathematics from the University of Lisbon, Portugal, and the MSc degree in Statistics and Information Management from the New University of Lisbon, in 2000 and 2004, respectively. He is currently working toward the PhD degree in Quantitative Methods in the ISCTE Business School (IBS), as a research assistant at the UNIDE – Business Research & Development Unit, Lisbon, Portugal. At the same time, he is a teaching assistant at ISEC – Coimbra Institute of Engineering. His research interests include the theory and applications of data analysis with particular focus on nonlinear Principal Components Analysis. In recent years considerable attention has been given to collaborative research, with the greatest emphasis on coauthoring papers by offering contributions to research design and data analysis.

#### 17h50-18h10

## Smooth interpolating curves on Euclidean spaces and other Riemannian manifolds

Speaker: Prof. Dr. Rui Rodrigues (ruicr@isec.pt)

Affiliation: ISEC - Coimbra Institute of Engineering

Abstract: In many engineering applications one has to find trajectories that are constrained to pass through some specific points with prescribed derivatives and required degree of smoothness. Such interpolation problems in Euclidean spaces have been studied for a long time and numerous interpolation algorithms have been designed. Spline functions have proved to be a very useful instrument in this area. They also found applications in economics, biology, medicine, etc. In its origins, splines were based on a piecewise constructive approach. Nowadays, interpolating splines are also found as solutions of some variational problems. This approach highlights their optimal properties and also provides a natural way to extend the classical theory to more complicated settings, such as the case when splines are required to live on a manifold. The extension to non Euclidean spaces is of particular importance in many applications in areas such as computer graphics, robotics and motion planning. As an example, with the development of robotics and computer graphics it has become important to find planning methods of spatial motion of rigid bodies, where not only position, but also orientation, are required to change smoothly. In spite of the interesting and deep theoretical developments introduced by the variational approach, the construction of interpolating splines on manifolds is still very limited. The main obstruction comes from the fact that the Euler-Lagrange equations associated to the variational approach are highly nonlinear. To overcome such difficulties many efforts have been concentrated in a more geometric analysis. The most well known geometric method to generate polynomial splines in Euclidean spaces is the De Casteljau algorithm, which is based on successive linear interpolations where the number of steps increases with the required degree of smoothness. A generalization of this geometric construction, where the fundamental idea was to replace line segments in an Euclidean space with geodesics in a manifold, is the most successful way to generate smoothing interpolating curves on manifolds, which are suitable for applications. An alternative geometric algorithm is presented that reduces the complexities of the De Casteljau construction, keeping the number of steps to a minimum, no matter how high the required degree of smoothness is. This approach is more flexible than the De Casteljau algorithm and also computationally less intensive, both on Euclidean spaces and on other Riemannian manifolds. The geometric algorithm is presented on Euclidean spaces, in order to get insight for generalizations to other Riemannian manifolds. The sphere case is presented and an example illustrates the implementation of the algorithm on S<sup>2</sup>.

**Short biography:** Rui Rodrigues works at the Department of Physics and Mathematics of Coimbra Institute of Engineering.He obtained his PhD in Mathematics in 2007 at the University of Coimbra and his main research interests include optimal control theory, linear systems and spline functions.

## Poster session – Theses in Biomedical Engineering running at ISEC

#### Poster 1:

## Look4MyBody

Sandra Filipa Correia<sup>1</sup>, Inês Rocha Matos<sup>1</sup>, José Matias<sup>1,2</sup>, Catarina Pereira<sup>3</sup>, Soraia Rocha<sup>3</sup> <sup>1</sup>ISEC, <sup>2</sup>GIAN, <sup>3</sup>ISA

Presenters: Sandra Filipa Correia (a21170879@alunos.isec.pt), Inês Rocha Matos (a21170354@alunos.isec.pt)

**Abstract:** Currently, there are several gyms in the market exclusively targeted at women. This type of gym it is proposed to provide to their customers a fast, effective and female-suitable physiognomy. This is a circuit training with eight/ten hydraulic resistance machines, whose weights are unique, and its values are calculated in adaption to the female body. In each session, there are so many customers as there are machines. At the end of approximately thirty minutes, each customer should be exercised in all machines. The aim of this project is to complete the hardware of the prototype of a monitoring system of loss of calories and distance covered in each machine. The values are updated on a graph that can be viewed by customers during the session.

#### Poster 2:

## Digital circuit development process for an iris recognition system used in subject identification

Tiago Correia<sup>1</sup>, Pedro Amaro<sup>1</sup>, Paulo Barbeiro<sup>2</sup>, Soraia Rocha<sup>3</sup>

<sup>1</sup>ISEC, <sup>2</sup>BlueWorks, <sup>3</sup>ISA

Presenter: Tiago Correia (tiago\_correia30@hotmail.com)

**Abstract:** Biometric identification is a reliable and fast authentication method that can be used in a large number of applications. Among all biometric identification processes, iris recognition is classified as highly reliable being one of the most accurate methods for user identification. The use of iris recognition algorithms have been implemented to this date using traditional computers with generic microprocessors that use sequential execution. This option though effective has obvious limitations in size, portability, and energy consumption and user friendliness among other. An effective alternative is to use application specific circuits that potentially allow faster identification process and considerable equipment form factor reduction by using parallel processing. The objective of this project is to implement an iris recognition digital circuit using a field-programmable gate array (FPGA). The development of the digital circuit is supported by a similar application implemented using Matlab. This approach allows the partial development of the digital circuit that will gradually replace the application of Matlab as circuit blocks are added to the digital system. PC/FPGA communication resources are being developed both at hardware and software level allowing an effective interchange process between Matlab and digital circuit calculation.

#### Poster 3:

## Biomass embedded system controller for home heating in an ambient assisted living environment

Pedro Amaro<sup>1</sup>, Hélder Oliveira<sup>1</sup>, Luís Jesus<sup>1</sup> <sup>1</sup>ISEC

Presenters: Hélder Oliveira (a21170352@alunos.isec.pt), Luís Jesus (a21171060@isec.pt)

**Abstract:** Ambient Assisted Living (AAL) is an emerging concept within medical and home care health assistance industry. Part of implementing this concept implies providing a stable and comfortable environment for users. To achieve this goal home automation system should have a strong bond to AAL systems. At the same time an increasing worry on how energy is used will press for sustainable AAL system development. Biomass heat generation can provide a low environment and financial cost if a careful burner control is implemented. This project implements a pellet stove embedded system controller that allows data interchanging with a wireless network. A PIC microcontroler implements a control for a pellet feeding motor, a forced ventilation motor and a set of temperature and pressure sensors, while the set point for burner operation is provided by the wireless network.

#### Poster 4:

#### Heart disorders diagnosis using sound spectral analysis and artificial neural networks

Carlos Almeida<sup>1</sup>, Sérgio Lourenço<sup>1</sup>, Fernando J. T. E. Ferreira<sup>1,2</sup>, Pedro Amaro<sup>1</sup>, Inácio Fonseca<sup>1</sup>

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Presenters: Carlos Almeida (carlosalmeida89@hotmail.com), Sérgio Lourenço (sergio.l1@hotmail.com)

**Abstract:** The heart sounds are generated by the beating of the heart and the resultant flow of blood through it. In cardiac auscultation, an examiner uses a stethoscope to listen for these sounds, which provide important information about the condition of the heart, ultimately allowing to identify some heart disorders. In healthy adults, there are two normal heart sounds that occur in sequence with each heart beat, being produced by the closing of the AV valves and semilunar valves. In addition to these normal sounds, a variety of other sounds may be present including heart murmurs, adventitious sounds, and gallop rhythms. Heart murmurs are generated by turbulent flow of blood, which may occur inside or outside the heart. Murmurs may be physiological (benign) or pathological (abnormal). Abnormal murmurs can be caused by stenosis restricting the opening of a heart valve, resulting in turbulence as blood flows through it. Abnormal murmurs may also occur with valvular insufficiency (or regurgitation), which allows backflow of blood when the incompetent valve closes with only partial effectiveness. Different murmurs are audible in different parts of the cardiac cycle, depending on the cause of the murmur. In this project, the aim is to analyse the heart sound spectrum using the fast Fourier transform (FFT) technique, and to implement and train an artificial neural network (ANN) to diagnose some heart disorders (ANN output) on the basis of the heart sound FFT components (ANN input). For that purpose, MATLAB software is used.

#### Poster 5:

## Automatic tracking of maximum fetal heartbeat signal in Doppler devices with multiple probes

Joana Figueira<sup>1</sup>, Sara Machado<sup>1</sup>, Catarina Pinho<sup>1</sup>, Fernando J. T. E. Ferreira<sup>1,2</sup>, Pedro Amaro<sup>1</sup>, Inácio Fonseca<sup>1</sup> <sup>1</sup>ISEC, <sup>2</sup>ISR-UC

Presenters: Joana Figueira (a21170880@alunos.isec.pt), Sara Machado (a21170362@alunos.isec.pt),

Catarina Pinho (a21170884@alunos.isec.pt)

**Abstract:** Fetal heartbeat monitoring is an important issue in risk and/or late pregnancies. Typically, the fetal heart rate is monitored by means of Doppler devices. In cardiotocography, the monitoring of the fetal heart rate and uterine contractions are simultaneously monitored. During constant, single-probe, Doppler-based monitorization, after adjusting the probe for heartbeat signal maximization, sometimes that signal is partially lost or it becomes very weak due to the movement of the baby being monitored, requiring a new adjustment of the probe, which can be problematic. In this project, a multi-probe Doppler system with multiple probes localized in different positions in the patient belly surface able to automatically track the best positioned probe is being developed. Such system will optimize the acquired heartbeat signal, even if the baby changes its position, avoiding the need for frequent probe adjustment. In the system being developed, the sound from the Doppler device is acquired by means of a DAQ board, connected to a PC. Four probes (placed in different positions) are connected to the Doppler device by means of an analog multiplexer, which is controlled by two digital bits generated by the DAQ board. A program developed in LabVIEW treats the acquired signals and, through proper algorithms, selects the probe that has the best signal. Once a probe is selected, the LabVIEW application acquires and processes the respective signal to measure the fetal heartbeat rate. The evaluation process of the signal quality of the probe is repeated after a predefined period, in order to guarantee that the probe with the best signal is used for the fetal heartbeat rate measurement.

Poster 6:

### Development of a circular stabilometre and a pressure-force measuring platform

Fábio Gouveia<sup>1</sup>, Maria João Vela<sup>1</sup>, Nuno Ferreira<sup>1</sup>

<sup>1</sup>ISEC

Presenters: Fábio Gouveia (a21170351@alunos.isec.pt), Maria João Vela (a21170886@alunos.isec.pt)

**Abstract:** Este projecto tem como objectivo desenvolver uma aplicação capaz de avaliar o equilíbrio dinâmico natural ou induzido de indivíduos. Avalia também o equilíbrio postural do indivíduo quando submetido a instabilidades na sua base de sustentação.

### Poster 7:

#### Evaluation of a laser cane for the blind

Sílvia Neves<sup>1</sup>, Diogo Seabra<sup>1</sup>, Paulo Fonte<sup>1,2</sup>

<sup>1</sup>ISEC, <sup>2</sup>LIP

Presenters: Sílvia Neves (a21170364@alunos.isec.pt), Diogo Seabra (a21170356@alunos.isec.pt)

**Abstract:** The project aims at developing and evaluating a laser distancemeter readout by a portable computer as an aid for blind people.

## Poster 8:

## Detector development for monitoring photon radiotherapy

Joana Gonçalves<sup>1</sup>, Liliana Sampaio<sup>1</sup>, Brígida Ferreira<sup>2</sup>, Paulo Fonte<sup>1,3</sup>, Maria do Carmo Lopes<sup>4</sup>, Paulo Martins<sup>3</sup>, Paulo Crespo<sup>1,3</sup>

<sup>1</sup>ISEC, <sup>2</sup>I3N-UA, <sup>1,3</sup>LIP, <sup>4</sup>IPOCFG, E.P.E.

Presenters: Joana Gonçalves (tog\_api@hotmail.com), Liliana Sampaio (liliana\_sampaio@hotmail.com)

Abstract: A gamma- and X-ray detection system aimed at providing clinical feedback to photon radiotherapeutic treatments is under R&D.

## Poster 9:

## Studying texture descriptors for CT image analysis

Isabel Abreu<sup>1</sup>, Cristina Mesquita<sup>1</sup>, Verónica Vasconcelos<sup>1,2</sup>

<sup>1</sup>ISEC, <sup>2</sup>Centro de Instrumentação

Presenters: Cristina Mesquita (a21170360@alunos.isec.pt), Isabel Abreu (a21170355@alunos.isec.pt)

**Abstract:** This work is part of a computer-aided diagnosis project whose objective is to help radiologists in computed tomography (CT) images analysis of lung parenchyma. Actually multidetector row CT (MDCT) scanners enable the acquisition of more than 300 sections per rotation, producing a huge volume of image data, making essential the use of computer-aided image analysis. Statistical texture-based methods are explored in order to characterize patterns associated with lung pathologies. A research of several software packages for visualization, image analysis and 3D lung segmentation is also an important part of the project.

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