BIOMEP 2015

Medical Image Science & Luminescence

International Conference

on Bio-Medical Instrumentation and related Engineering and Physical Sciences

June 18-20, 2015

TEI of Athens

Organized by the Department of Biomedical Engineering (MISCIRLU Project), Technological Educational Institute (TEI) of Athens, Greece

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BOOK OF ABSTRACTS

BIOMEP 2015 has been co-funded by the European Union (European Social Fund) and Greek National Resources under the framework of the "ARISTEIA" project MISCIRLU code no.1476 of the "Education & Lifelong Learning" Operational Programme

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Preface

The International Conference on Bio-Medical Instrumentation and related Engineering and Physical Sciences (BIOMEP 2015) was organized by the Department of Biomedical Engineering of the Technological Educational Institute (TEI) of Athens, Greece, within the framework of the "ARISTEIA" program, MISCIRLU project, code 1476, on June 18-20, 2015.

The scope of the conference was to provide a forum on the latest developments in Biomedical Instrumentation and related principles of Physical and Engineering sciences. Scientists and engineers from academic, industrial and health disciplines were invited to participate in the Conference and to contribute both in the promotion and dissemination of the scientific knowledge.

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Thursday 18 June 2015

9:30 – 11:00 **Session 1**. **Scintillators and Phosphors**
Session Chairpersons: *E. Zych,* Wroclaw University, Poland & *N. Kalyvas,* T.E.I. of Athens

9:30-9:50 Invited speech: Medical Image Science through luminescence (MISCIRLU project)

I. S. Kandarakis*, I. Valais, P. Liaparinos, G. Fountos, N. Kalyvas, C. Michail, S. David

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Keywords: Luminescence; Image Science ; Modulation Transfer Function ; Noise Power Spectrum ; Detective Quantum Efficiency.

From conventional intensifying screens to multicrystal blocks of ring detectors, luminescent materials (scintillators and phosphors) coupled to optical sensors, are traditionally associated with most developments in position sensitive radiation detectors employed in Medical Imaging. Materials are employed in the form of granular screens, structured (needle-like) crystals, single crystal or multicrystal transparent blocks or storage phosphor plates. In the present investigation, description of detector performance followed experimental, analytical and Monte Carlo methods based on Luminescence efficiency, decay time, spatial and spectral distribution of emitted light as well as on signal and noise analysis in both space and spatial frequency domains. Within this framework basic quality metrics, such as the Modulation Transfer Function (MTF), the Noise Power Spectrum (NPS) and the Detective Quantum Efficiency (DQE) were evaluated. In experimental studies the aforementioned metrics are evaluated for various materials in the form of screens. Algorithms were implemented incorporating the methods for experiment based calculations of MTF and NPS. Finally the DQE was calculated for each case. The designed software for the parameters calculation was presented in a graphical user interface (GUI) environment (MINORE v1), which is designed from our group. Luminescence efficiency, signal and noise analysis are valuable tools for the evaluation of luminescent materials as candidates for medical imaging detectors

Acknowledgement
This research has been co-funded by the European Union (European Social Fund) and Greek national resources under the framework of the "ARISTEIA" project MISCIRLU code 1476 of the "Education & Lifelong Learning" Operational Programme.

9:50-10:10 Invited speech: Phosphors Processing and their Properties – the Case of SrS:Ce

D. Kulesza[1], K. Fiaczyk[1], A. Wiatrowska[2], E. Zych[1,3,*]

[1] Faculty of Chemistry, University of Wroclaw, Poland, 14F. Joliot Curie Street, 50-383 Wroclaw, Poland
[2] Philips Research, Materials Technology Department
High Tech Campus 04, 5656 AE Eindhoven, The Netherlands
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Keywords: Strontium sulfide, Ce^{3+} luminescence, material processing

SrS:Ce is a known luminescent material with a high brightness emission in the 450-600 nm region and peaking around 480 nm. Our experiments on sintered SrS:Ce pellets revealed that a new emission centrum appeared with luminescence in the range of 570-800 nm, see Fig. 1. The emission has all the characteristics of Ce^{3+} luminescence. Thus, the red luminescence band is composed of two components separated by about 2200 cm^{-1}, which matches the splitting of the $^2F_{5/2}$ and $^2F_{7/2}$ states. Also the luminescence decay time reaching 35 ns at 25 K is typical for Ce^{3+}. It gets shorter with increasing temperature and at RT the red emission is already noticeably quenched. The excitation features of both emissions, the regular bluish green and the irregular red one, are very much separated and altogether cover the whole range of 200-450 nm range of wavelengths. Temperature dependence of the luminescence characteristics will be discussed together with the possible structure of the irregular Ce^{3+} luminescent center.

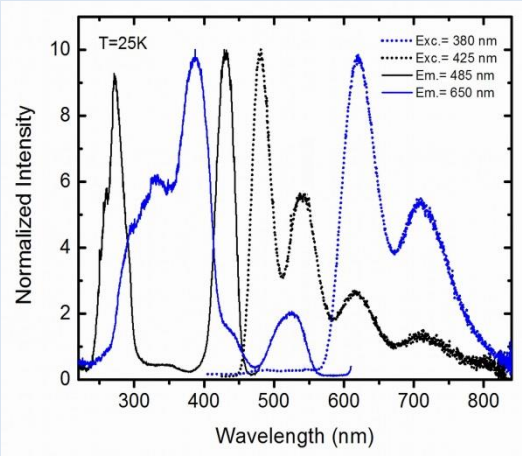

Fig 1. Emission and excitation spectra revealing existence of two different Ce^{3+} luminescence centers in SrS:Ce after sintering at high temperatures.

Acknowledgement

This work was supported by POIG.01.01.02-02-006/09 project co-funded by European Regional Development Fund within the Innovative Economy Program. Priority I, Activity 1.1. Sub-activity 1.1.2, which is gratefully acknowledged.

10:10-10:30 Invited speech: Morphology control of Lu_2O_3:Eu x-ray phosphor

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Keywords: Lutetium Oxide, Morphology Control, Radioluminescence

Lutetium oxide is an interesting host for Rare Earth-activated X-ray phoshpors due to its impressive density of 9.84 g/cm^{3}and high effective Z-number (63.7). With the energy band gap of about 5.85 eV, Lu_2O_3:Eu was recognized to have potential to produce about 75,000 ph/MeV upon ionizing radiation excitation. The extraordinary absorption coefficient of X-rays by photoelectric effect rather than Compton scattering allows using thinner lutetia phosphor layers for X-ray intensifying screens, which translates into reduced light scattering, and thus better image quality. Clearly, Lu_2O_3:Eu may offer very important advantages as X-ray phosphor if only its light yield could be improved and morphology could be well controlled. Therefore, attempts were made to synthesize Lu_2O_3:Eu phosphors using such techniques as hydrothermal and flux-aided (Li_2SO_4+SiO_2) methods. We shall show, that these two synthesis methods allowes controlling the size and shape of the phosphor grains depending by means of technological parameters (see Fig.1). Furthermore, depending of the method of synthesis, the radioluminescence of Lu_2O_3:Eu powders reached 50%–120% of the commercial Gd_2O_2S:Eu. More details about synthesis, structure and radioluminescence properties of lutetia powders we will be shown in our presentation.

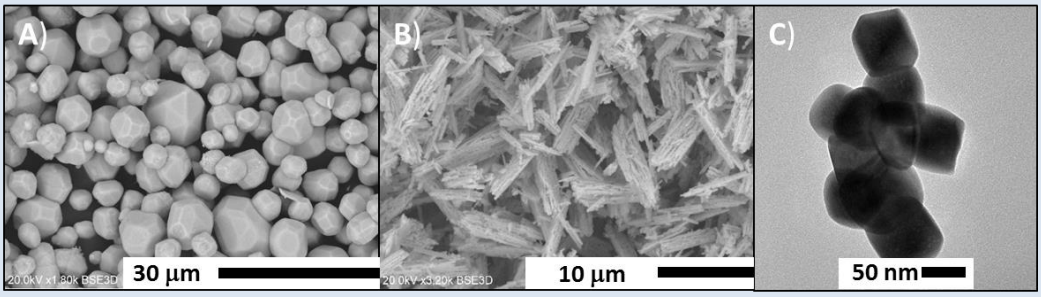

Figure 1. SEM and TEM images of Lu_2O_3:Eu powders were prepared by A) flux-aided method and hydrothermal synthesis in B) pH=8, C) pH=12.

Acknowledgement
This work was supported by Operational Programme Human Capital No. UDA-POKL.04.01.01-00-054/10-01 09 project "Development of the potential and educational offer of the University of Wroclaw - the chance to enhance the competitiveness of the University" co-funded by European Union within the European Social Fund. Activity 4.1. Sub-activity 4.1.1, which is gratefully acknowledged.

10:30 – 10:40 the role of near infrared fluorescence imaging in endocrine surgery: Systematic review

E. Yiannakopoulou

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Keywords: near infrared fluorescence imaging, endocrine surgery, thyroid surgery, parathyroid surgery, adrenal surgery

Endocrine surgery is technically demanding, as endocrine glands are small organs that cannot be easily identified from surrounding structures. In addition, tumors of endocrine glands have commonly a favorable prognosis, enabling thus tumor enuclation and organ preservation. Novel intraoperative imaging modalities could enable the performance of safer and less radical operations by endocrine surgeons. This paper aimed to investigate the role of near infrared fluorescence imaging in endocrine surgery. Electronic databases were searched with the search terms 'NIRF, endocrine surgery, thyroid, parathyroid, adrenal, pancreas for the time period up to and including March 2015.. Eight papers were identified, including experimental studies, case series or case reports. Possible applications of NIRF in endocrine surgery include: (a) identification of parathyroid glands during thyroid surgery, thus enabling the preservation of parathyroid glands (b) the feasibility of partial adrenalectomy through tumor localization, (c) identification of adrenal glands from surrounding structures during laparoscopic adrenalectomy, thus reducing the chances of hemorrhage and conversion to open surgery, (d) intraoperative imaging of paragaglioma, (e) localization of insulinoma thus enabling tumor enuclation. In conclusion, NIRF imaging could allow parathyroid gland identification resulting in the reduction of parathyroid gland injury during thyroid surgery. Furthermore, NIRF imaging could enable partial adrenal and pancreatic sparing surgery.

10:40 - 10:50 A theoretical study of optical photon propagation in granular scintillator detectors .

N. I. Kalyvas, C. M. Michail, G. P. Fountos, I. Valais, P. Liaparinos, S. David, I. Kandarakis.

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Keywords: luminescence, optical photons, propagation, model

Optical photon propagation plays an important role in the evaluation of scintillator materials as X-ray converters for medical imaging applications. An increased number of optical photons reaching the output can result to less incident X-rays, thus reducing patient dose. The optical photon propagation is affected by the type of the scintillator surface (granular, columnar, ceramic), the wavelength of the produced optical photons, the index of refraction of the material and the lateral dimensions of the scintillator. In addition the grain size, or the column diameter should be considered. In this work a theoretical model studying the propagations per 1μm layer of granular scintillators is utilized. The model is compared with experimental absolute efficiency results of $GdAlO_3$*:Ce, YAP:Ce,* Lu_2O_3*:Ce,* Gd_2O_2S*:Eu,* Gd_2O_2S*:Pr and Gd2O2S:Pr,Ce,F irradiated at 60kVp X-ray tube voltage. The scintillators were in the form of phosphor screens, while in the case of* Lu_2O_3*:Ce the scintillators were in the form of compressed pills. It was found that screen thickness affects the propagation per layer for the same material. For example* $GdAlO_3$*:Ce phosphor exhibit a range of propagation between 47% for 14.7mg/cm*^{2} *to 70% for 121.1 mg/cm*^{2} *surface density. The highest percentage (98.8%) was found for the 222 mg/cm* ^{2} Lu_2O_3*:Ce phosphor compressed pill and the 71.2mg/cm*^{2} *Gd2O2S:Pr,Ce,F phosphor screen. In general a phosphor screen with high uniformity may exhibit higher propagation percentage per layer.*

Acknowledgement

This research has been co-funded by the European Union (European Social Fund) and Greek national resources (1476) under the framework of the "ARISTEIA" project MISCIRLU code 1476 of the "Education & Lifelong Learning" Operational Programme.

10:50 - 11:00 X-ray imaging performance of thin semitransparent films of $LuPO_4$:Eu

I. E. Seferis[1], J. Zeler[1], C. Michail[2], I. Valais[2], G. Fountos[2], N. Kalyvas[2], A. Bakas[3], I. Kandarakis[2], E. Zych[1,4]

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Keywords: X-ray imaging, $LuPO_4$:Eu, films

In the present work we demonstrate the fabrication technique of semitransparent layers of nanoparticulated (~20 nm) $LuPO_4$:Eu phosphor, present their basic luminescent properties and give results of their performance in a planar imaging system with CMOS photodetector. For comparison, the imaging performance of Gd_2O_2S:Eu phosphor screen prepared by sedimentation is also shown. The X-ray detection parameters as well as the luminescence efficiency of the investigated screens will be discussed. Results show that the in-line transmittance at ~600-700 nm varies in respect to the thickness of the films from 40-50% for a film of 67 µm thick to 4-12% when the thickness increased to 460 µm, while X-ray detection parameters get enhanced as the thickness of the films increases. Those results seem to affect the luminescence efficiency curves of the films under poly-energetic X-ray radiation of various tube energies. The normalized noise power spectrum values were found similar between $LuPO_4$:Eu films and screen using commercial Gd_2O_2S:Eu powder. The detective quantum efficiency of our films is clearly lower than Gd_2O_2S:Eu screen from 2 to 10 cy/mm frequency range while the modulation transfer function is lower from 0 to 5.5 cy/mm frequency range. The acquired data allow to predict that high-temperature sintering of our films under pressure may help to improve their imaging quality, since such a processing should increase the luminescence efficiency without significant growth of the grains, and thus without sacrificing their translucent character.

Acknowledgement

This research has been supported by the Marie Curie Initial Training Networks (ITN) action under the LUMINET project, grant agreement no. 316906.

11:30 – 13:10 **Session 2**. **Medical Imaging I**
Session Chairpersons: *Prof. R. Speller,* University College London, UK *and Assoc. Prof. G. Fountos,*T.E.I of Athens

11:30-11:50 Invited speech: An evaluation of the clinical potential of tissue diffraction studies

R. Speller[1], S. Abuchi[2], Y. Zheng[1], N. Vassiljev[1], A. Konstantinidis[1], J. Griffiths[1]

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Medical imaging is a long established part of patient management in the treatment of disease. However, in most cases it only provides anatomical detail and does not provide any form of tissue characterisation. This is particularly true for X-ray imaging. Recent studies on tissue diffraction have shown that true molecular signatures can be derived for different tissue types. This talk will look at the evidence to suggest that tissue diffraction could be used to support diagnostic interpretation and the technology available to carry out these measurements. Breast cancer, liver and heart disease have been studied at UCL using different approaches for data collection and analysis. The talk will discuss in some detail the tissue diffraction systems developed at UCL and results from these systems will be presented. The limitations of the techniques will be discussed and the future potential for clinical implementation considered.

11:50-12:10 Invited speech: Predicted image quality of a CMOS APS x-ray detector across a range of mammographic beam qualities

A. C. Konstantinidis

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Keywords: CMOS APS X-ray detector, Image Simulation, X-ray Performance, Mammography, Beam Quality, Image Quality

Digital X-ray detectors based on Complementary Metal-Oxide-Semiconductor (CMOS) Active Pixel Sensor (APS) technology have been introduced in the early 2000s in medical imaging applications. In a previous study the X-ray performance (i.e. presampling Modulation Transfer Function (pMTF), Normalized Noise Power Spectrum (NNPS), Signal-to-Noise Ratio (SNR) and Detective Quantum Efficiency (DQE)) of the Dexela 2923MAM CMOS APS X-ray detector was evaluated within the mammographic energy range using monochromatic synchrotron radiation (i.e. 17-35 keV). In this study image simulation is used to predict how the mammographic beam quality affects image quality. In particular, the experimentally measured monochromatic pMTF, NNPS and SNR parameters are combined with various mammographic spectral shapes (i.e. Molybdenum/Molybdenum (Mo/Mo), Rhodium/Rhodium (Rh/Rh), Tungsten/Aluminium (W/Al) and Tungsten/Rhodium (W/Rh) anode/filtration combinations for a given tube voltage (in kVp)). The image quality is measured in terms of Contrast-to-Noise Ratio (CNR) and Detectability Index using synthetic breast phantoms. The results can be used to optimize the imaging conditions in order to minimize patient's Mean Glandular Dose (MGD).

12:10 – 12:20 Lower limit of detection in x-ray diffraction measurements of breast tissue equivalent samples

Y. Zheng[1], N. Vassiljev[1], A. Konstantinidis[2], J. Griffiths[1], R. Speller[1]

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[2]Diagnostic Radiology - Christie Medical Physics and Engineering, The Christie NHS Foundation Trust, Manchester, M20 4BX, UK
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Keywords: CMOS APS, X-ray Diffraction, Breast Cancer Detection

A wafer scale dual camera CMOS APS (namely DynAMITe) has been developed to enable high quality transmission images and X-ray diffraction (XRD) measurements to be acquired using the same detector. This detector system could form the basis for a new approach to mammography whereby following a conventional mammogram, the radiologist could interrogate suspicious regions using X-ray tissues diffraction whilst the patient is still present and establish the true extent of disease. A starting point is to quantify the minimum detectable amount of breast cancer within a realistic thickness phantom. Perspex has a similar diffraction pattern to healthy breast tissue while water is similar to breast tumour, hence, these two materials can be used as tissue equivalent test objects for X-ray diffraction measurements. Preliminary results show linear agreement between the ratio of Perspex to water and the ratio of the diffraction peak intensities at 1.1nm-1 and 1.6nm-1. The minimum detectable limit for a component of this two 'tissue' mix was found to be 5%.

Acknowledgements
DynAMITe was developed under the EPSRC Multidimensional Integrated Intelligent Imaging Plus (MI-3 Plus) programme (EP/G037671/2).

12:20-12:30 CMOS Active pixel sensor x-ray detector for dual energy contrast enhanced digital mammography

I. Billas[1], A. C. Konstantinidis[2] and R. D. Speller[3]

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[2]Christie Medical Physics and Engineering, The Christe NHS Foundation Trust, Manchester, United Kingdom
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Keywords: Dual Energy (DE), Contrast Enhanced Digital Mammography (CEDM), CMOS APS

Clinical applications have shown that the use of dual energy (DE) contrast enhanced digital mammography (CEDM) can explore angiogenesis in breast carcinoma by tracking the uptake and washout of an injected contrast medium in breast tissue. The present work focuses in the implementation of DE CEDM with complementary metal oxide semiconductors (CMOS) active pixel sensor (APS) x-ray detector to effectively measure the iodine projected thickness with low dose and high image quality. The x-ray performance of the detector is evaluated and the optimum DE conditions are estimated through image simulation. Breast phantoms are carefully prepared to replicate the properties of real breast tissue and a 2 mm diameter tube is placed inside the phantom for the injection of the different contrast media concentrations.
Results showed that the contrast of the DE image is enhanced by a factor of about 17 and 8 from the low- and high-energy images, respectively. The total mean glandular dose is 1.4 mGy, which does not exceed the equivalent of a typical mammogram. The combination of DE CEDM with CMOS APS detector can effectively measure iodine projected thicknesses with an accuracy of within about 3%. Finally, it is shown that CMOS APS detector performance is within acceptable clinical accuracy, capable to detect an iodine projected thickness of 0.8 mg/cm2 and comparable with the state-of-the-art technology reported in literature.

12:30 - 12:40 Hybrid Pixel Detectors for gamma/X-ray imaging

D. Hatzistratis[1,2], G. Theodoratos[1,3], V. Zografos[1,4], I. Kazas[5], D. Loukas[5], and C. P. Lambropoulos[1].

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Keywords: Hybrid, CMOS, pixel, detectors

Hybrid pixel detectors are made by direct converting high-Z semi-insulating single crystalline material coupled to CMOS readout electronics. They are attractive because direct conversion exterminates all the problems of spatial localization related to light diffusion, energy resolution is far superior from the combination of scintillation crystals and (silicon) photomultipliers and lithography can be used to pattern electrodes with very fine pitch.

We are developing 2-D pixel CMOS ASICs, we connect them to pixilated CdTe crystals with the flip chip and bump bonding method and we characterize the hybrids.

We have designed a series of circuits, whose latest member consists of a 50x25 pixel array with 400um pitch and an embedded controller. In every pixel a full spectroscopic channel with time tagging information has been implemented. The detectors are targeting Compton scatter imaging and they can be used for coded aperture imaging too.

Hybridization using CMOS can overcome the limit put on pixel circuit complexity by the use of TFT transistors in large flat panels. Hybrid active pixel sensors are used in dental imaging and elsewhere. Thus X-ray imaging can benefit from the work done on dynamic range enhancement methods developed initially for visible and infrared CMOS pixel sensors. A 2-D CMOS ASIC with 100um pixel pitch to demonstrate the feasibility of such methods in the context of X-ray imaging has been designed.

Acknowledgement

The research has been funded by the FP7-SEC-218000 COCAE, the ESA C21213/NL/PA Contract and by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: ARCHIMEDES III. Investing in knowledge society through the European Social Fund.

12:40 - 12:50 3-D Localization of Gamma Ray Sources with Coded Apertures for Medical Applications

I. Kaissas[2], C. Papadimitropoulos[1], C. Karafasoulis[3], C. Potiriadis[2] and C. P.Lambropoulos[1].

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Keywords: CdTe, Coded Apertures, Gamma Camera, triangulation,

Several small Gamma Cameras for radioguided surgery using CdTe or CdZnTe have parallel or pinhole collimators. Coded aperture imaging is a well-known method for gamma ray source directional identification, applied in astrophysics mainly. The increase in efficiency due to the substitution of the collimators by the coded aperture masks renders the method attractive for gamma probes used in radioguided surgery.

We have constructed and operationally verified a setup consisting of two CdTe gamma cameras with Modified Uniform Redundant Array coded aperture masks of rank 7 and a video camera. The active area for each detector is 4.4×4.4 cm^2 and it has 16384 pixels with 350um pitch. The setup is able to detect sources emitting photons from 15KeV up to 200KeV with 1KeV resolution. The 3-D position of point-like radioactive sources is estimated via triangulation using the directional coordinates determined by the decoding of the images acquired by the gamma cameras. Additionally, the resulting location of the radioactive source is fused in the video image. We have developed code for both fast and detailed simulations and we have verified the agreement between experimental results and simulations. In addition we will present a simulation study for the spatial localization of clusters of point sources with low energy (^{99m}Tc, 140 keV) and varying activities using coded aperture masks with rank higher than 7.

Acknowledgement

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12:50 - 13:00 Calcium/Phosphorus mass ratio for breast microcalcification characterization

N. D. Martini[1], V. N. Koukou[1], C. M. Michail[2], I. S. Kandarakis[2], G. C. Nikiforidis[1] and G. G. Fountos[2]

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Keywords: dual energy, Ca/P, breast calcifications

Mammographic microcalcifications represent one of the most reliable features of breast cancer. Three different types of mammary microcalcifications have been identified; calcium oxalate, calcium carbonate and hydroxyapatite. Calcium oxalate is mostly associated with benign lesions of the breast, while calcium carbonate is associated with both benign and malignant lesions and hydroxyapatite is associated with malignant tumors. A quantitative parameter that characterizes the calcification, such as the Calcium/Phosphorus (Ca/P) mass ratio, is of great interest. In this simulation study, a dual energy method for the determination of Ca/P mass ratio in calcifications was developed in order to distinguish between malignant and non-malignant lesions. The Ca/P mass ratio was calculated for every energy combination between 18-60keV. For the implementation of the method, with polyenergetic X-rays, various tube voltages, filter materials and thicknesses were examined. Initial simulation results indicate that this method can be used in microcalcification characterization however further investigation is required.

Acknowledgement

This work was supported by Grant E.040 from the Research Committee of the University of Patras (Programme K. Karatheodori).

13:00 - 13:10 Experimental and theoretical study of the photoreceptor effect in indirect conversion digital detectors

N. I. Kalyvas, I. Valais, C. M. Michail, G. P. Fountos, P. Liaparinos, S. David, I. Kandarakis

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Keywords: Indirect Detectors, Photon Transfer Curve, photoreceptors, clinical conditions

The measurement of digital detector performance is usually performed through calculating quality metrics such as the modulation transfer function (MTF) the noise power spectrum (NPS) and the detective quantum efficiency (DQE). Other important parameters that should be considered are the photon transfer curve (PTC) which categorizes the noise variance and the response of the detectors electronics which is useful in real time and high rate clinical applications. The scope of this work was to examine the noise properties of three different prototype indirect detectors, under clinical conditions. The detectors studied were: a Gd_2O_2S:Tb/CMOS for mammography and radiography applications, a 33.3mg/cm^2 Gd_2O_2S:Eu/CMOS for mammography applications and a 65.1mg/cm^2 Gd_2O_2S:Eu/CMOS for radiography applications. In addition the inherent MTF of the CMOS photoreceptor was evaluated by the PSF method. An electronic circuit was designed to study photoreceptor response. Finally the coefficient of variation (CV) of the signal in terms of electrons was theoretically estimated and compared to the experimental pixel values. It was found that under clinical exposure conditions (7.3 μGy to 335 μGy to detector surface) the PTC curves did not reach the saturation region. The dynamic range of the detectors, were below 72dB suggested by the CMOS manufacturer, for clinical X-ray conditions. The theoretical values of (CV) where lower than the experimental ones. The measured difference can be attributed (i) to the CMOS electronic and image manipulation procedures and (ii) to the combined effect of screen structure mottle and fixed pattern noise. Finally the calculated MTF curves showed that optical photon wavelength affects the inherent MTF of the semiconductor.

Acknowledgement

This research has been co-funded by the European Union (European Social Fund) and Greek national resources (1476) under the framework of the "ARISTEIA" project MISCIRLU code 1476 of the "Education & Lifelong Learning" Operational Programme.

15:00 - 16:15 **Session 3. Round Table: Pediatric CT dosimetry**
Session Chairpersons: *Assoc. Prof. E. Efstathopoulos,* Medical Radiation Physics, 2nd Dept. of Radiology, Medical School, UOA and *Dr. F. Makri,* Paediatric General Hospital ''Ag. Sofia''

15:00 - 15:15 Overview of CT dosimetry methods

S. D. Kordolaimi

2nd Department of Radiology, Medical School, University of Athens,
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Keywords: CT dosimetry, Effective dose, Radiation risk

In this presentation, the various models and methodologies currently existing for the estimation of the patient dose and, by extension, the carcinogenesis probability as well as the way that this is derived are presented.

In particular, the standard method for the calculation of effective dose either through the dose-length product or through available software programs which are based on Monte Carlo measurements conducted in mathematical phantoms as well as patient-specific methods for patient dose calculation are discussed. The estimation of cancer risk induced by low-dose radiation exposure will be also discussed as well as the suitability of the effective dose to predict the cancer risk and what the alternatives are.

15:15 - 15:30 Establishment of National Diagnostic Reference Levels (DRLS) for Pediatric Computed Tomography (CT) examinations

S. Economides

Greek Atomic Energy Commission

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Keywords: DRLs, Pediatric Dosimetry, CT

DRLs play an important role to the optimization of medical exposures. The Greek Atomic Energy Commission (EEAE) has already established DRL values for diagnostic radiology, nuclear medicine and interventional cardiology procedures performed to adults. Moreover, EEAE has recently initiated the collection of dosimetric data in order to establish DRLs for pediatric diagnostic and interventional procedures.

This study presents the procedure followed as well as the associated results, for the establishment of DRLs for pediatric CT examinations: brain, chest and abdomen. Fourteen (14) public and private hospitals and clinics countrywide, specialized or involved in pediatric radiology, participated in this study. The collection of dosimetric data was facilitated through special registration forms and questionnaires which were distributed to the respective diagnostic radiology departments. The CTDI and DLP values were collected by the departments' medical physicists either directly from the post study data page (dose report) or by performing measurements for the applied examination protocols. Pediatric patients were grouped according to their weight (i.e. <10kg, 10-20kg, 20-35kg and >35kg) and age (i.e. <1m, 1m-1y, 1–5y, 5–10y and 10–15y). The implementation of appropriate corrections and reduction factors was also investigated.

15:30 - 15:45 Individualized CT dosimetry in pediatric patients

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Keywords: Pediatric Dosimetry, CT, TLDs, MC simulation

Individualized dosimetry is of great importance especially in pediatric patients given their greater post-exposure life expectancy and their increased radiosensitivity compared with adults.

The aim of this work is to establish a methodology for estimating patient-specific dosimetry and cancer risk from computed tomography (CT) examinations in pediatric population.

Our Department in collaboration with 'Agia Sofia' Children's Hospital has launced an individualized dosimetry study in pediatric patients who underwent brain and abdomen-pelvis CT exams on a 16-slice CT scanner according to the Hospital's protocol. The dosimetry was based on ''in vivo'' measurements using thermoluminescent dosimeters (TLDs) placed on the patient's body surface. Special attention was given on the accurate calibration of TLDs. Skin doses were converted to organ doses using anthropomorphic phantoms and geometric relationships. The results were verified using Monte Carlo (MC) simulation techniques from each pediatric patient's CT images.

Open issues regarding the sample of pediatric patients' required and the pediatric protocols to be used for an accurate dosimetry are also discussed.

The study is in progress and only preliminary results will be presented.

Acknowledgement

«The project was funded by the John S. Latsis Public Benefit Foundation. The sole responsibility for its content lies with its authors».

15:45 - 16:00 Personalized CT dosimetry Monte Carlo simulations using pediatric computational phantoms

P. Papadimitroulas

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Keywords: Monte Carlo, pediatric, dosimetry, personalized

The last 40 years Monte Carlo (MC) simulations serve as a "gold standard" tool for a wide range of applications in the field of medical physics. As the computing technology is developing, MC simulations tend to be essential in daily clinical practice. Regarding imaging diagnostic applications, such as computed tomography (CT), the assessment of deposited energy are of high interest, so as to better analyze the risks and the benefits of the procedure. The latest years a big effort is done in personalized dosimetry, especially in pediatric applications. In the present study GATE toolkit was used and computational pediatric models have been modelled for the assessment of dosimetry during CT examinations. The pediatric models that were used come from the XCAT and IT'IS series and are in the range of 5-15 years old. The X-ray spectrum of a Brightspeed CT scanner was simulated and validated with experimental data. Specifically, a DCT-10 ionization chamber was irradiated twice using 120kVp with 100mAs and 200mAs, for 1 sec in 1 central axial slice (thickness=10mm). The absorbed dose was measured in air resulting in differences lower than 4% between the experimental and simulated data. The simulations were acquired using ~10^{10} number of primaries in order to achieve low statistical uncertainties. Dose maps were also saved for quantification of the absorbed doe (in Gy) in several critical organs of children during CT acquisition.

16:00 - 16:15 Automated DICOM metadata and volumetric anatomical information extraction for dosimetry

D. Papamichail

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Keywords: DICOM metadata, volumetric maps, GUI

Patient-specific calculations based on simulation techniques have as a prerequisite the modeling of the modality system and the creation of voxelized phantoms. This procedure require the knowledge of scanning parameters and patients' information included in a DICOM file as well the image segmentation. However, the extraction of this information is complicated and time-consuming.

The objective of this study was to develop a simple graphical user interface (GUI) to (i) automatically extract metadata from every slice image of a DICOM file in a single query and (ii) interactively specify the regions of interest (ROI) without explicit access to the radiology information system.

The user-friendly application developed in Matlab environment. The user can choose a series of DICOM files and manage their text and graphical data. The metadata is automatically formatted and presented to the user as a Microsoft Excel file. The volumetric maps are formed by interactively specifying the ROIs and by assigning a specific value in every ROI. The result is stored in DICOM format, for data and trend analysis. The developed GUI is easy, fast and and constitutes a very useful tool for individualized dosimetry One of the future goals is to incorporate a remote access to a PACS server functionality.

Acknowledgement

«The project was funded by the John S. Latsis Public Benefit Foundation. The sole responsibility for its content lies with its authors».

16:30 - 18:00 **Session 4. Round Table: Special Techniques in Radiotherapy**
Duration 90 min
Session Chairpersons: *Dr. P. Platoni, Medical Physicist,Attikon Hospital, UOA and Dr. C. Antypas, Medical Physicist, Aretaieion Hospital, UOA*

16:30 - 16:50 Total Skin Electron Beam Irradiation in Greece

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Keywords: Total Skin Electron Beam Therapy (TSEB), Cutaneous T-cell lympoma, Radiation Therapy

Total Skin Electron Beam (TSEB) irradiation is considered as the treatment of choice for cutaneous T-cell lymphoma (CGTL). This technique was first established in our Department in 2011 and since now it has not been applied in another Radiotherapy Department in Greece.

So far, eleven patients have received therapy, using the "Six-dual-field" technique in a linear accelerator. The creation of wide and uniform electron fields (≈200 cm × 80 cm) at SSD=380 cm ,is achieved by using two symmetrical 6 MeV electron beams combined with 17.5° tilts concerning the horizontal direction. For the set-up of treatment specially designed equipment provides the modulation of the beam and immobilization of the patient during treatment. The patient takes ,in total six treatment positions. Finally dose uniform delivery monitors by thermo-luminescense dosimetry (TLDs).

Patient dosimetry showed a very good agreement with the expected mean dose of 2Gy as mean patient dose. Furthermore, minimum and maximum values were at the level of 1.5 Gy and 3.5 Gy. Spatial variations of the dose distribution can provide essential insights on the patient irradiation conditions and can assist vitally in the dosimetric optimization of the applied clinical protocol.

As conclusion, TSEB has been implement with safely and successfully in our department's clinical therapeutic protocol.

16:50 - 17:05 Image Guided Brachytherapy: The paradigm of Gynecologic and Partial Breast HDR Brachytherapy

S. Diamantopoulos, I. Kantemiris, A. Konidari, P. Zaverdinos
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Keywords: HDR Brachytherapy, GYN, APBI

High dose rate (HDR) brachytherapy uses high strength radioactive sources and temporary interstitial implants to conform the dose to target and minimize the treatment time. The advances of imaging technology enable accurate reconstruction of the implant and exact delineation of high-risk CTV and the surrounding critical structures. Furthermore, with sophisticated treatment planning systems, applicator devices and stepping source afterloaders, brachytherapy evolved to a more precise, safe and individualized treatment. At the Radiation Oncology Department of Metropolitan Hospital Athens, MRI guided HDR gynecologic (GYN) brachytherapy and accelerated partial breast irradiation (APBI) with brachytherapy are performed routinely. Contouring and treatment planning are based on the recommendations of the GEC – ESTRO Working group. The task of this presentation is to reveal the advantages of 3D image guided brachytherapy over 2D brachytherapy. Thus, two patients treated at our department (one GYN and one APBI) will be presented. The advantage of having adequate dose coverage of the high risk CTV and simultaneous low doses to the OARs when using 3D image-based brachytherapy will be presented. The treatment techniques, equipment issues, as well as implantation, imaging and treatment planning procedures will be described. Quality assurance checks will be treated separately.

17:05 - 17:20 Proton beams in Radiotherapy

S. Zefkili

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There is a worldwide interest in the medical use of proton beams with energies ranging between 65 and 250 MeV as a conformal tool in radiotherapy. Whereas the first facilities were based on research centers in nuclear physics, the current tendency is towards a progressive integration within the hospital, with modern equipment developed specifically to this application.The physical and technological basis of protontherapy is presented as well as a synthesis of the procedures and tools available nowadays.For its inherent ballistic qualities, proton beams can increase the dose to the target volume, whilst lowering the integral dose delivered to the patient and protecting critical organs. For a certain number of clinical indications, proton-beam radiotherapy constitutes already the best choice proven by clinical trials. For other indications, the potential benefit of protons still requires clinical validation, but they are seen as the future technique to be adopted in radiotherapy. A synergy and technology transfer between conformal techniques is making possible to increase the quality and the precision of treatments and consolidate the place of proton therapy within the therapeutic arsenal of radiation treatment against the cancer.

Friday 19 June 2015

9:00 – 10:30 **Session 1. Biomedical Data Processing**
Session Chairpersons: *Prof. D. Cavouras and Prof. E. Ventouras,* T.E.I. of Athens

9:00-9:20 Invited speech: Towards a model for automatic voice pleasantness classification

L. Coehlo,
Politecnico do Porto, Portugal

In the last few years we have assisted to a increasingly growing number of systems and devices that use voice based interaction. For a continued use of these systems and for a good market acceptance, the interface must be reliable and pleasant, to provide an optimal user experience. However many users present complaints about the voice: it is too slow, it is too harsh, etc. There are currently very few studies that try to evaluate how pleasant is a voice from a perceptual point of view when the final application is a speech based interface. In this talk I will present an objective definition for voice pleasantness based on the composition of a representative feature subset based on a physiological model derived from psychometric evaluations. Additionally an automatic voice pleasantness classification and intensity estimation system will be shown.

09:20 – 9:30 Software platform for managing the classification of error-related potentials of observers

P. Asvestas[1], E.-C. Ventouras[1], S. Kostopoulos[1], K. Sidiropoulos[1], V. Korfiatis[2], A. Korda[2], A. Uzunoglu[2], I. Karanasiou[2,3], I. Kalatzis[1] and G. Matsopoulos[2]

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Keywords: Evoked Potentials (EPs); Error-Related Negativity (ERN); Classification; Artificial Neural Networks (ANN); Support-Vector Machines (SVM)

Human learning is partly based on observation. Electroencephalographic recordings of subjects who perform acts (actors) or observe actors (observers), contain a negative waveform in the Evoked Potentials (EPs) of the actors that commit errors and of observers who observe the error-committing actors. This waveform is called the Error-Related Negativity (ERN). Its detection has applications in the context of Brain-Computer Interfaces. The present work describes a software system developed for managing EPs of observers, with the aim of classifying them into EPs corresponding to observations of either correct or incorrect actions. It consists of an integrated platform for the storage, management, processing and classification of EPs recorded during error-observation experiments. The system was developed using C# and the following development tools and frameworks: MySQL, .NET Framework, Entity Framework and Emgu CV, for interfacing with the machine learning library of OpenCV. Up to six features can be computed per EP recording per electrode. The user can select among various feature selection algorithms and then proceed to train one of three types of classifiers: Artificial Neural Networks, Support Vector Machines, k-nearest neighbor. Next the classifier can be used for classifying any EP curve that has been inputted to the database.

Acknowledgement

This research has been co-funded by the European Union (European Social Fund) and Greek national resources under the framework of the "Archimedes III: Funding of Research Groups in TEI of Athens" project of the "Education & Lifelong Learning" Operational Programme.

9:30 - 9:40 Automatic Segmentation of Focal Liver Lesions in MR Images by means of Marcov-Random Fields with edge-driven Fuzzy C-means initialization

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Keywords: Focal Liver Lesions, Magnetic Resonance Imaging, Segmentation, Fuzzy C-Means, Markov Random Field

Purpose: To achieve robust and efficient Focal Liver Lesions (FLLs) segmentation on routine non-enhanced, T2-weighted Magnetic Resonance (MR) images.
Methods and Materials: A Clinical dataset of 82 MR liver Images was included in the study for FLLs border extraction algorithm. First, an initialization step is performed that employs edge information derived from Dyadic Wavelet Transform (DWT) as input to Fuzzy C-means (FCM) unsupervised clustering algorithm. An Edge Indicator Function (EIF) is computed from the wavelet image in order to locate the positions of edges that correspond to local maxima in the wavelet domain. The mean intensity value is then calculated of the area between consecutive edges of each column of the MR images and fed as input to the FCM algorithm to acquire the initialization image. The resulted image is applied as initial image to the Markov-Random-Field Model towards final lesion segmentation.
Results: The FLLs contours were extracted with very high accuracy. Compared with manual segmentation by an expert radiologist the automatic segmentation had an average Jaccard similarity coefficient of 0.90 +/- 0.23 for all MR images included in the study.
Conclusion: An automatic segmentation technique integrating textural and edge information for FLLs border extraction in MR liver images was designed and presented. The proposed segmentation scheme may be employed as a pre-processing step towards FLLs classification in a Computer Aided Diagnosis system.

9:40 - 9:50 Optimal Elasticity Cut-off value for discriminating Healthy to Pathological Fibrotic patients employing Fuzzy C-Means automatic segmentation in Liver Shear Wave Elastography images.

I. Gatos,[1] S. Tsantis,[1, 2] A. Skouroliakou,[3] I. Theotokas,[4] P. S. Zoumpoulis,[4] G. C. Kagadis[1]

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Keywords: Chronic Liver Disease, Fibrosis, Ultrasound, Shear Wave Elastography, Fuzzy C-Means

Purpose: To determine an optimal elasticity cut-off value for discriminating Healthy from Pathological fibrotic patients by means of Fuzzy C-Means automatic segmentation and maximum participation cluster mean value employment in Shear Wave Elastography (SWE) images.

Methods and Materials: The clinical dataset comprise 32 subjects (16 Healthy and 16 histological or Fibroscan verified Chronic Liver Disease). An experienced Radiologist performed SWE measurement placing a region of interest (ROI) on each subject's right liver lobe providing a SWE image for each patient. Subsequently Fuzzy C-Means clustering was performed on every SWE image utilizing 5 clusters. Mean Stiffness value and pixels number of each cluster were calculated. The mean stiffness value feature of the cluster with maximum pixels number was then fed as input for ROC analysis.

Results: The selected Mean Stiffness value feature an Area under the curve of 0.8633 (Figure 1) with Optimum Cut-off value of 7.5 kPa with sensitivity and specificity values of 0.8438 and 0.875 and balanced accuracy of 0.8594. Examiner's classification measurements exhibited sensitivity value of 0.8125 with 7.1 kPa cutoff value.

Conclusion: A new promising automatic algorithm was implemented with more objective criteria of defining optimum elasticity cut-off values for discriminating fibrosis stages for SWE. More subjects are needed in order to define if this algorithm is an objective tool to outperform manual ROI selection.

Acknowledgments

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9:50 - 10:00 Tract-based spatial statistics analysis and fMRI in patients with small cell lung cancer before prophylactic cranial irradiation treatment.

S. Benezi [1,2], K. Bromis[1], E. Karavasilis[3], I. S. Karanasiou[1], M. Koutsoupidou[1], G. Matsopoulos[1], E.-C. Ventouras[4], N. Uzunoglu[1], V. Kouloulias[5], M. Papathanasiou[5], A. Foteineas[5], E. Efstathopoulos E[5], N. Kelekis[5], D. Kelekis[3].

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Keywords: Diffusion Tensor Imaging; DTI, Tract-Based Spatial Statistics; TBSS, functional Magnetic Resonance Imaging; fMRI, Small Cell Lung Cancer; SCLC, Prophylactic Cranial Irradiation; PCI, Fractional Anisotropy; FA, Mean Diffusivity; MD.

Prophylactic cranial irradiation (PCI) is known to improve survival to a significant degree in Small Cell Lung Cancer (SCLC) patients. The main goal of PCI is to eliminate any possible microscopic parts of metastatic tumor in the brain before they become clinically manifest. PCI has become a standard of care for selected patients with limited and extensive SCLC showing positive outcome with systemic treatment. Diffusion tensor imaging (DTI) and functional MRI (fMRI) are non-invasive MRI techniques. DTI is very sensitive to white matter structure and measures the diffusion of water molecules in the brain, which varies depending on the direction, density and myelination of white matter fibers. fMRI measures brain activity by measuring changes in the local oxygenation of blood. The scope of our current research is to investigate potential differentiations in DTI as well as fMRI images in 17 SCLC patients before PCI compared to the healthy group (13 volunteers). Thus, in this study, we employ TBSS to test the voxel-wise differences in fractional anisotropy (FA), mean diffusivity (MD) and the principal diffusivities between healthy volunteers and patients with SCLC before PCI. Additionally, we aim to explore for potential differentiations in brain regions that are functionally linked, using resting state and task-related fMRI.

Acknowledgement

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF)-Research Funding Program: THALIS – NTUA, "Study and Analysis of Medical Data using structural and functional Magnetic Resonance Imaging procedures (MRI/DTI/fMRI): Assessment of changes induced by Brain Radiotherapy" (MIS 380151).

10:00 - 10:10 Artificial intelligence methods applied to parameter optimization in detection of atrial fibrillation

D. Arotaritei, C. Rotariu.

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Keywords: R-R intervals, Atrial Fibrillation, Differential Evolution, Fuzzy rules, Massive Datasets.

The heart beat intervals (RR time series) contain useful information for arrhythmia detection. The most common linear methods used in HRV are (based on RR interval): NN50, pNN50, RMSSD, SDNN, SDSD, SDANN, LTI and STV. Other combination of methods as TPR (Turning Point Ratio) and (SE) Shannon Entropy along with RMSSD (Root Mean Square of the Successive Differences) have been proposed as descriptors in recent papers.

Artificial intelligence offers a variety of methods, tools and algorithms than can overcome some of the drawbacks of the classic methods. Among these methods, neural networks (NN) and evolutionary algorithms (especially genetic algorithms – GA) are the most popular. Some of the methods take the advantage of intelligent reasoning as in fuzzy systems and some combinations NN-fuzzy system proved to successful solution for classification problems.

In this paper we present a novel method to develop an atrial fibrillation (AF) based on statistical descriptors and hybrid neuro-fuzzy and crisp system. The inference of system produce rules of type if-then-else that care extracted to construct a binary decision system: normal of atrial fibrillation. We use TPR, SE and RMSSD along with a new descriptor, Teager-Kaiser energy, in order to improve the accuracy of detection. The descriptors are calculated over a sliding window that produce very large number of vectors (massive dataset) used by classifier. The length of window is a crisp descriptor meanwhile the rest of descriptors are interval-valued type. The parameters of hybrid system are adapted using differential evolutionary algorithm with fitness multiobjective target: highest values for sensibility and sensitivity. The rules are extracted and they are part of the decision system.

The proposed method was tested using the Physionet MIT-BIH Atrial Fibrillation Database. The ECG signals from database are processed for automatic beats detection and ectopic beats removal. The experimental results revealed a good accuracy of AF detection in terms of sensitivity and specificity (above 90%).

Acknowledgement

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10:10 - 10:20 G-Autonomy of EEG recordings of psychotic patients in undergoing the primitive expression form of dance therapy

E.-C. Ventouras[1], I. Lardi[1], S. Dimitriou[1], A. Margariti[2,3], P. Chondraki[2], N.-T. Economou[2], H.Tsekou[2], T. Paparrigopoulos[2], P. Ktonas[2].

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Keywords: Primitive expression; dance therapy; electroencephalography (EEG); brain connectivity; G-autonomy

Primitive expression (PE) is a form of dance therapy (DT) that involves an interaction of ethologically and socially based forms which are supplied for re-enactment. Brain connectivity has been measured in electroencephalographic (EEG) data of patients with schizophrenia undergoing PE DT, using the correlation coefficient and mutual information. Those parameters do not measure the existence or absence of directionality in the connectivity. The present study investigates the use of the G-autonomy measure of EEG electrode voltages of the same group of schizophrenic patients. G-autonomy is a measure of the "autonomy" of a system, indicating the degree by which prediction of the system's future evolution - in the present case of the voltage values in the time series recorded at an electrode - is enhanced by taking into account its own past states, in comparison to predictions based on past states of a set of external variables - in the present case the voltage values of other electrodes. Indication is provided for an acute effect of early-stage PE DT expressed by the augmentation of G-autonomy in the delta rhythm and an acute effect of late-stage PE DT expressed by the reduction of G-autonomy in the theta and alpha rhythms.

Acknowledgement

We would like to thank the 1st Psychiatric Clinic of the University of Athens Medical School, Eginition Hospital, for providing the patients and overall encouragement for this study. In particular, we appreciate the contribution of Dr. E. Daskalopoulos and of Profs. E.Aggelopoulos, D.Dikeos, A.Pehlivanidis, N.Stefanis, and G.Vaslamatzis. The support of Profs. G.Papadimitriou and C.Soldatos is especially appreciated.

10:20-10:30 Incorporation of a two metres PET scanner in STIR library.

C. Tsoumpas[1], C. Brain[2], T. Dyke[2], D. Gold[1], Cherry-Qi-Badawi Labs[3]

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The Explorer project aims to investigate the potential benefits of a total-body 2 metre long PET scanner. The following investigation incorporates this scanner in STIR library and demonstrates the capabilities and weaknesses of existing reconstruction (FBP and OSEM) and single scatter simulation algorithms. It was found that sensible images are reconstructed but at the expense of high memory and processing time demands. FBP requires 4 hours on a core; OSEM (15 subsets) 2 hours per iteration if ran in parallel on 15 cores high performance computer. The single scatter simulation algorithm shows that on a short scale, up to a fifth of the scanner length, the assumption that the scatter between direct rings is similar to the scatter between the oblique rings is approximately valid. However, for more extreme cases this assumption is not longer valid, which illustrates that consideration of the oblique rings within the single scatter simulation will be necessary, if this scatter correction is the method of choice.

11:00 – 12:15 **Session 2**. **Round table: <u>The intervention of Health and Welfare Inspector in the Biomedical Instrumentation field</u>**
Session Chairpersons: *Dr. S. Evangelatos, General Health Inspector, Ministry of Health and F. Dinaki, Special Inspector, General Inspector of Public Administration*

11:00 - 11:15 The Opportunities and Risks of the Inspection in the Field of Biomedical Instrumentation

F. Dinaki,

Special Inspector of the Office of General Inspector of Public Administration

Key words: Bioinstrumentation, risk analysis, risk assessment, control risk, cost-effectiveness, efficiency, welfare State.

Bioinstrumentation is the application of electronics and measurement principles and techniques to develop devices used in diagnosis and treatment of disease. Computers are becoming increasingly important from the microprocessor used to do a variety of small tasks in a single purpose instrument to the extensive computing power needed to process the large amount of information in a medical imaging system.

The rapid evolution, the increasing complexity of the bioinstrumentation and the relevant incorporation into the Health Care System raise some issues concerning the safety and validity from the scientific point of view of the inspections and reviews that are conducted by the authorized auditing mechanisms of the state in the biomedical instrumentation field.

The effectiveness on the one hand of diagnosis and treatment of disease through the incorporation of bioinstrumentation, the range of specific knowledge that is needed, and on the other hand the criteria of selecting certain devices from a variety of offered products, the increasing cost that the state is responsible to pay in order to offer better health services to the citizens, the social need for the reinforcement of the welfare State, are some of the issues that define the opportunities and risks of the inspections in the field of biomedical instrumentation.

The variety of risks that may face inspections mechanisms in such a specialized field may prevent their successful completion. Catalytic role here plays the ability of the authorized auditing mechanisms of the state to recognize and ultimately reduce the risks posed with the recruitment of qualified staff and adoption of control standards internationally recognized.

11:15 - 11:30 Quantitative Data of SEYYP Inspection in Biomedical Instrumentation Field

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Keywords: quantitative data of SEYYP

This study presents quantitative data derived from inspections and findings of SEYYP in the field of Biomedical Engineering. SEYYP operates under the law 2920/2001. SEYYP supervises the implementation of laws related to health both in public and private sector of health services. Thus, the 2013 SEYYP issued orders were ex officio or after:

a) Orders of the Health Minister
b) Orders of the General Inspector of Public Administration
c) Written complaints from citizens and
d) Requests from other public authorities.

Corresponding findings issued concerned regular audits, special audits, sworn administrative investigation, preliminary investigations and re-inspections. A significant percentage of the inspections findings were related to Biomedical Engineering issues.

SEYYP inspection reports included referrals to the prosecutor for criminal responsibilities, further conduction of sworn administrative investigations, disciplinary control of public servants, proposals for improvement and involvement of other public authorities.

11:30 - 11:45 Intervention of Health and Welfare Inspector concerning the use of neurostimulator in central nervous system in Greece

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Keywords: PET/CT

The Purpose of this study is to present the interventions of SEYYP regarding the Deep Brain Stimulation (DBS) application in specific clinical cases.
During 2014 we have investigated the correct use DBS method in two Neurosurgical Clinics in public and private hospitals as well as the following legal procedures from the Clinics and the national services.
The following results has been discovered:

(a) The neurostimolators have been acquired from determinate companies
(b) The guide lines have not followed for all the patients
(c) The medical files were not updated following the indications of international guide lines
(d) The involved service (Central Health Council) that had the authority to approve or not relative requests, took positive decisions in 99% of the cases, without to collect or cross check the evidence that it was provided.

SEYYP has offered suggestions for both the way of information collection that set up the indication of DBS application by equivalent medical specialists and the way of their inspection contributing to the right function of N/S Clinics and public resources economizing.

11:45 - 12:00 Cytostatics Preparation Units in Greek Healthcare System

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Keywords: Laminar Air Flow, Cytotoxic Preparation Unit

Cytotoxic drugs handling in a healthcare unit, deals with potential carcinogenic, mutagenic and reprotoxic (CMR) materials. International practice gives priority to the centralized preparation of CMR drugs over distributed preparation, which induces quality of pharmacotherapy but is also conducting to substantial savings. Well trained personnel must be occupied in every step (preparation, distribution, hazard evaluation) and space (three separated rooms) or equipment (workbench Laminar Air Flow type IIB or III, with HEPA filters, exhaust air system etc) are described. National guidelines describe in many countries the procedures that must be followed. In Greece there is not a legal framework or specific guidelines about the formation and operation of a Cytostatic Preparation Unit. Until recently few hospitals in Greece disposed a Cytostatic Preparation Unit. Even these perform its own procedures, usually far from the international guidelines. SEYYP, through the inspections it perform with different aspects (covering risk assessment, personnel, training, hazard evaluation etc) in all stages of cytostatic handling, may conduct to recommendations for a rational implementation of guidelines on the prevention of occupational risks and to the creation of a central unit for preparing cytostatics. It also could help healthcare units to consolidate specific mandatory procedures to manage and control the different aspects of job organization.

12:00 - 12:15 The Intervention of Health and Welfare Inspector for Purchasing PET/CT Scanners at Public Hospitals in Greece

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Keywords: PET/CT

The purpose of this study is to present the intervention of SEYYP, in PET/CT scanners purchasing process, in public hospitals in Greece.
The SEYYP after complaints checked the procedures followed by the Hospital, as well as from other relevant bodies, in PET/CT scanners purchasing process. The most important results from this investigation were the following. The scientific opinion for the necessity of a PET/CT scanner was not requested from Biomedical Engineering Department. The purchasing process was implemented with criterion the lowest price per diagnostic act in accordance with Article 7 of Law. 2955/2001. Radiopharmaceuticals characterized as medical supplies in violation of current regulations. The proposals of SEYYP among others include: The establishment of uniform technical requirements for the PET / CT scanners as well as for all high technology Medical Instrumentation is necessary. A "health map", including the needs, for the all the country's hospitals for high technology Medical Instrumentation, must be prepared as soon as possible. The "health map" must take into consideration the type of hospitals, their capacity in beds etc. The cooperation of Biomedical Engineering is necessary in this process. Furthermore SEYYP suggested that when purchasing high technology Medical Instrumentation, a report from the Department of Biomedical Engineering which justifies the need for this is obligatory. Another suggestion was that the Biomedical Engineer must be participating in the committees that they are responsible for the purchase of this kind of Instrumentation.

12:20 - 13:30 **Session 3. Novel Applications in Treatment and Diagnosis**
Session Chairpersons: *Prof. A. Bakas* T.E.I. of Athens and *Assist. Prof. A. Skouroliakou,* T.E.I. of Athens

12:20 – 12:30 Practical aspects of patient – specific Dosimetry in peptide receptor Radionuclide Therapies: how to and why

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Keywords: Dosimetry, MIRD, NeuroEndocrine Tumors, Peptide Receptor Radionuclide Therapy

Peptide Receptor Radionuclide Therapy (PRRT) is a treatment option for inoperable or metastasized NeuroEndocrine Tumors (NETs). The therapeutic principle of PRRT is the internal irradiation of tumors, by the binding of radiolabeled somatostatin analog peptides with NETs somatostatin receptors. The significant role of patient-specific dosimetry arises from the need for personalized therapy planning. The therapeutic radiopharmaceuticals most commonly used are ^{90}Y-[DOTA^{0},Tyr^{3}]-octreotide (^{90}Y-DOTATOC) and ^{177}Lu-[DOTA^{0},Tyr^{3},Thr^{8}]-octreotide (^{177}Lu-DOTATATE). Patient-specific imaging is performed either with an imaging radiopharmaceutical of suitable characteristics, or with the exact same therapeutic one. Planar, SPECT or PET images are acquired after injection of the imaging radiopharmaceutical. In the scope of this study, the methodology of the Conjugate View (CV) imaging based dosimetry approach is presented. Image quantification and dosimetric analysis are based on the Medical Internal Radiation Dose (MIRD) Committee formalism. For an appropriate temporal sampling a minimum of three time points, near the effective half-life T_{eff}, ~3 T_{eff} and ~5 T_{eff}, should be chosen for the uptake and washout phases. After calibration of the imaging system, additional correction factors for attenuation, self-attenuation, scatter and background activity should be determined in order to convert the count rate to activity values. Organ and NETs actual volumes should be introduced in MIRD mathematical formula for patient-specific dosimetric estimations.

12:30 – 12:40 Assessment of the effect of spatial dose delivery inaccuracies on DVHs: Simulation studies in pituitary-tumour and brain-metastases cases

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Keywords: DVH, spatial delivery inaccuracy, pituitary tumour, brain metastases

This work aims at presenting a simplified methodology for quantitatively assessing the effects of spatial dose delivery inaccuracies on DVHs and surveying the maximum displacement acceptable. Planning-CT scans along with RStructure dicom-RT and TPS-calculated RDose dicom-RT files from two cases (pituitary-tumour and multiple (6) brain-metastases) were imported to an open source software (3D-slicer). Spatial dose delivery errors (1-3mm) were systematically introduced to RDose by manually displacing the RDose dataset volume along the x, y and z axes (left-right, anterior-posterior, and cranio-caudal directions respectively) while keeping spatially stationary the planning-CT scans and RStructure datasets. The DVHs, D_{mean}, D_{min}. D_{max}, $D_{95\%}$ and Dose Reference were calculated for the nominal dose delivery scenario (no displacement), as well as for various simulation scenarios representing different spatial dose delivery errors. Acquired results in the pituitary-tumor case suggest that a relatively small spatial dose delivery error of 1mm in each axis resulted in minor DVH alterations for all structures. Cranio-caudal spatial errors of 3mm induced considerable DVH differences in contrast to left-right 3mm displacements. The worst case scenario investigated, i.e., 3mm displacement in each axis, resulted in important DVH alterations for the PTV and the organs-at-risk. Similar results were obtained for PTVs in the brain-metastases case.

12:40 - 12:50 TGF-B Induced epitheleal – mesenchymal transition modeling

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Keywords: Epithelial-mesenchymal transition, TGF-β, GRN inference.

Epithelial cells undergo a process called epithelial to mesenchymal transition (EMT). This happens either during physiological conditions such as embryonic development or in pathological conditions such as cancer progression. During EMT, cells lose their epithelial characteristics and acquire a migratory ability. Transforming growth factor-beta (TGF-beta) signaling is considered to play an important role in EMT by regulating a set of genes through a gene regulatory network (GRN). This work aims at EMT GRN modeling using publicly available experimental data (gene expression microarrays data along with data from reverse transcription PCR (RT-PCR)). This process, often referred to as network inference, involves the identification of the network structure, which concerns the GRN topology (interactions between genes), and the establishment of model parameters, which concerns the type and strength of interactions.
The time-series network identification (TSNI) algorithm was implemented in Matlab for inferring the EMT GRN. TSNI is based on ordinary differential equations and it is time-series data oriented.
Receiver operating characteristic (ROC) and precision-recall (P-R) curves were constructed and the areas under them were used for evaluating the algorithm performance regarding network inference. The inferred GRN can then be combined to the TGF-beta signaling pathway for modeling the entire EMT process.

12:50 - 13:00 On the implementation of a novel patient-specific QA process for pre-treatment radiotherapy plan verification in brain tumor patients. An hypophysis VMAT treatment case study

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Keywords: radiotherapy, individualized, quality assurance

Pre-treatment plan verification and QA in modern radiotherapy is essential for reassuring both treatment effectiveness and patient safety. The current conventional methods used for this purpose are not patient-specific. In this work, a novel patient-specific methodology is presented and applied for a hypophysis VMAT treatment. By combining 3D-printing technology and polymer gel dosimetry, a selected patient head dosimetry phantom was constructed. The 3D dosimeter phantom duplicates the selected patient anatomical structures in terms of external surface and bone structures. The patient soft tissue is represented by a VIPAR polymer gel dosimeter. This 3D-avatar was treated as if it was the real patient: set-up, image guidance and irradiation were performed in exactly the same way as planned for the real patient. The irradiated patient-specific dosimetry phantom was subsequently MR-scanned for the derivation of T2-maps. Since there is a direct relationship between T2-values and absorbed dose, the T2-maps are a direct representation of the delivered 3D-dose pattern. These MR-scans were co-registered with the real patient CT scans. This co-registration revealed qualitatively the accuracy of radiation delivery in terms of spatial dose delivery accuracy relative to the real patient anatomical structures. Moreover, a quantitative analysis resulted to a direct comparison between the TPS calculated DVHs and this work measured corresponding DVHs. This novel clinical tool could result to safer radiotherapy treatments.

Acknowledgement

The present work was funded by 'RTsafe P.C.' (www.rt-safe.com)

13:00-13:10 Configuration, Validation, and Evaluation of the dose calculation algorithm Acuros® XB

S. Zefkili, I. Birba

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Radiotherapy is one way to fight cancer. Acuros® XB developed by Varian Medical Systems is a dose calculation algorithm based on the Boltzmann transport equations (LBTE). It was developed to meet both treatment planning needs for external photon beam radiotherapy: the accuracy and speed of dose calculation in presence of heterogeneities within the patient such as the lungs (air), bone, and non-biological implants, which can significantly affect the dose to the patient, in particular using small or irregular fields.

The optimization of the treatment of a single patient is achieved through a computerized system called TPS (Treatment Planning System) for predicting the dose distribution. It is essential to implement strict quality assurance procedures to verify the correct calculation of the dose by the TPS and to know its limits.

We will therefore study how the Acuros XB algorithm calculates the dose by using the Boltzmann transport equations. We will configure it by integrating and validating libraries of dosimetric databases for photon beams. We will assess the new dose calculation through various tests for conventional and conformal radiotherapy, so it can be used in clinical routine for RapidArc® treatments. We will use the methodology proposed by the report of the ESTRO (booklet No.7.) for quality control of Acuros XB algorithm in the TPS. We will present the results of each testing level by comparing them to the specified tolerances.

15:00 - 16:00 **Session 4. Medical Devices and Innovations**
Session Chairpersons: *Assoc. Prof. M. Kallergi, TEI of Athens and Dr. M. Metaxas, Ph.D., Radiation Protection Officer, B.R.F.A.A.*

15:00 – 15:10 The application of the Selective Laser Sintering technique (SLS) in the production of dental bioconstructions

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Introduction

Over the past two decades, Medicine and Dentistry have adopted industrial techniques to manufacture prosthetic bioconstructions, in purpose to improve their biological and mechanical properties. Specialties such as Orthopedics base the success of their applications on the performance of these techniques. This evolution has also influenced Dentistry for the production of dental bioconstructions. The most up to date new technique is the Selective laser Sintering (SLS).The purpose of this review is to give a detailed description of the SLS technique, the clinical applications and the advantages and disadvantages in Dentistry.[1]

The SLS technique

In this technique, after the digital design of the bioconstruction, an intensive laser ray is used to sinter the material, supplied in the form of powder, for the fabrication of a stable structure.

Clinical applications of SLS technique The SLS technique is applied in a variety of dental bioconstructions, such as the manufacture of metal-substrate in metal-ceramic works, the metal frameworks in partial dentures, and in dental bioconstructions (for example dental implants)[4]

Advantages and Disadvantages of SLS technique

Advantages

1. *Short production time*
2. *Easy use*
3. *Negligible porosity*
4. *Improved mechanical properties*
5. *Little materials consumption*
6. *Simple post sintering process*

Disadvantages:

1. *High cost of installation*
2. *High surface roughness*

Conclusions:

SLS technique is a newly promising technique which opens new horizons for the precise and low cost fabrication of dental bioconstructions.

15:10 - 15:20 A low cost sensor controller for health monitoring

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Keywords: Health monitoring, sensor control, medical sensors, low power, communication protocol

Aging population can benefit from health care systems that allow their health and daily life to be monitored remotely. Blood pressure, temperature, measurements or more advanced tests like Electrocardiograms (ECG), Electromyograms (EMG), glucose test, etc can be ordered through such a healthcare system while urgent situations can be detected and handled on time. The results of these tests can be stored with security in a remote cloud, accessed for example by the supervisor doctor. Such systems are often used to monitor non-life threatening patient health problems and their advantage in lowering the cost of the healthcare services is obvious. A low cost commercial medical sensor kit has been used in the present work, trying to improve its features like measurement accuracy and stability, power consumption, security, etc. This Sensor Controller communicates with a Gateway installed in the patient's residence and a tablet or smart phone used for giving instructions to the patient through a comprehensive user interface. A flexible communication protocol has been defined supporting any short or long term sensor sampling scenario. The experimental results show that it is possible to achieve low power consumption by applying appropriate sleep intervals to the Sensor Controller and by deactivating periodically some of its functionality. The information exchanged is protected by additional encryption and authentication services that have been employed.

Acknowledgement

This work has been developed by Analogies S.A. in the framework of the ELTAB project.

15:20 - 15:30 Repeatability of Corneal Astigmatism Measurement Evaluated with Color LED Reflection Topography

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Keywords: LED topography; Point-Source Topography; VU topographer; axis of astigmatism; Cassini Topographer; astigmatism; steep meridian; against-the-rule astigmatism; with-the-rule astigmatism; astigmatism repeatability.

Purpose: To evaluate the clinical efficacy of a novel corneal topography device and investigate distribution and repeatability of astigmatism measurements (axis and magnitude) in healthy and pre-cataract eyes.

Methods: Anterior corneal surface astigmatism was investigated in 195 eyes via a novel multicolored-spot reflection topographer (Cassini, i-Optics). Two groups were studied, healthy patients (control group-A) and pre-cataract patients (group-B). Three consecutive acquisitions on the same eye were obtained. Repeatability was assessed via Bland-Altman plot analysis.

Results:The control group-A (mean age 34.3 years) had on average 'with-the-rule' astigmatism, while the older-age pre-cataract group-B (mean age 72.3 years) had on average 'against-the-rule' astigmatism. Average astigmatism magnitude repeatability measurement was in group-A from 0.451 D, while in the pre-cataract group-B was 0.387 D, respectively.

Average astigmatism axis repeatability measurement in the group-A was 5.42°, and in group-B, 5.47. The axis repeatability was related to the magnitude of astigmatism. Within the 0.00-1.00 D astigmatism subgroup repeatability was 5.34°, to reach 2.56° within 3.00 to 6.00 D astigmatism subgroup.

Conclusions: We confirm previous studies reporting astigmatism shift from an average 'with-the-rule' to 'against-the-rule' with aging. This novel corneal topography device appears to offer high specificity in estimating corneal astigmatism.

15:30-15:40 Modeling and Simulation of the Knee Joint with Kinect for Prosthetics and Rehabilitation

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Keywords: Mechanical knee, prosthetics, Microsoft Kinect, knee modelling

The purpose of this project was the modeling and simulation of the knee joint. First, a computer model of the knee joint was created, which was controlled by Microsoft's Kinect for Windows. Kinect is using an infrared projector and a monochrome CMOS sensor to create a depth map independent of lighting conditions. It also includes an RGB video camera to record in real time and a set of microphones for voice recognition and verbal instructions. A combination of open source software such as Blender, Python, Kinect and NI_Mate were implemented for the creation and control of the computer model based on movements of a live model. Second, the knee joint was simulated with a mechanical construction. The construction was based on prior work that was improved in functionality by replacing stepping with servo motors and spur with worm gears, modifications that increased significantly flexibility and accuracy of the knee's movements. Third, the computer model and Kinect were connected to the mechanical simulation in order to control knee movement remotely. The real time communication of the model and the robotic knee was achieved through programming in Python and Arduino language. The successful outcome showed that Kinect offers a powerful tool in the modeling of human physiology and the development of prosthetics and other assistive technologies

15:40 - 15:50 Epithelial Three – Dimensional Thickness as a Sensitive Tool of Keratoconus Diagnosis.

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Keywords: Anterior segment optical coherence tomography; keratoconus; epithelial thickness imaging; Novel corneal epithelial thickness asymmetry indices; three-dimensional mapping; Pentacam; topographic keratoconus grading; index of surface variance; index of height decentration..

Purpose To investigate epithelial thickness distribution characteristics in a large group of keratoconic patients employing anterior-segment optical coherence tomography (AS-OCT).

Methods The study group-A (nA=160 eyes) consisted of clinically diagnosed keratoconus eyes; the control group-B (nB=160) consisted of non-keratoconic eyes. Three separate, 3-dimensional epithelial thickness maps were obtained employing anterior segment OCT and enabled investigation of pupil center, average, mid-peripheral, superior, and inferior, in addition to maximum, minimum, and topographic epithelial thickness variability. Intra-individual repeatability of measurements was assessed. We further introduce correlation of the epithelial data via newly defined indices. The epithelial thickness indices were then correlated to two Scheimpflug imaging–derived anterior surface irregularity indices, the index of height decentration (IHD) and the index of surface variance (ISV).

ResultsIntra-individual repeatability of epithelial thickness measurement in the keratoconic group-A was on average 1.67µm. For the control group-B, repeatability was on average 1.13µm. In the keratoconic group-A, pupil center epithelial thickness was 51.75±7.02 µm, while maximum and minimum were 63.54±8.85 µm and 40.73±8.51 µm. In the control group-B, epithelial thickness at the center was 52.54±3.23 µm, maximum 55.33±3.27 µm and minimum 48.50±3.98 µm. Topographic variability was 6.07±3.55 µm in the keratoconic group-A, while for the control group-B 1.59±0.79 µm. Both epithelial thickness variability and range, defined as minimum-maximum, correlated tightly with the indices of IHD and ISV.

Conclusions AS-OCT offers ease of use and high predictability of in-vivo epithelial thickness measurement in keratoconus. Increased overall epithelial thickness in keratoconic eyes, in comparison to normal, was documented, with potential particular clinical importance in relation to milder and/or suspect stages of keratoconus. Increased topographic thickness variability and range was found to be in tight correlation with keratoconus severity.

15:50 - 16:00 Enhanced Topography-Guided Excimer Laser Ablation for Progressive Keratoconus Management: Incorporation of Cyclorotation and Modified Laser Sequence.

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Keywords: Cross-linking; high-fluence cross linking; transepithelial cross linking; keratoconus; KXL; Athens Protocol; Cyclorotation.

Purpose: To comparatively investigate the efficacy of the enhanced Athens Protocol procedure, which incorporates cyclorotation compensation, in comparison to the previously applied Athens Protocol procedure, in which no cyclorotation compensation was incorporated.

Methods: Two groups were formed. In group-A ('cyclo' nA=110 eyes), cyclorotation compensation was applied, while in group-B ('non-cyclo' nB=110 eyes), no cyclorotation compensation was applied. Analysis was based on digital processing of Scheimpflug-imaging derived topographic curvature difference maps. Thus we objectively measured differences between targeted (surgical planning) and achieved ablation pattern. We computed the vector (r, θ) corresponding to the steepest (peak topographic) corneal point (cone) on the pre-operative surgical planning map (rp, θp) and the curvature difference map (rd, θd), and calculated the differences between the peak topographic angular data: Δθ=|θp - θd| and the weighted angular difference WΔθ=Δθ•Δr.

Results: For group-A (cyclo) average Δθ was 7.18±7.53 (0 to 34) ° and WΔθ was 3.43±4.76 (0.00 to 21.41) mm. For group-B (non-cyclo), average Δθ was 14.50±12.65 (0 to 49) ° and WΔθ was 10.23±15.15 (0.00 to 80.56) mm. The cyclo group-A had on average smaller angular difference as well as weighted angular difference by a statistically significant margin (Δθ p-value =0.0058 and WΔθ p-value =0.015).

Conclusions:The data in this study indicate that incorporation of cyclorotation compensation in customized topography-guided treatments leads to improved correlation between targeted and achieved changes.

16:30 - 17:30 **Session 5. Round Table: Quality and Safety in Hospital Environment**
Session Chairpersons: *Dr. M. Evangelatou, Dr. T. Giannouli and Dr. G. Pappous,* National Evaluation Center of Quality & Technology in Health S.A. and *Prof. N. Palikarakis,* University of Patras

17:30-17:40 Needs assessment in primary health care in Greece

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Keywords: Primary Health Care, health technology assessment, medical devices, GAP analysis, modular design

The integration of the former EOPYY Healthcare Units, the Health Centers and the Health Posts of the Greek National Healthcare System, to the new Primary Health Care Network – PEDY, has brought up the need to evaluate the installed medical equipment and to conduct a needs assessment analysis in order either to redistribute existing equipment or prioritize the purchase of new, taking into consideration the challenge of implementation of cutting edge technologies. Under this frame, in collaboration with the World Health Organization, international guidelines and good practices were researched and reviewed [1] [2]. As a result, a novel medical equipment per facility scheme was introduced, co-estimated along with
population and epidemiological data. Further work is focused on the development and introduction of a modular hub design, around Hospital Servives, related to different medical practices necessary in Primary Health Care and accustomed to healthcare professionals' mobility.[1] Primary Care in the driver's seat, Organizational reform in European primary care, European Observatory on Health Systems and Policies Series [2] Needs Assessment for Medical Devices, WHO Medical device technical series, WHO Library

17:40-17:50 Impact of Economic Crisis on the Greek National Health System: A Statistical analysis of the factors contributing to the quality of health care in Greece, in terms of medical personnel and medical equipment .

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Key Words: Greek National Health System (GNHS), Logistic Regression, Public Health care in Greece.

The Greek National Health System (GNSH) has been established in 1982.Its purpose was the free provision of medical and hospital treatment to the population of Greece through the establishment of Centers of Health in every part of the Greek State. We investigate through a sample survey among 1393 patients the degree of satisfaction of Greeks for their National System as well as the factors which contribute to the improvement or deterioration of the quality of health in Greece in the context of the present economic crisis. An exploratory factor Analysis was carried out and it has identified the following main factors of inefficiency of GNSH: (a) Shortage of medical doctors and fully equipped medical centers in the Greek islands and remote areas. (b) Corrupt dealings of medical doctors with patients in order to have promt medical assistance. (c) Corrupt dealings between Medical administrators and pharmaceutical companies.(d). High cost of medical services and medicines provided by GNSH. (e). Inefficiency and loose functioning of the System of National Medical Emergency Services (EKAV). (b) We perform One Way Analysis of Variance and from the multiple Comparisons Test we conclude that the insured in the National Organization for Provision of Health Services to Public Employees(ΕΟΠΥΥ) and Private Employees(ΙΚΑ) are very dissatisfied with the services of the National System of Health, whereas the insured in the Organization of Health Services for Agricultural Workers (OGA) are less dissatisfied from (ESY). (c) A Multinomial Logistic Regression reveals that the factors of dissatisfaction with GNHS : Shortage of medical Doctors, shortage of medical equipment, especially surgical one, corruption in the areas of medical services and Medicines ,high cost of Services and Inefficient functioning of (EKAV) are statistically significant at the 0,05 level of significance.

Reference

Simou E. and Koutsogeorgou E. (2014). Effects of the economic crisis on health and healthcare in Greece in the literature from 2009 to 2013: A systematic review.*Health Policy/ dx.doi.org/10.1016/ j.healthpol.2014.02.002, Elsevier Ireland Ltd.*

Saturday 20 June 2015

9:00 – 10:30 **Session 1**. **Medical Imaging II**
***Session Chairpersons*:** *M. Gambaccini and A Taibi,* Universita degli studi di Ferrara, Italy

9:00-9:20 **Invited speech: Digital mammography with synchrotron radiation: characterization of a novel computed radiography system**

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Breast X-ray imaging is a continuous research field to define dedicated equipment, with specialized X-ray sources and efficient detectors to improve image quality with an equal or even lower patient's dose. The Needle Imaging Plate HM5.0, produced by Agfa, has been characterized using Synchrotron Radiation to assess the performance of this novel imaging chain in comparison to conventional mammographic equipment. The detection performance has been initially assessed in terms of Detective Quantum Efficiency (DQE) and its computation showed that DQE curves are very close to the typical results for DR systems.

Image threshold contrast has been then evaluated using the CDMAM phantom and another phantom with PMMA inserts that allows one to observe the typical interference pattern of phase-contrast imaging. The analysis has been completed with a scoring of visible details in the radiographs of the TORMAM phantom and thus confirming that monochromaticity leads to an equal image quality with a lower glandular dose and phase-contrast effects lead to an increase in anatomical structure detectability.

Finally, a preliminary evaluation of clinical images showed a clear improvement in image quality thanks to phase-contrast contribution and to detector performance.

9:20-9:40 **Invited speech: Echo-Doppler system performance measurement with constant and pulsatile flow generators**

M. Gambaccini and F. Calderoni

Department of Physics and Earth Science - University of Ferrara, Italy

The response of an Echo-Doppler system in steady state and pulsatile flows is presented. An anthropomorphic phantom that mimics the neck, with two cavities inside which reproduce carotid and jugular vessels has been used. Steady state and pulsatile flows regime are obtained with a dedicated pumping system and dedicated Blood Mimiching Fluid for providing an Echo_Doppler signal has also been used. Flows measurements performed with tipical physiological value by two expert sonographer will be presented and discussed.

09:40 – 9:50 Simultaneous measurement of R2* and fat fraction of the liver by a multi-echo gradient-echo pulse sequence in a breath hold

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Keywords: Liver, quantitative MRI, R2*, fat fraction, multi-echo, gradient-echo

Quantitative MRI proves to be an inexhaustible field of information in medicine. One important application is the evaluation of iron liver hemosiderosis in patients with β-Thalassaemia, hemochromatosis, and other hematologic diseases. The most sensitive, reproducible and robust method is the measurement of the relaxation rate constant R_2 which has been correlated to liver iron concentration at 1.5 Tesla via liver biopsies. The determination of liver R_2* can be accomplished by the use of a breath-hold gradient-echo multi-echo (16 echoes) sequence and a least-squares-fit of the measured signal intensity to echo time. In the absence of fat (water only), a single exponential function suffices to fit the data. In the presence of fat (liver fat infiltration), a biexponential function modified by a sinusoidal function can fit the multi-echo data and provide separately R_2* for water and fat, the frequency difference between water and fat and the fat fraction. At the same time it corrects the R_2* value acquired by least-squares fitting to a single exponential function, i.e., yielding simultaneously more accurate information of iron concentration and fat infiltration. The proposed methodology has been applied to imaging data obtained from subjects with varying degree of liver hemosiderosis and/or fat infiltration.*

09:50 - 10:00 The Application of Computed Tomography in Wound Ballistics Research

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Keywords: wound ballistics, human body, density, CT, Hounsfield

In wound ballistics research there is a relationship between the data that characterize a bullet and the injury resulted after shooting when it perforates the human body. The bullet path in the human body following skin perforation as well as the damaging effect cannot always be predictable as they depend on various factors such as the bullet's characteristics (velocity, distance, type of firearm, etc.) and the tissue types that the bullet will pass through. The purpose of this presentation is to highlight the contribution of Computed Tomography (CT) in wound ballistics research. Using CT technology and studying virtual "slices" of specific areas on scanned human bodies, allows the evaluation of density and thickness of organs, such as the skin, the subcutaneous tissue, the muscles, the vital organs and the bones. Density data taken from Hounsfield units can be converted in g/ml by using the appropriate software. By evaluating the results of this study, the anatomy of the human body utilizing ballistic gel will be reproduced in order to simulate the path that a bullet follows. The biophysical analysis in wound ballistics provides another application of CT technology, which is commonly used for diagnostic and therapeutic purposes in various medical disciplines.

10:00-10:10 Contrast to Noise Ratio and Contrast Detail Analysis in Mammography: A Monte Carlo Study

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The mammographic spectrum is one of the major factors affecting image quality in mammography. In this study, a Monte Carlo (MC) simulation model was used to evaluate image quality characteristics of various mammographic spectra. The anode/filter combinations evaluated were those traditionally used in mammography (Mo, Rh and W anode combined with Al or k-edge filters) for tube voltages between 26 and 30 kVp. The imaging performance was investigated in terms of Contrast to Noise Ratio (CNR) and Contrast Detail (CD) analysis by involving human observers, utilizing a mathematical CD phantom properly designed to mimic the commercially available CDMAM phantom. The phantom, made of PMMA, comprised two identical spherical air inhomogeneities of logarithmically varied diameter (90 to 250 μm); one placed at the center and the second randomly positioned at one of the four corners of the phantom. All MC generated images were scored independently by two observers. The CNR was calculated by measuring the signal intensity under the central inhomogeneity and the corresponding standard deviation. Observers' performance was based on the mean CD score, related to the detection of the randomly positioned inhomogeneity. Tube voltage had a limited effect on both CNR and CD scores, especially for larger inhomogeneities. W-anode spectra filtered with k-edge filters demonstrated an improved performance, that sometimes was better compared to softer x-ray spectra, produced by Mo or Rh anode. Regarding the filter material, k-edge filters showed superior performance compared to Al filters.

10:10 - 10:20 A dual energy method for breast microcalcification imaging: experimental results

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Keywords: dual energy, breast imaging, CNR

In this work a dual energy method for microcalcification detection was developed. Two radiographic X-ray beams were used at *40/70kVp*, filtered with *100μm Cadmium and 1000μm Copper for the low/high-energy.* A *high resolution CMOS* sensor (RadEye HR) combined with *Min-R 2190 scintillator screen was used. Two different phantoms were irradiated: (i) a 4.2cm slab phantom consisting of 50% PMMA and 50% polyethylene slabs with various hydroxyapatite calcification thicknesses (50-500μm), and (ii) the ACR mammographic accreditation phantom. Furthermore, a human breast specimen was imaged and compared to screening mammography image. Contrast to noise ratio from the dual energy subtracted images (CNR_{DE}) and mean glandular dose (MGD) were calculated. Experimental results showed that the proposed dual energy method improves the detectability and visibility of the breast microcalcifications.*

Acknowledgement

This research has been co-funded by the European Union (European Social Fund) and Greek national resources under the framework of the "Archimedes III: Funding of Research Groups in TEI of Athens" project of the "Education & Lifelong Learning" Operational Program.

10:20 - 10:30 Dynamic infrared thermography study of blood flow relative to lower limp position

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Keywords: Dynamic Thermography, Thermographic Camera, Infrared, Thermograms

Thermography is an established method for studying skin temperature distribution. Temperature distribution on body surface is influenced by a variety of physiological mechanisms and has been proven a reliable indicator of various physiological disorders. Blood flow is an important factor that influences body heat diffusion and skin temperature.In an attempt to validate and further elucidate thermal models characterizing the human skin, dynamic thermography of the lower limp in horizontal and vertical position was performed, using a FLIR T460 thermographic camera. Temporal variation of temperature was recorded on six distinct points of the limp. Specific points were initially cooled by the means of an ice cube and measurements of the skin temperature were obtained every 30 seconds as the skin temperature was locally reduced and afterwards restored at its initial value. The return to thermal balance followed roughly the same pattern for all points of measurement, although the heating rate was faster when the foot was in horizontal position. Thermal balance was achieved faster at the spots that were positioned on a vein passage.Our results confirm the influence of blood flow on the thermal regulation of the skin. Spots located over veins exhibit different thermal behaviour due to thermal convection through blood flow. Changing the position of the foot from vertical to horizontal, effectively affects blood perfusion as in the vertical position blood circulation is opposed by gravity.

11:00 – 12:00 **Session 2.** **Dosimetry in Radiology and Nuclear Medicine**
Session Chairpersons: Dr. *J Horrocks,* London, UK and *Dr. C. Hourdakis, Greek Atomic Energy Commission*

11:00-11:20 Invited speech: An evaluation of the impact of digital imaging on radiographic practice and patient doses.

J. Horrocks and K. Violaki

Clinical Physics, The Royal London Hospital, Barts Health NHS Trust, London E1 1BB

Direct digital imaging technology was implemented in all areas in general and mobile radiology at Barts and the Royal London Hospitals in 2012. Evidence from recent radiation incident investigations indicates optimum exposure factors are not consistently selected, with the greater dynamic range of the digital detectors allowing sub-optimal practice. To investigate further patient dose data was extracted from the Radiology Information System for adult chest x-ray examinations in 2013, covering over 50,000 studies in the Trust. Chest X-ray examinations were selected as they are low dose but frequent examinations. The patient dose data are evaluated taking into account x-ray system type and detector performance measurements, and individual cases studies used to highlight where practice can be improved.

11:20 – 11:30 Organ dose and risk assessment in paediatric radiography using the PCXMC 2.0

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Keywords: paediatric radiology, dose, risk assessment, Monte Carlo

Abdominal and chest radiographs are most common in paediatric radiology. X-ray examination of children attracts particular interest, mainly due to the increased risk for the expression of delayed radiogenic cancers as they have many years of expected life remaining. This study aims to calculate the organ dose and estimate the radiation Risk of Exposure Induced cancer Death (REID) to paediatric patients, using the PCXMC 2.0 Monte Carlo code utilizing BEIR VII risk factors. Exposure parameters and patient data were recorded of 240 children undergoing chest or abdomen x-ray examinations, separated almost equally in four age categories 1, 5, 10 and 15 years old. The organs receiving the highest dose in all patient groups were liver, lungs, stomach, thyroid, pancreas, breast, spleen in chest radiographs and liver, lungs, colon, stomach and ovaries, uterus, (for girls) and prostate (for boys) in abdomen radiographs. The effective dose, according to ICRP 103, was for the chest 0.49×10^{-3} - $1.07 \times 10^{-3}\ mGy$, *while for the abdomen* $1.85 \times 10^{-3}\ mGy$ - $3.02 \times 10^{-3}\ mGy$. *The mean REID value was* 1.254×10^{-4} *for abdomen and* 0.645×10^{-4} *for chest. The risk was extremely low for both chest and abdomen examinations for all groups studied.*

11:30 - 11:40 The electromagnetic environment of magnetic resonance imaging systems. Occupational exposure assessment reveals RF harmonics

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Keywords: MRI safety, Electromagnetic fields, Occupational exposure

Magnetic Resonance Imaging (MRI) systems played a crucial role in the postponement of the former occupational electromagnetic fields (EMF) European Directive (2004/40/EC) and in the formation of the latest exposure limits adopted in the new one (2013/35/EU). Moreover, the complex MRI environment will be finally excluded from the implementation of the new occupational limits, leading to an increased demand for Occupational Health and Safety (OHS) surveillance. The gradient function of MRI systems and the application of the RF excitation frequency result in low and high frequency exposures, respectively. This electromagnetic field exposure, in combination with the increased static magnetic field exposure, makes the MRI environment a unique case of combined EMF exposure. The electromagnetic fields level in close proximity of different MRI systems have been assessed at various frequencies. Quality Assurance (QA) & safety issues were also faced. Preliminary results show initial compliance with the forthcoming limits in each different frequency band, but also revealed peculiar RF harmonic components, of no safety concern, to the whole range detected (20-1000MHz). Future work is needed in order to clarify their origin and characteristics.

Acknowledgement

We would like to acknowledge: The Director of ACTA Ltd, Mr. A. Georgiou, as well as Mr. N. Marinakis, for being so kind to provide us, free of charge, with the IDA- 3106 Narda equipment.

11:40 - 11:50 Dosimetric evaluation to medical workers operating in a PET/CT department after the use of dynamic techniques.

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Aim: Due to the high-energy tracers emitting 511 KeV used in PET/CT departments and considering the risks associated to ionizing radiation that have been derived from previous studies, special attention is needed when dealing with radiation protection aspects in a PET/CT modality . New radiopharmaceuticals such us [18F]-fluorothymidine and 18F fluoromethylcholine are used, new imaging dynamic techniques are performed new measurements concerning the doses to staff are needed. Aim of this study was to measure the effective wholebody dose of the personnel in comparison with measurements that have been made in the past.

Method: The estimation of equivalent dose from external dosimetry for all members of the staff was monitored with the use of TLDs badges and electronic dosimeters. In our department 18F-FDG, 18F-FCT, 18F-FCH is available in multi dose vials.

Results: We compared the first six months of 2014 a period in which no FLT or FCH procedures were performed, with the second semester in which 36 FLT and 26 FCH examinations were performed. The average number of FDG patients was the same for every day. The measurements for the nurses show increased wholebody dose of about 7-12% and that is due to the longer time spent near the patient. Concerning the technologist doses, an increase of about 15-21% was measured because they are near to patient at the time of the injection.

Conclusions: From our results we can observe that although there is an increase of the doses for technologists and nurses the numbers are significantly lower than the recommended annual dose limit by Euratrom 97/43.

11:50 - 12:00 Medical workers operating in Nuclear Medicine vs PET/CT: Radiation exposure comparison

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Purpose: *The aim of this study was to compare the gamma dose received by dedicated medical workers operating in the first PET/CT department in Greece and also by dedicated medical workers operating in conventional Nuclear Medicine procedures in the same center.*
Method: *To estimate the effective dose from external exposure, all 9 members of the staff had TLD badges worn at the upper pocket of their overall and digital dosimeters worn at the side pocket. Nurses and Medical Physicists also had TLD rings.*

Results: *In the period of January 2014 to December 2014 a total of 1006 PET/CT and 2311 conventional Nuclear Medicine procedures were performed. The collective effective and finger doses received by all 4 members of the PET/CT staff were the following: Nurse 1 received 2,94 mSv as a whole body dose and 6,84 mSv as a hand dose and Nurse 2 received 2,87 mSv whole body dose and 5,91 mSv hand dose respectively. Technologists 1 and 2 received 1,95 mSv and 1,56 mSv as the whole body dose respectively. Technologists 3,4 and 5 received 1,85 mSv, 1,76 mSv and 1,82 mSv as whole body doses respectively*

Conclusion: *The higher value of gamma dose for PET/CT workers by comparison with the staff operating conventional Nuclear Medicine procedures is attributable to the higher specific gamma constant of ^{18}F, as well as the longer exposure time required for accurate positioning.*

12:00-12:10 Measuring the effective dose to caregivers from patients undergoing common radionuclide therapies: Dosimetry strategies

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Keywords: RadioNuclide Therapies, Caregivers, Radiation dose, Measurements

Nuclear Medicine incorporates both diagnostic examinations and RadioNuclide Therapies (RNTs). RNTs offer considerable advantages in the treatment approach of certain diseases. The most common administrations are in radioiodine treatments, Peptide Receptor Radionuclide Therapy (PRRT) and RadioImmunoTherapy (RIT). The radionuclides mainly used are ^{131}I, ^{90}Y *and* ^{177}Lu. *Once the radiopharmaceuticals are administered, patients become sources of radiation to persons in their proximity. This fact leads to the investigation of the potential radiation hazard to caregivers of patients undergoing RNTs. This study presents the methodology used for the measurement of caregivers' effective doses from such patients. Depending on the therapeutic protocol and dosimetric assessments either an inpatient or an outpatient approach is followed. Patient discharge criteria are defined from widely accepted dose constraints, from real exposure rate measurements, or from remaining activity assessments. The most common dosimeters used to measure the radiation doses to caregivers are direct-reading or indirect-reading dosimeters. In case that monitoring of different rooms or different time periods is required, each caregiver is provided with more than one dosimeter. The duration of monitoring depends upon the radiopharmaceutical effective half-life. Finally, appropriate monitoring or evaluation of radioactive airborne and liquid discharges to the environment is required by Euratom.*

12:20-12:40 **Invited speech: Scientific Misconduct**

C. Kappas,
Dept of Medical Physics, University of Thessaly, Greece

The motivation and reasons to commit scientific misconduct can be searched in a combination of reasons implicating the individual's personality / scientific solidity and his/her professional environment (even if the most common reason for inadvertent plagiarism is simply an ignorance of the proper forms of citation), e.g.: career pressure, lack of competence lack of awareness, personal attitudes, availability of Internet resources, Institutional features, laziness, easiness of fabrication. Excuses are also numerous, e.g.: "Why sweat over producing an analysis that has already been done better, by someone who knows more?", "Everyone else is doing it", "I didn't know", "I couldn't find the source", etc...

The consequences of such practices can be severe for both the offender and the community. Particularly in medicine, there are health implications based on dubious or suspicious research findings and scientific misconduct constitutes a serious violation of the law and the Hippocratic Oath.

Medical doctors, faculty members, researchers, students, are devoted to the promotion and dissemination of knowledge at the highest level of excellence. This demands ethos and leads to obligations beyond the self-evident obligation of compliance with the laws.

This presentation briefly describes the main forms of what is called "scientific misconduct", e.g. plagiarism, self-plagiarism, fabrication, guest/gift authorship, peer review failure, image manipulation, ghostwriting and misappropriation of data and ideas of others. It also points out the responsibilities of authors, co-authors, "bystander" colleagues and Institutions, academic and/or legal punishment and the ways to avoid scientific misconduct and chiefly plagiarism.

12:40 – 13:30 **Session 3. Round Table: Advanced Techniques in Radiotherapy**
Organized by HAMP
Session Chairpersons: *Assoc. Prof. K. Theodorou, Medical Physics, Medical School, University of Thessaly and S. Nikoletopoulos, Medical Physicist, Secretary General of HAMP*

12:55 - 13:10 Dose Painting, Image guidance and Treatment delivery techniques for Adaptive Radiotherapy

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Keywords: Dose painting, image guidance, adaptive radiotherapy

Advanced radiotherapy techniques generate steep dose gradients in order to conform the dose to complex shaped tumors while sparing surrounding critical organs at risk (OARs). Dose can be delivered either with normal or with hypo fractionation leading to a potential increase of therapeutic index. Treatment plans are based on a pretreatment CT scan that provides a snapshot of patient's anatomy. However additional imaging modalities, such as MR or PET scans, permit the visualization of molecular biological pathways and are used to accurately delineate clinical tumor volumes with the definition of Biological Target Volume.

Adaptive Radiotherapy is a treatment technique that systematically improves the radiation dose distribution delivered to a patient during a course of radiotherapy taking into account either the biological function and/or patient, organ temporal variations.

The present study focuses on the use of adaptive strategies by means of dose painting, image guidance and treatment delivery techniques.

13:10 - 13:25 Image Guided Techniques

E. Koutsouveli

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Keywords: IGRT, Quality control, Imaging

Image Guided Radiotherapy (IGRT) is the process of frequent two or three dimensional imaging, during a course of radiation treatment, in order to improve treatment accuracy and efficiency. The anatomy of patients receiving radiotherapy often varies significantly during the treatment course. Combined with uncertainties in treatment set up and steep dose gradients used to cover the target volumes while sparing the organs at risk, the changes could result in dose distributions that deviate significantly from the original treatment plan. The need for accurate and frequent imaging is highly increasing due to the complexity of treatment techniques used, variety of interfaces, stages and processes which could increase the risk of treatment misadministration.

Successful delivery of treatment is achieved by imaging the treatment site either before or during treatment. There are various devices or imaging modalities used to perform this function (MV, kV, US,MRI imaging). A quality control program should be implemented prior to use image guided systems regarding safety tests, geometric integrity, system operation, image quality parameters, image dose.

High quality images enable more accurate and precise placement of dose, give users the confidence to shrink treatment margins and adapt treatment during the course of fractionated radiotherapy.

15:00 – 16:00 **Session 4. : Emergency/ICU/Surgery and Home-Care Technology**
Session Chairpersons: *Prof. B. Spyropoulos and Dr. A. Tzavaras,* TEI of Athens

15:00 - 15:20 Invited speech: Successfully Aging: An Illusion A Burden Or An Opportunity?

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Keywords: Active Ageing, Home-care, House-call, Life expectancy

The percentage of the elderly within the population of Europe tends to doubling over the next decades. The impressive increase in life expectancy that has been observed since the middle of the 19thcentury and the high, still growing, mean population age constitute a "Novum" in human history. This demographic change is not limited to Europe, but reflects rather a global trend. By the middle of the 21st Century, it is likely to be more people over 50 years, than below 15 years, upon the globe. Thus, world population growth is set to slow down significantly, especially in BRICS and a market is slowly created worldwide, associated to these trends. Life prolonging, in order to be worth-living, should be accompanied with an enormous medical-managerial, social and economic challenge, analogous to the effort needed to grow-up the children and the youth and to support them to enter their social and professional life. The BRICS are deficient in these sectors and a part of their surplus, earned through the industrial explosion, especially in China and India, should be invested for the improvement of the rather poor living conditions, of their own population, especially the ageing part. The EU has a valuable social experience and an excellent scientific and technical background, related to Health-care and Active-ageing, achieved through the highest public social-expenditure in the world. This high social-expenditure, combined with the transfer of the world industrial production eastwards, is among the main reasons of the present European stagnation. Endeavoring a large-scale cooperation, between EU and BRICS, concerning Health-care and Active Ageing, is an important and legitimate objective, because it would stimulate the prosperity of the ageing populations in these countries, as well as, the economic growth of the Health-care and Active-Ageing related enterprises in Europe, leading to mutually beneficial outcomes.

15:20 - 15:30 ¨Experimental Determination Of The Modulation Transfer Function (MTF) Of Bed-Side Devices Employed In Home-Care

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Keywords: Home-care, House-call, IVD-PoCT, IVD-bedside devices, MTF-errors

The purpose of this paper is to present a bedside Point-of-Care system, to be employed combined for in-vitro and in-vivo Diagnostics, based on any digital camera, smart-phone, scanner and/or any digital microscope. A cardinal prerequisite to successfully fulfill this task is the individual and experimental determination of the Modulation Transfer Function (MTF) of all involved equipment. The system can capture and handle color absorption and/or reflectance data, as well as, full macroscopic and digital camera images and more specific colors on dry-chemistry strips, colored forms (e.g. blots, dots etc.) on preloaded microfluidics-chips, or micro-arrays, "blood-smears" on microscopy slides, images of skin, breasts, wound etc acquired under white or red light. The acquired colors, patterns and/or image data, are transmitted, along with a reference set of relevant absorption and reflectance standard-data, allowing for the determination of the MTF of each device, based on the related spectra, acquired with an Ocean Optics UV-VIS-NIR modular-spectrometer and the partially automatic evaluation of colors and patterns, by employing custom developed software-tools. MTF-measurements are presented including Reflection Spectra, RGB-values, Original and scanner-transmitted color-palettes etc. enabling the MTF-calculation, i.e. the influence of the individual characteristics of the employed equipment on the wavelengths transmitted. This method allows for the transmission errors correction and diminishes their influence on home-care and self-examination procedures.

15:30 - 15:40 Algorithms and software for fibrillation detection in home-care

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Abstract: Automated External Defibrillators (AED) are commonly used in out of hospital settings since they analyze the patient's electrocardiogram and decide on whether to deliver electrical shock to the heart. The algorithms applied for detecting Ventricular Fibrillation should be accurate and simple for real time applications. The presentation will review the basic AED algorithms operating in the time domain, suggest a new algorithm, and compare their performance on international databases.

15:40 - 15:50 Secured Web-Based Home-Care Management

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Keywords: Home-care, House-call, User-control, security and authentication.

The main function of the developed software is the creation of a Home-care plan, upon the transition of a patient from Hospital to Home-care. It allows for any Physician to assign an appropriate set of diagnostic, monitoring, treatment diagnostic, nursing etc. Home-care supervision activities allow for personal health records to be generated at home, enabling hospitals, health care providers and families to track and respond to critical behavioral and clinical patient data. Security and user-control utilize a role-based access model, defining the users and their permissions, within each module, ensuring that only eligible users have access to patient information. We have created a security web server that manages all requests that need to be secure to and from the recipient, implemented using Microsoft ASP.NET Web API 2. The exposed API requires the use of Https/SSL, in order to allow for the execution of any action. We have created a digital certificate on our IIS Server, which the user has to originally accept. After the certificate acceptance, all calls that are being made, are considered secured at the transmission layer. We also use anti forgery techniques to prevent cross site request forgery (CSRF) like altering the query string on the browser.

15:50 - 16:00 Quality Assurance (QA) Optimization of Tandem Mass-Spectrometry (Ms/Ms) employed for Neonatal-Screening by using Specific Aminoacids and Acylcarnitines standard-solutions

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Keywords: Neonatal Screening, Tandem Mass Spectrometry (MS/MS), Quality-Assurance, Acylcarnitines standard-solutions, mass-scanning-protocols.

Neonatal-screening aims to detect, metabolic or not, heritable disorders in Newborn. In each country there is an authority (e.g. the Discretionary Advisory Committee on Heritable Disorders in Newborns and Children, DACHDNC) of the U.S. Department of Health & Human Services) aiming to reduce morbidity and mortality in newborns and children who have, or are at risk for, heritable disorders. In Greece, the National Newborn-screening Program was initiated in 1974 and is performed by the Institute of Child Health. A Recommended Universal Screening Panel (RUSP) proposed by DACHDNC includes 31 core and 26 secondary conditions, which every baby should be screened for. Tandem-MS is a method of choice for crucial screening-parameters and it is the purpose of this paper to present our Quality-Assurance optimization efforts in Neolab-MS system that includes:

- *The employment of specific Aminoacids and Acylcarnitines standard-solutions, defining the normal/upnormal-ranges of the processed-samples.*
- *Monitoring of temperature, cone voltage, pressure, flow etc. Settings.*

Four main mass-scanning-protocols can be performed in samples/standards in microplates (precursor ion-scan, product ion-scan, neutral loss-scan, and selected reaction monitoring). Neutral-loss-scan (222.2 Da second-MS-offset) for Aminoacids and Precursor-ion-scan for Acylcarnitines (85.0 Da product-ion) are selected. The performed test-runs so far show very good reproducibility of the experimental results, with the used reference-solutions.

16:30 – 17:20 **Session 5. Biomedical Instrumentation – Applications in Nanomedicine**
Session Chairpersons: *Assist. Prof. G. Loudos, TEI of Athens and Dr. M. Georgiou, BET Solutions*

16:30 - 16:45: Non-invasive temperature measurements in magnetic induced hyperthermia using nanoparticles

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Hyperthermia using magnetic nanoparticles is a new, promising technology, which is using temperature increase to either control drug release and/or achieve selective destruction of cancer cells via hyperthermia. However, in order to test nanoparticles on design level it is necessary to develop accurate techniques for measuring temperature increase. This becomes more serious in in vivo studies, where it is very useful to measure temperature increase in the tumor or other target organ/tissue, as well as monitor whole body temperature increase. Although a number of methods are used on laboratory level (thermometer, optical fiber etc), they fail to provide accurate in vivo information of temperature increase during a hyperthermia session. The use of near infrared camera is a rather promising techniques, which however needs to be properly calibrated, in order to take into account all physical restrictions of hyperthermia and temperature diffusion. In this work an experimental procedure is being proposed and the protocol is tested through comparative measurements between optical fibers and near infrared camera under different hyperthermia condition, using magnetic nanoparticles.

16:45 - 17:00: Molecular imaging during magnetic induced hyperthermia: Technical limitations and proposed solutions

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Targeted drug delivery using multifunctional nanoparticles is a rapidly evolving field due to their attractive chemical and physical properties. Magnetic nanoparticles can be additionally heated by the application of an external magnetic field and either allow controlled drug release or even selective destruction of cancer cells via hyperthermia. However, it is crucial to develop non-invasive imaging techniques that can provide in vivo information to determine nanoparticles spatiotemporal biodistribution, in order to assess whether they have successfully reached the target organ/tissue, they remain stable, they concentrate on other non-desirable sites and additionally to image response to therapy and if possible drug release. Radiolabelling multifunctional nanoparticles with gamma-isotopes including Tc-99m, In-111, Ga-68, F-18 etc allows the application of standard nuclear medicine techniques for their in vivo imaging using Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET). The need for simultaneous imaging during hyperthermia has raised several engineering issues, mostly related to the interaction of magnetic field and imaging systems. The recent evolution of Silicon Photomultipliers, which are used in the PET/MR technology provide for the first time the means to develop detectors compatible with hyperthermia equipment. In terms of HYPERGNOSTIC the design considerations for such imaging prototypes are presented as well as the first results for detector modules readout.

17:00 - 17:20: Nanomedicine as a new vehicle for funding biomedical instrumentation

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Over the past decade a rapidly increasing number of groups, mainly originating from the field of pharmacy and chemistry, are designing, developing and evaluating nanoparticles for targeted drug delivery, diagnostic purposes and other exciting applications. While the debate around the practical value of nanomedicine remains open, it is obvious that the word "nano" attracts funding and numerous nano-related projects are funded in terms of FP6, FP7 and now Horizon 2020. Nowadays the first nano-based products have received approval for clinical trials and some are already products, thus there is a shift from nanoparticles design projects to nanoparticles application projects. In this rapidly changing environment, the role of biomedical engineering is still limited. Although nanomedicine is a highly interdisciplinary topic, there is still lack of efficient communication between scientists that cover complementary expertise in the field. However, the exploitation of nanoparticles in medicine requires deep knowledge of both imaging and therapeutic technologies and bridging this gap could refresh the field of medical physics in a period where existing technologies seem to reach their limits. In this talk indicative applications that show the added value of exploiting biomedical engineering in nanomedicine will be shown, through the case-example of a small engineering laboratory, which attracted funding and enriched its activities through this interaction

Parallel Poster Session-A (10:00– 13:30) Thursday 18-05-2015
Session Chairpersons: *Dr. S. David, Dr. C. Michail and Ms. V. Koukou*
24 Posters

Thursday 18 June

Effect of the concentration on the X-ray Luminescence Efficiency of a Cadmium Selenide/Zinc Sulfide (CdSe/ZnS) Quantum Dot nanoparticle solution

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Keywords: quantum dot; nanoparticles; luminescence efficiency

This paper reports the luminescence efficiency (LE) of toluene dissolved Cadmium Selenide/Zinc Sulfide (CdSe/ZnS, Sigma-Aldrich, Lumidot 694622) quantum dot samples (QDs) after exposure to x-rays of variable radiation flux. The distinctive influence of the weight over volume (w/v) concentration of the samples in LE was investigated in detail. The light absorption of the QDs was measured with the Perkin Elmer spectrometer after UV irradiation of 1nm-steps. The absorbed light distribution was unsymmetrical and exhibited a local minimum at 640 nm. The light emission of the QDs was additionally measured after UV irradiation. The distribution of the emitted light was symmetrical with a maximum at 640 nm. The w/v concentration of the QDs varied between $7.1x10^{-5}$ mg/mL to $28.4x10^{-5}$ mg/mL. The samples were handled in a cubic $12.5x12.5x45mm^3$ quartz cuvette. Each sample was excited under x-ray irradiation, in the energy range from 50 to 140 kVp using a BMI General Medical Merate tube with rotating Tungsten anode and inherent filtration equivalent to 2 mm Al. The X-ray LE, induced by the $28.4x10^{-5}$ mg/mL QDs found higher, however, the distinction was vague in the highly concentrated samples. The maximum efficiency was obtained at the 90 kVp for the QDs of the $21.3x10^{-5}$ mg/mL w/v concentration. In the high energy range (120-130 kVp) all concentration levels exhibited comparable X-ray induced LE. The luminescence properties of the investigated QDs appear promising for x-ray detection applications.

CT exams in Greece for the years 2012 and 2013

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Keywords: CT exams

The purpose of this study is to present quantitative data on executed CT exams in public and private health services throughout the country, as derived from control SEYYP, which was made by order of the Minister of Health.
The audit found that the CT exams performed in Greece per thousand inhabitants, were above the average, compared with other European countries. Furthermore the installed and operated CT scanners per 1,000 inhabitants found that they were above the average than those operating in other EU countries. This recording also revealed that the most CT scanners located in diagnostic laboratories in the private health services. Also most CT exams performed, in private health services, it is not possible to accurately calculate due to non-mission of the annual statistics from these laboratories. In public hospitals on different cities, fewer CT exams performed, compared with the corresponding average of executed CT exams in all public hospitals in Greece, although that the situation of their CT scanners were from good to excellent. Additionally at the same city, in the same period, the private Laboratories performed more CT exams than the public hospital. Some public hospitals in the country perform only 300 CT exams per year per CT scanner, while in other public hospitals this number was > 20,000. Furthermore it was interesting that the number of CT exams per thousand residents in some public hospitals was much smaller than the corresponding average of all public hospitals. Additionally found that in public hospitals, doctors untitled with the medical specialty prescribed CT exams. Finally another audit founding was that diagnostic protocols and procedures for investigating clinical cases as well as control mechanisms to confirm the indication of performing CT exams, do not exist. SEYYP made proposals to improve all the aforementioned.

Optical Coherence Tomography in Ophthalmology: Two Systems, Two Different Principles. An overview.

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The aim of this study is to provide a brief overview of the physical principles behind Optical Coherence Tomography (OCT) and to discuss two state---of---the---art OCT systems used in ophthalmology. OCT is a noninvasive optical technique
That can provide cross---sectional images of biological tissues. It uses low (time)
Coherence interferometry (LCI) to generate two dimensional (2D) images based
On optical scattering from internal biological microstructures. OCT images are B---scans integrated from laterally adjacent LCI A---scans, similar to ultrasonic pulse---echo imaging. The two techniques implemented in OCT are Time Domain
(TD) and Fourier Domain (FD) LCI---OCT. The two systems described here are both FD---OCT systems. The first one using a monochromatic tunable fast scanning laser source of 1310 nm (swept source fFD---OCT) and a photodetector
To detect a wavelength---resolved interference signal, designed specifically for anterior segment imaging. The second one using a superluminescent diode (SLD)
Source of 840 nm (widefield enfacesFD---OCT) and a spectrometer based detection. Although OCT is mostly used in ophthalmology due to its limited penetration depth in tissues, it can find many biomedical applications. It is already being used in some aspects of cardiovascular imaging, with the potential
Of cardiac OCT, and other applications, like gastroenterology and dermatology,
Are already under research.

Electronic monitoring system of patients with chronic diseases

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Keywords: chronic diseases, temperature measurement, heart rate measurement, oxygen saturation measurement, blood pressure measurement, Arduino Yún,

Chronic diseases include a wide range of health problems such as diabetes, asthma, heart disease and sleep disorders. In many cases, chronic diseases require some form of monitoring of health status, especially in the later stages of disease progression.
In this paper, an electronic system that monitors certain vital signs (heart rate, temperature, blood pressure, oxygen saturation) of a patient suffering from a chronic condition is described. The system has been developed around the Arduino Yún, which is an integrated platform in small form factor allowing the simultaneous acquisition of various signals. The Arduino Yún has been expanded by means of a special board that provides the interface with the sensors. The platform has been set up to act as a web server that facilitates real time access in the readings of all sensors through a webpage. In case of emergency (elevated temperature, tachycardia, bradycardia, or elevated blood pressure), the system can send alerts in the form of email or SMS to relatives or medical staff. Furthermore, the system provides the capability of sending and storing measurements in a Google Docs worksheet.

Biomedical Impact in Implantable Devices-The Transcatheter Aortic Valve as an example

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Objective*: To update of the scientific community about the Biomedical Engineering involvement in the implantable devices chain. Moreover the Transcatheter Aortic Valve (TAV) replacement, in the field of cardiac surgery, will be analysed as an example of contemporary implantable technology.*

Methods*: A detailed literature review regarding Biomeds participating in the implantable medical product chain, starting from the design of the product till the final implantation technique. Transcatheter Aortic Valve characteristics (design, hemodynamics, material technology etc) are discussed. The scientific – educational impact of Biomeds has been reviewed.*

Results*: The scientific – educational role of Biomeds has clearly been established. Certain parts of the product chain are implemented almost exclusively by experienced Biomedical Engineers. The transcatheter aortic valve device has been chosen as an example. The successful professional should have a multidisciplinary knowledge, including medicine, in order to pursue the challenges for such intuitive technology. This clearly indicates that Biomedical Engineers are among the most appropriate scientists, if not the most, to accomplish such tasks.*

Conclusions*: The Biomedical Engineering involvement in medical implantable devices has been widely accepted by the scientific community, worldwide. It's important contribution, starting from the design and extended to the development, clinical trials, scientific support, education of other scientists (surgeons, cardiologists, technicians etc), and even to sales, makes Biomedical Engineers a valuable player in the scientific arena. Notably, the sector of implantable devices is constantly raising, as emerging technologies continuously set up new targets.*

Integrated system for remotely monitoring critical physiological parameters

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Monitoring several human parameters (temperature, heart rate, blood pressure etc.) is an essential task in health care in hospitals as well as in home care. This paper presents the design and implementation of an integrated, embedded system that includes an electrocardiograph of nine leads and two channels, a digital thermometer for measuring the body temperature and a power supply. The system provides networking capabilities (wired or wireless) and is accessible by means of a web interface that allows the user to select the leads, as well as to review the values of heart rate (beats per minute) and body temperature. Furthermore, there is the option of saving all the data in a Micro SD memory card or in a Google Spreadsheet.

The necessary analog circuits for signal conditioning (amplification and filtering) were manufactured on printed circuit boards (PCB). The system was built around Arduino Yun, which is a platform that contains a microcontroller and a microprocessor running a special LINUX distribution. Furthermore, the Arduino Yun provides the necessary network connectivity capabilities by means of the integrated Wi-Fi and Ethernet interfaces. The web interface was developed using HTML pages with JavaScript support.

The system was tested on simulated data as well as real data, providing satisfactory accuracy regarding the measurement of the heart rate (± 1 bpm error) and the temperature ($\pm 0.5^{\circ}\mathrm{C}$ *error).*

Computational study of the optimum gradient magnetic field for the navigation of spherical particles into targeted areas

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Keywords: Magnetic driving, Nanoparticles, CFD, MRI

The use of spherical magnetic nanoparticles that are coated with drugs and can be navigated to targeted areas is proposed for the cure of cancer. The particles' are navigated by magnetic field gradients that can be produced by an MRI device. In the present work, a computational study for the estimation of the time evolution of the gradient magnetic field is presented in order to ensure the optimum driving of the particles into the targeted area. For this purpose, the presented method includes all the forces that acting on the particles and make them move. The method is based on a iteration algorithm that intent to minimize the deviation of the particles from a desired trajectory. In this way, the gradient magnetic field is temporally adjusted in a suitable way such that the particles' distance from the trajectory to be decreased.

For the evaluation of the potentials of this computational method, series of simulations with different numbers of optimization parameters for the magnetic field, fluid velocities, and concentrations of particles were performed. Using the above mentioned method, it was depicted that with the increase of the optimization parameters of the gradient magnetic field, the particles' deviation of the desired trajectory is decreased. Important role in the particles' deviation is found to play the velocity of the fluid, because when fluid velocity in the artery is increased, steeper gradients of the magnetic field are needed for the decrease of the trajectory's deviation. Moreover, results are found to have low dependence from the particles' concentrations that are considered in the simulations.

MINORE: A Medical Image, Noise and Resolution Evaluation Software

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Keywords: GUI, C#, image quality

The evaluation of a detector performance requires an easy to use interface capable for calculating image quality metrics like the Modulation Transfer Function (MTF), the Noise Power Spectrum (NPS), the distribution of pixel values etc. The resolution is usually defined at the spatial frequency corresponding to 5 or 10% of the Modulation Transfer Function (MTF). Noise indicates the limits of the system for imaging structures difficultly differentiated from the background. Finally image histogram can demonstrate the pixel value distribution. This work presents a Graphical User interface (GUI), called MINORE, for the evaluation of detector image quality characteristics. The presented GUI has been developed in C# computer language for MS Windows. MINORE can read standard format images (.bmp, .jpg, .tif) and calculate the histogram, the Line Spread Function (LSF), the MTF and the 1D Noise Power Spectrum (NPS) from a selected Region Of Interest (ROI). The user can extract the ROI, LSF, MTF and NPS arrays for further calculations. The MTF and NPS methods incorporated in the MINORE are based in published scientific literature. MINORE results have been compared with published data for commercially available digital mammography systems.

Acknowledgement

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Effect of energy on imaging performance of electronic portal imaging devices

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Keywords : Portal Imaging Devices, Modulation Transfer Function, Noise Power Spectrum, Detective Quantum Efficiency.

In the present work various image quality metrics were experimentally estimated for Electronc Imaging Devices (EPID), at different energies, and various values of monitor units (MU) and dose rates. A large number of images of the QC3 test phantom were obtained and evaluated for different LINAC (Elekta iViewGT) energies, MUs and dose rates in order to calculate and extract graphs of Modulation Transfer Function (MTF), Normalised Noise Power Spectrum (NNPS), Detective Quantum Efficiency (DQE), Figure of Image Quality (FIQ), Contrast to Noise Ratio (CNR) and Signal to Noise Ratio (SNR). MTF estimation was based on the Square Wave Response method using the corresponding region of the phantom. MTF curves were found to be only slightly affected by energy and dose rate, being slightly better at higher dose rates and higher energy. NNPS graphs were found with irregular shape at low MUs and energies and were smoother at higher both MUs and energies. The DQE graphs and the FIQ values had little differences among the two energies and MUs. On the other hand both CNR and SNR curves were clearly higher at 6 MV and lower at 18 MV. It was found that the spatial frequency dependent metrics, such as MTF, DQE, which are related to detector performance, showed a tendency to increase when the energy, the dose rate and MUs were increased. However, the contrast to noise ratio was found considerably lower at high energy.

Remote monitoring of temperature and humidity in medical environments

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The purpose of this paper is to present an integrated wireless and portable system for monitoring temperature and humidity in a medical environment (e.g. ICU). The system consists of two autonomous sensors for measuring parameters and the central processing unit, in which the data will be sent to be recorded, displayed and stored, and for any further processing.
Each sensor measures both temperature and humidity. The wireless data transfer is carried out by a network of three nRF24L01+ RF transceivers, which operate in the worldwide license-free 2,4 GHz ISM (Industrial, Scientific and Medical) band and have ultra low power consumption (under 14mA – Rx/Tx mode, sub µA – idle mode).
The sensors pass the data to the main processing unit, which consists of a Raspberry Pi. After the appropriate digital processing, the real-time measurements are displayed on a built-in display. Also, the system is capable of uploading the data to a SQL database on the Internet, making it available to approved users.
Finally, the system is really user-friendly and simple, and its portability and wireless data transfer make it perfect for use in medical environments, without setting up wired connections or altering the existing facilities.

Modeling Patients' Height in PET/CT from Image and Anthropometry Data

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Keywords: Height model, PET/CT, Anthropometry, SUV-Peak

The purpose of this work was the development of a model for the estimation of the height of patients undergoing PET/CT examinations. Height is not regularly recorded in the clinic independently. It is usually reported by the patients and is highly inaccurate. Height, however, is a parameter required for the estimation of quantitative PET parameters such as the maximum or peak standard uptake value (SUV) based on mean lean body mass. In order to remedy the lack of accurate height measurements, we developed a model to estimate height from the CT slices of a whole body PET/CT scan. Forty patients, who underwent PET/CT examination for lymphomas were used for the development of the model; the same imaging protocol was used for all patients. The DICOM header of the CT images provided information on the number of slices within selected reference points, slice spacing, and slice thickness. Reference anatomical points were the bottom of the jaw body and the lowest part of the coxal bone (inferior ramus of ischium) that were clearly defined on both the CT images and the anthropometry sketches. The model was tested on 11 whole body scans of patients where height was independently measured. The accuracy of the model was of the order of ±1 cm. In conclusion, it is possible to determine the height of patients as needed for quantitative PET measurements using simple.

Comparison of Vibration – Controlled Transient Elastography (VCTE) and Shear Wave Elastography (SWE) using Liver Biopsy as 'Gold Standard' for the diagnostic approach of chronic hepatitis and liver cirrhosis

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Keywords: Chronic Liver Disease, Fibrosis, Ultrasound, Elastography.

Purpose: This study compares two methods of liver elasticity determination, Shear Wave Elasticity (SWE) and Vibration Controlled Transient Elastography (VCTE-Fibroscan) using Liver Biopsy (LB) as 'Gold Standard' for the diagnostic approach of chronic hepatitis and liver cirrhosis.

Materials and Methods: 393 consecutive patients (96 normals and 297 with chronic liver disease (CLD) with LB and histology examination) were included in the study. A B-Mode and Color/Power Doppler examination is performed on each patient for examining liver morphology and hemodynamic study of the portal vein. SWE and VCTE measurements were performed on the right lobe of each patient's liver and were used for ROC analysis.

Results: ROC analysis was performed to each of the two methods showing $AUC_{SWE} = 0.9066$ *and* $AUC_{FIB} = 0.921$ *for F=F4 Cirrhosis,* $AUC_{SWE} = 0.9177$ *and* $AUC_{FIB} = 0.9311$ *for* $F \geq F3$ *Fibrosis Stage,* $AUC_{SWE} = 0.8669$ *and* $AUC_{FIB} = 0.8746$ *for* $F \geq F2$ *Fibrosis Stage,* $AUC_{SWE} = 0.927$ *and* $AUC_{FIB} = 0.899$ *for* $F \geq F1$ *Fibrosis Stage. Best cut-off values were calculated for each method corresponding stiffness values ranges to Metavir fibrosis stages: (SWE/VCTE): F=F4:13,8/11,2 kPa, F ≥ F3: 11,3/9,3 kPa, F ≥ F2: 8,2/7,8 kPa, F ≥ F1: 6,8/5,7 kPa.*

Conclusion: The study shows that both VCTE and SWE can differentiate between the 5 Metavir fibrosis stages and that SWE is more reliable in discriminating normal subjects from subjects with CLD (F ≥ F1).

Acknowledgement

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Collection, processing and visualization of ultrasound and elastography images for diagnosis , prevention and treatment approach to chronic hepatitis , cirrhosis and hepatocellular carcinoma" of the National Strategic Reference Framework (NSRF).

Study on the optical diffusion performance of granular phosphors employed in medical imaging

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Keywords: Optical transport, granular phosphors, medical imaging

Powder phosphors are commonly used in several applications in biomedical imaging. In particular, for X-ray imaging applications, the optical diffusion performance of the phosphor enhances the quality of the final image and contributes to diagnosis validity. The light emission performance of the phosphors is influenced directly by the optical and the structural properties of the phosphor. In the last decade, with the development of science and technology in the field of materials, several methods and techniques have been developed and successfully used for the preparation of granular phosphors of improved optical and structural properties (e.g., grains of close-packed spatial distribution, grain sizes in nanoscale etc). The aim of the present study was to investigate the variation of the optical parameters under the variability of different optical (e.g., light wavelength, refractive index) and structural (packing density, grain diameter) properties. One of the major targets of this investigation was to provide an overall understanding of how the aforementioned properties could enhance the efficiency of the X-ray detector by optimizing the light emission performance of the phosphor layer (amount and distribution of the emitted light quanta). In addition, examination of the optical transportation was carried out in order to proceed to a clearer conclusion of how the transportation of the optical signal is affected. Results showed that the key parameter in optical diffusion studies was the number of the light photon interactions with the phosphor grains.

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Shielding of Sensitive Electronic Devices in Magnetic Nanoparticle Hyperthermia Using Arrays of Coils

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Keywords: magnetic shielding; magnetic nanoparticle hyperthermia

In Magnetic Nanoparticle Hyperthermia (MNH) an externally applied electromagnetic field transfers energy to the magnetic nanoparticles in the body, which in turn convert this energy into heat, thus locally heating the tissue they are located in. This external electromagnetic field is sufficiently strong so as to cause interference and affect sensitive electronic equipment. Standard shielding of magnetic fields involves Faraday cages or coating with high-permeability shielding alloys; however, these techniques cannot be used with optically sensitive devices, such as those employed in Optical Coherence Tomography or radionuclide imaging. In this work we present a method to achieve magnetic shielding using an array of coils. The magnetic field generated by a single coil was calculated using the COMSOL physics simulation toolkit. Software was written in C/C++ to import the single-coil data, and then calculate the positions, number of turns and currents in the shielding coils in order to minimize the magnetic field strength at the desired location. Simulations and calculations have shown that just two shielding coils can reduce the magnetic field by 3-4 orders of magnitude.

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PVAL Breast phantom dual energy calcification detection

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Keywords: dual energy, microcalcifications, polyvinyl alcohol, hydroxyapatite

Microcalcifications are the main indicator for breast cancer. Dual energy imaging can enhance the detectability of calcifications by suppressing the tissue background. Two digital images are obtained from two different spectra, for the low- and high-energy respectively, and a weighted subtracted image is produced. In this study, a dual energy method for the detection of the minimum breast microcalcification thickness was developed. The integrated prototype system used, consisted of a modified tungsten anode X-ray tube combined with a high resolution CMOS sensor. The breast equivalent phantom used was an elastically compressible gel of polyvinyl alcohol (PVAL). Hydroxyapatite was used to simulate microcalcifications with thicknesses ranging from 50 to 500μm. The custom made phantom was irradiated with 40kVp and 70kVp Tungsten (W) anode spectra filtered with 100μm Cadmium and 1000μm Copper, for the low- and high-energy, respectively. Microcalcifications with thicknesses 300μm or higher can be detected with mean glandular dose (MGD) of 1.62mGy.

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Effect of common building materials in narrow shaped x-ray fields transmission

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Keywords: dental radiography, building materials, radiation protection, secondary radiation

Narrow shaped X-ray fields may be used in various imaging applications, like panoramic X-rays. This work studies the radio protection effect of common building materials such as, single and double plasterboard, single ceramic tile and glass block in exposure applications simulating panoramic radiography . The measurements were performed at a 70 kVp conventional radiographic equipment (Philips Optimus). A narrow X-ray field irradiating a cylindrical plexiglas phantom was used. The distance between the phantom and the tube focus was 83 cm. The dimensions of the field at the phantom surface were 16 cm x 2 cm. The distance between the central point of phantom and the point of measuring secondary radiation was 50 cm. A spectrometer and an ionization chamber (survey meter) were used for measuring secondary radiation. The secondary dose rate, without material was 0.5 mSv/hr. The secondary dose rate after shielding the ionizations chamber with single plasterboard was 300.0 μSv/hr and with double plasterboard was 150.0 μSv/hr. Although the absolute secondary dose rate values are expected different in dental radiology, due to different X-ray tube output and distances the transmission data indicates that for X-ray tube voltages used in dental radiology the double plasterboard absorbs 70.0% of the incident dose rate.

Decay time measurements of powder scintillators used in X-ray imaging indirect detectors.

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Keywords: powder phosphors, X-ray imaging, decay time

New X-ray imaging techniques based on indirect scintillator detectors such as digital breast tomosynthesis or photon counting spectral Computed Tomography needs a fast scintillator material (short decay time) to convert the ionizing radiation (x-ray, gamma ray) to visible photons [1]. Scintillation light pulses (flashes) are usually characterized by a fast increase of the intensity in time (pulse rise time) followed by an exponential decrease. The decay time of a scintillator is defined by the time after which the intensity of the light pulse has returned to 1/10 of its maximum value after a flash excitation [2]. In this study, scintillation decay time properties of five selected powder scintillator materials namely LSO:Ce, YAG:Ce, GOS:Tb, GOS:Pr and GOS:Pr,Ce,F are examined. For the characterizations, powder samples were prepared in circular shape with 9 cm diameter and were directly positioned on the input window of a Hamamatsu H1949-51 photomultiplier tube (PMT.) The PMT was supplied with High Voltage of -1800V). The excitation of the screens were performed using a radioactive Cs-137 gamma ray source (1uCi). For the readout of the pulses produced by the PMT a current to voltage conversion (via a 1kΩ resistor to ground) and a 200MHz digital oscilloscope were used. The decay times of the LSO:Ce and YAG:Ce phosphors were measured lower than 100 ns while the GOS:Pr and GOS:Pr,Ce,F have decay times equal to 3000ns and 4000ns respectively. GOS:Tb phosphor presented very high decay time equal to $1x10^6$ ns and large afterglow.

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X-ray Luminescence efficiency of GAGG:Ce single crystal scintillators for use in Tomographic Medical Imaging Systems

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Keywords: Inorganic scintillators, X-ray imaging, GAGG:Ce

The purpose of the present study was to evaluate different scintillator crystal samples with a cross section of 3x3mm^2 and various thicknesses ranging from 4mm up to 20mm of the new mixed $Gd_3Al_2Ga_3O_{12}$:Ce (GAGG:Ce) scintillator material under X-ray irradiation for possible applications in Tomographic Medical Imaging systems. Evaluation was performed by determining the luminescence efficiency (LE) (emitted light energy flux over incident x-ray energy flux) in x-ray energies employed in general X-ray imaging [1]. For the luminescence efficiency measurements, the scintillator samples were exposed to X-rays using a BMI General Medical Merate tube, with rotating Tungsten anode and inherent filtration equivalent to 2 mm Al. X-ray tube voltages between 50 to 130 kV were selected. An additional 20 mm filtration was introduced in the beam to simulate beam quality alternation by a human body. The emitted light energy flux measurements were performed using an experimental set up comprising a light integration sphere (Oriel 70451) coupled to an EMI 9798B photomultiplier tube which was connected to a Cary 401 vibrating reed electrometer [2]. The GAGG:Ce sample with dimensions 3x3x10 mm^3 exhibited higher LE values, in the whole X-ray energy range examined. LE value equal to 0.013 was recorded for this crystal at 130 kVp – a setting frequently used in Computed Tomography applications.

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Absolute efficiency and statistical distribution of the light flashes emitted by the GOS:Pr powder phosphor screens under X-ray general radiography imaging conditions.

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Keywords: powder phosphors, X-ray imaging, Gd_2O_2S:Pr

The aim of the present study was to examine the light emission efficiency of Gd_2O_2S:Pr (GOS:Pr) powder scintillators under X-ray general radiography imaging conditions. To this aim, six scintillating screens (from 34 to 137 mg/cm^2) were prepared in our laboratory, by sedimentation of Gd_2O_2S:Pr powder in fused silica substrates [1]. Parameters related to X-ray detection, i.e. the energy absorption efficiency (EAE) and the quantum detection efficiency (QDE) were calculated. Absolute luminescence efficiency measurements were performed within the range of X-ray tube voltages (50–130 kVp) used in general radiography applications. The light energy flux measurement experimental setup, comprised a light integration sphere coupled to a photomultiplier tube (PMT) connected to a Cary 401 vibrating reed electrometer [2]. The X-ray exposure was measured by means of a Victoreen 4000M+ exposure meter. The statistical fluctuations of the light flashes emitted by the screens of various coating thicknesses under a monoenergetic gamma radiation source were determined by performing pulse height spectra measurements. The experimental apparatus is based on a Hamamatsu H1949-51 PMT connected to a properly 10μs shaping amplifier and a digitization system. Results showed that GOS:Pr powder screens with coating thickness up to 80 mg/cm^2 presents high QDE values (up to 40%) in the voltage range used in general radiography applications. Maximum A.E values achieved by the screen with 137 mg/cm^2 coating thickness equal to 14.3 E.U under 110kVp. The GOS:Pr screens has very broad pulse height spectra under monoenergetic irradiation. This effect is more pronounced in thick screens resulting in a significant broadening of the statistical distribution of scintillating emitted light flashes by those screens.

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Robotic Health Assistant: A Line-Following Prototype

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Keywords: Health robotics, automated transport, robotic nurse, aging health

Purpose: This project's long term goal is the development of a robotic system that could be used in a hospital, healthcare facility, or home environment to help administer care and support to patients and/or medical staff. The short term goal is the development of a low-cost, easily controlled but accurate and robust prototype system that could initially deliver drugs and supplies between two fixed points.

Materials and Methods: The prototype line-following robot, named LiFeBo, is based on a simple circuit of basic electronic elements, e.g., resistors, transistors, diodes, potentiometers, and photoresistors, mounted on four wheels driven by two motors. A line of masking tape is used for guidance.

Results: The circuit of the robot was first constructed on a breadboard. Initial testing showed expected and successful performance. Namely, the photoresistors receive light reflected from the masking tape that modifies their resistance value. This subsequently modifies the input voltage to the DC motors. The connection of the circuit to wheels and motors is currently implemented and tested. Results will be presented at the conference.

Conclusion: In the next 30 years, the number of people over 65 years of age is expected to almost double due to affordable and accessible medical technology. Such increase will pose significant demands on healthcare delivery. Simple and affordable robotic assistants and nurses, such as the one proposed here, could provide effective solutions to the problem.

Component based normalization method for rotating dual head PET scanner.

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In the component based normalization the coefficients are factorized into different groups, each reflecting a source of variation. The following normalization factors were considered:

- *axial block profiles and geometric factors,*
- *detector intrinsic efficiency,*
- *transverse geometric factors*

A planar dual head PET system, simulated with GATE, was used for the evaluation of the normalization algorithms. Each head contains one Hamamatsu H8500 PSPMT with 50×50 mm active size; an LSO crystal array with 20×20 pixels, 2×2×10 mm^3 in size.

The two heads rotated 180◦, with 10◦ per step, around the FOV. The ^{176}Lu intrinsic radioactivity was taken into consideration. The low level threshold was set to 200 keV and the energy window was set to 350 - 650 keV. Each rotation step had duration 60sec.

The simulated data were bined into 3D sinograms with 176 detectors and 88 radial bins. The mean interaction distance was taken into account. But no arc-correction was performed; hence distortions on the edges of the FOV are expected.

The normalized and non-normalized reconstructed images of a water cylinder with ^{18}F-FDG, are presented in Fig 1 (a) and Fig1 (b) respectively. The corresponding profiles from the center of the images are presented in Fig1(c) and Fig1 (d).

As one can see the normalization process strongly improves the uniformity inside the FOV. The hot spot in center of the FOV, a product of the geometry of the scanner, is replaced by an approximately flat area and the limits of the FOV are well defined.

Currently we are incorporating more components in our normalization model, like dead-time, random and arc-correction.

A Theoretical study of the MTF of columnar phosphor based digital detectors used in Medical X-ray Imaging

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Keywords: Columnar phosphors, model, MTF, CsI:Tl

Scintillators, either in granular or columnar type, are used in medical x-ray imaging combined with optical detectors, to acquire a better image while decreasing the exposure required. Their role is to convert x-ray energy into optical photons which in sequence expose the optical detector. In this work, the propagation of optical photons in columnar phosphors has been studied theoretically utilizing a two dimensional analytical model. The aim of the model was to calculate the Line Spread Function (LSF), derived by considering the optical photon spatial spread to the output. This model is based on physical and geometrical principles and accounts for the multiple reflections of the produced optical photons, on the sides of a crystal column, as well as the multiple forward and backward propagations of these optical photons inside the crystal. The model was applied in CsI:Tl columnar phosphor (9 μm diameter and 150 μm thickness) combined with an a-Si optical detector. The LSF was obtained by fitting. Increasing of the crystal thickness resulted to degradation of the MTF. Additionally, increasing the sampling pixel size resulted to degradation of the MTF, in accordance with literature.

Information capacity of Gd_2O_2S:Pr, Ce,F scintillators coupled to CMOS sensor

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Keywords: Image Quality; CMOS sensors; Inorganic Scintillators; Gd_2O_2S:Pr,Ce,F

The aim of the present study was to examine the information capacity of a CMOS digital imaging optical sensor coupled to custom made gadolinium oxysulfide powder scintillators, doped with praseodymium, cerium and fluorine (Gd_2O_2S:Pr,Ce,F) screens. The screens, with coating thicknesses 35.7 and 71.2 mg/cm^2, were prepared in our laboratory from Gd_2O_2S:Pr,Ce,F powder (Phosphor Technology, Ltd) by sedimentation on silica substrates and were placed in direct contact with the optical sensor. Image quality was determined through the single index image quality parameter, information capacity (IC). The CMOS sensor/Gd_2O_2S:Pr,Ce,F screens combinations were irradiated under the RQA-5 (IEC 62220-1) beam quality. The detector response function was linear for the exposure range under investigation. Under the general radiography conditions, both Gd_2O_2S:Pr,Ce,F screen/CMOS combinations exhibited comparable information capacity values to previously published results concerning Gd_2O_2S:Eu scintillators, thus could be considered for general radiography applications.

Influence of iterative reconstruction algorithms on PET image resolution

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Keywords: PET; MTF; image quality; Monte Carlo

The aim of the present study was to assess image quality of PET scanners through a thin layer chromatography (TLC) plane source. The source was simulated using a previously validated Monte Carlo model. The model was developed by using the GATE MC package and reconstructed images obtained with the STIR software for tomographic image reconstruction, with cluster computing. The PET scanner simulated in this study was the GE DiscoveryST. A plane source consisted of a TLC plate, was simulated by a layer of silica gel on aluminum (Al) foil substrates, immersed in 18F-FDG bath solution (1MBq). Image quality was assessed in terms of the Modulation Transfer Function (MTF). MTF curves were estimated from transverse reconstructed images of the plane source. Images were reconstructed by the maximum likelihood estimation (MLE)-OSMAPOSL, the ordered subsets separable paraboloidal surrogate (OSSPS), the median root prior (MRP) and OSMAPOSL with quadratic prior, algorithms. OSMAPOSL reconstruction was assessed by using fixed subsets and various iterations, as well as by using various beta (hyper) parameter values. MTF values were found to increase with increasing iterations. MTF also improves by using lower beta values. The simulated PET evaluation method, based on the TLC plane source, can be useful in the resolution assessment of PET scanners.

Parallel Poster Session-B (10:30– 13:30) Friday 19-05-2015
Chairpersons: *Dr. N. Efthimiou and Dr. S. Kostopoulos*
23 Posters

Friday 19 June

A scintigraphic system based on SiPM-arrays optimized for small animal imaging

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Keywords: Mouse-sized gamma camera, Silicon Photomultiplier (SiPM), pixelated scintillator, CsI(Na)

In this abstract we present the development of a SPECT camera based on Silicon Photomultipliers (SiPMs). The SiPMs arrays are coupled to a pixelated CsI(Na) scintillator array with pixel size 1.45mm x1.45mm x 5mm and 0.25mm pitch. The SiPMs model is ArrayC-30035-144P-PCB, the 3rd generation of SiPMs from SensL, which features very low dark count rate, combined with high PDE extended in the blue light spectral region. Each array has external dimensions 50mm x 50mm consisting of 144 SiPMs with 3mm x 3mm pixel size in a 12x12 configuration. Two SiPMs array are placed side-by-side with 1mm gap between them to form a 50mm x 100mm field of view, suitable for small animal imaging. The anodes of both SiPMs arrays are reduced to 4 position signals through a patented diode circuit readout, developed from AiT Instruments. Four free running Analog to Digital Converters (ADCs) continuously digitize the position signals at 50 MHz sampling rate. The digitized data are fed into a Field Programmable Gate Array (FPGA) provided in the SP605 Evaluation Board (Xilinx Inc.) for event processing. The information of interest extracted from the digitized data is written temporarily to an external memory provided on the board and is transferred to a Personal Computer (PC), via Ethernet link, for image reconstruction. Primarily, the evaluation of the system was limited to planar mode; Following the QSPECT software will be used for the reconstruction of the SPECT system.

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SiPM-based PET camera for small animal imaging

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Keywords: Mouse-sized gamma camera, Silicon Photomultiplier (SiPM), pixelated scintillator, BGO

We present the design and development of a dual-head PET camera based on Silicon Photomultipliers (SiPMs). The SiPMs arrays are coupled to a pixelated BGO scintillator array with pixel size 2mm x 2mm x 5mm. The SiPMs model is ArrayC-30035-144P-PCB, the 3rd generation of SiPMs from SensL which features very low dark count rate, combined with high PDE extended in the blue light spectral region. Each array has external dimensions 50mm x 50mm consisting of 144 SiPMs with 3mm x 3mm pixel size in a 12x12 configuration. The anodes of the SiPMs arrays are reduced to 4 position signals through a patented diode circuit readout, developed by AiT Instruments. Four free running Analog to Digital Converters (ADCs) continuously digitize the position signals at 65 MHz sampling rate. The digitized data are fed into a Field Programmable Gate Array (FPGA) provided in the LX150t Development Kit (Xilinx Inc.) for event processing. The information of interest extracted from the digitized data is written temporarily to an external memory provided on the board and is transferred to a Personal Computer (PC), via Ethernet link, for image reconstruction. Initial experimental results show that the energy resolution of the scintillator is ~20%, while the evaluation of the system on image level with custom reconstruction algorithm is in progress.

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Investigation of Attenuation Correction in SPECT Using Textural Features, Monte Carlo Simulations, and Computational Anthropomorphic Models

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Keywords: SPECT; attenuation correction; GATE Monte Carlo toolkit; computational anthropomorphic model; XCAT; textural features

Purpose: *To present and evaluate a new methodology to investigate the effect of attenuation correction (AC) in SPECT using textural features analysis, Monte Carlo techniques and a computational anthropomorphic model.*

Methods: *The GATE Monte Carlo toolkit was used to simulate SPECT experiments with the XCAT computational anthropomorphic model, filled with a realistic biodistribution of ^{99m}Tc-N-DBODC. The simulated gamma camera was the Siemens ECAM Dual-Head, equipped with a parallel hole lead collimator, with an image resolution of 3.54x3.54 mm^2. Thirty six equispaced camera positions, spanning a full 360° arc were simulated. Projections were calculated after applying a ±20% energy window or after eliminating all scattered photons. The activity of the radioisotope was reconstructed using the MLEM algorithm with and without AC. Twenty-two textural features were calculated on each slice, using 16 and 64 grey levels. A mask was used to identify only those pixels that belonged to each organ.*

Results: *Twelve of the twenty-two features showed practically no dependence on AC, regardless of the organ involved. In both the heart and the liver, the Mean and Standard Deviation were the features most affected by AC. In the liver Skewness, Kurtosis, Long-Run Emphasis mean and range, Grey-Level Non-Uniformity mean, and Run Percentage mean were affected by AC on some slices only. These results were not affected by the number of grey levels (16 vs 64) or the data used for reconstruction: with the energy window or without scattered photons.*

Conclusions: *The Mean and Standard Deviation were the main features affected by AC. In the heart no other feature was affected. In the liver, other features were affected but the effect was slice-dependent. The number of grey levels did not affect the results.*

Acknowledgement

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OS-MRP-OSL in comparison to post-filtered OSEM, in high noise simulated PET images

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Keywords: PET, medical image reconstruction, high noise, low statistics

Short scans or reduced injected radioactivity concentrations can introduce multiple benefits in Positron Emission Tomography (PET) e.g. increased patient throughput, reduced motion artefacts, reduced dose on patients and clinical personnel. However, reduced count statistics caused by short scan times or reduced injected doses result in noise propagation, which affects the image quality and diagnostic value. In this study we compare the OS-MRP-OSL reconstruction algorithm with post-filtered OSEM in simulated PET images with high levels of noise. An analytical simulation was performed based on real MR data for the Philips Gemini TF geometry. Initial results are displayed in Fig. 1. The presented results demonstrate that by properly adjusting the penalization factor (β), in the case of OS-MRP-OSL either the FWHM of the Gaussian filter for OSEM the diagnostic valuability of the data is significantly improved. Analysis in terms of Contrast to Noise Ratio (CNR) and Root Mean Square Error (RMSE) showed that, in the optimal configuration, OS-MRP-OSL outperforms OSEM.

Modeling Gold Nanoparticles as Discrete Particles vs a Solution in Monte Carlo Simulations

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Gold Nanoparticles (GNPs) are promising radiation therapy agents due to their enhanced cell-killing. The dosimetric properties and effect of GNPs at the nanoscale and cellular level are investigated using Monte Carlo (MC) simulations. Due to MC software limitations, the GNPs are modeled as a continuous solution of gold in water, rather than as discrete particles.

The purpose of this work is to examine the validity of this approach. The GATE MC toolkit (v6.2) was used to simulate the irradiation of a 10x10x10 cm^3 water phantom with a realistic 6 MV photon beam. The direction of the photons was perpendicular to the phantom, and the number of particles generated was $25x10^9$. An additional rectangular structure was defined inside the phantom containing a given amount of gold, either in the form of a solution, or as a collection of discrete, spherical, regularly-spaced GNPs. Both solid and hollow GNPs were simulated, of diameter 10 nm, 50 nm, and 100 nm. In the case of the hollow GNPs, the diameter of the hollow part was one-half the diameter of the entire GNP. Various gold concentrations were simulated, ranging from 1 to 7mg Au/g. The results presented illustrate the microscopic dose inhomogeneity achieved with discrete GNPs compared with the solution.

Denoising methods in Ultrasound images via GUI

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Keywords: Ultrasound, Speckle Noise Reduction, Wavelet Local Maxima, Singularity Detection, Graphical User Interface

The establishment of Ultrasonography (US) as a leading tool in the majority of medical applications worldwide, is directly associated with the evolution of imaging technology. Despite the profound advantages of ultrasonography, US images carry a granular pattern, so called speckle, which constitutes a major image quality degradation factor. When an ultrasonic wave with uniform intensity is incident either on a rough surface or on tissue particles that are spaced at less than the axial resolving distance of the US system, presented contribution phenomena are being generated with the result of deformation of the anatomical structures and the variation in the intensity of the reflected sound waves (gray scales). The resulting image degraded by speckle US does not correspond to the actual tissue microstructure. Speckle noise deteriorates image quality, fine details and edge definition. Two methods [1], [2] were designed and implemented by means of graphical user interface. At first the statistical distribution of the coefficients of the transformation wavelets and the employment of wavelet local maxima across scales in a coarse to fine manner towards noise speckle reduction. In addition, various quantitative indices have been computed in order to assess speckle reduction performance and edge preservation properties of the aforementioned methods.

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The importance of registration optimizer to ILD quantification and follow up: quasi Newton and simultaneous perturbation

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Keywords: Image registration, optimizer

Computed tomography (CT) imaging is a powerful modality for the quantification of (Interstitial Lung Disease) ILD disease extent and monitoring of change in a follow-up framework. ILD response quantification involves comparison of quantified disease extend between scans obtained at different time instances. Alterations in lung field radiological appearance, caused by diffused disease progression in the lung, as well as the elastic nature of lung tissue, challenge registration of ILD affected lung fields. Evaluation of registration algorithms in ILD quantification is critical for a reliable selection of a registration scheme. Due to lack of a gold standard, the selection of the optimal registration scheme remains an open issue. In this study the effect of two types of registration optimizers, Quasi Newton (QS) and Simultaneous Perturbation (SP), are assessed.

A set of 32 registration schemes are considered and tested in 5 cases of artificially warped lung field data. The registration schemes are evaluated using two distance metrics, the distance between corresponding points: (a) in ILD affected regions and (b) in normal parenchyma. In addition the Lung Volume Overlap Error, was also considered. The results show high performance as well as time efficiency in case of QS.

Optimization of the exposure settings in brain CT by utilizing an image quality phantom.

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Keywords: Brain CT, Tube potential, Tube current-time product, Image quality, Radiation dose

The objective of this study was to investigate how changes in tube potential and current-time product affect image quality and radiation dose in Brain CT.
For this purpose, an image quality phantom was scanned with a 16-slice CT scanner at 90, 120 and 140 kVp, for various mAs values, while all other scanning parameters were kept constant. Size specific dose estimate (SSDE) values were obtained using a pencil ionization chamber and a CTDI phantom. Objective image quality evaluation was conducted by calculating image noise, low contrast detectability (LCD%) and dose efficacy.
It was observed that increase in tube voltage resulted in image noise and LCD improvement. Same picture for tube current-time product as well, however the dependence of these indices from kVp is stronger than from mAs. Concerning dose efficacy, for low dose settings slight changes in dose induced great variations in image noise while for high dose settings great variations in dose resulted in small variations in image noise. For the same SSDE, 120 and 140 kVp provided comparable image quality which was superior to that corresponded to 90 kVp.
Consequently, in Brain CT examinations where low contrast details are of utmost importance, low tube voltages should be avoided.

Evaluation of a small animal C-shaped PET system using GATE Monte Carlo

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Keywords: small animal, PET, Monte Carlo

Commercial clinical and preclinical PET scanners rely on full cylindrical geometry for whole body scans as well as for dedicated organs. In this study we propose the construction of a low cost dual-head PET system dedicated for small animals with minimum or no rotation. The incorporation of SiPM arrays provides the means to design flexible PET scanners so as to improve sensitivity, with limited number of detector heads. Monte Carlo simulation studies were performed using GATE toolkit to evaluate the optimum design in terms of sensitivity of a C-shaped PET system. The PET model is based on SiPMs and BGO crystals. Four different implementations of the dual-head PET system were modeled with the two heads being opposite (0°, 15°, 30° and 45° tilt angle within the modules). Geometrical phantoms were used for the quantification of resolution and sensitivity, as well as for the development of normalization correction. STIR software was used for reconstruction, implementing an efficient multi-threaded ray tracing technique to calculate the line integral paths in voxel arrays. The developed reconstruction technique is semi-flexible and automatically adjusts the size of the FOV according to the shape of the detector's geometry. The results showed an improvement in sensitivity of ~32% in case of 30° tilt angle and ~47% in case of 45° tilt angle compared to 0° case.

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FPGA based digital readout system for a small animal imaging gamma camera

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Keywords: Mouse-sized gamma camera, Position Sensitive Photomultiplier Tube (PSPMT), CsI(Na), Data Acquisition System (DAQ), Field Programmable Gate Array (FPGA), Free running Analog to Digital Converters (ADCs)

We present the development of a low-cost digital readout system for a mouse-sized gamma camera. The imaging system consists of a pixelated CsI(Na) scintillator 60 x 30 array with crystal elements size 1.45 x 1.45 x 5 mm^3 and 0.25 mm septa coupled to two H8500 Position Sensitive Photomultiplier Tubes (PSPMT) (Hamamatsu, Japan) with 2mm thick borosilicate glass and silicone grease (BC630, Saint-Cobain). The resulting detector active area is 50 mm x 100 mm. The two PSPMTs have 128 anode outputs, which are reduced to four position signals using a symmetric charge division circuit (SCD). Four free running Analog to Digital Converters (ADCs) continuously digitize the position signals at 40 MHz sampling rate. The digitized data are fed into a Spartan 6 Field Programmable Gate Array (FPGA) provided in the SP605 Evaluation Board (Xilinx Inc.) for event processing. An embedded system was developed for the acquisition, using Xilinx's Embedded Development Kit (EDK) and Microblaze processor. The information of interest extracted from the digitized data is written temporarily to an external memory provided on the board and is transferred to a Personal Computer (PC), via Ethernet link, for image reconstruction. Initial experimental results show that the current system can provide an efficient readout solution for such dedicated nuclear imaging systems, while significantly minimizing the cost and overall dimensions of readout electronics.

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Assessment of the skeletal status in postmenopausal women by MR Relaxometry in comparison to X-ray absorptiometry techniques

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Keywords: osteoporosis, MRI relaxometry, DXA, pQCT

Objective. The aim of this study was to evaluate the correlation between active transverse relaxation time T_2^* as measured by MRI, and areal or apparent volumetric bone mineral density respectively as measured by DXA and peripheral quantitative computed tomography.
Material and Methods. T_2^* relaxation times of the lumbar spine and tibia were measured using a 3.0T and a 1.5T MRI scanner, in 8 postmenopausal osteoporotic women [mean age: 64.9 ± 7.8 (1 S.D.) years] and 5 postmenopausal osteoporotic women [mean age: 68.4 ± 9.1 (1 S.D.) years] respectively. A control group of 5 healthy female volunteers [mean age: 33.3 ± 10.4 (1 S.D.) years] was used for comparisons and subjects performed the examination in both scanners. Both groups of postmenopausal and control group performed pQCT of the tibia and DXA of the lumbar spine and bone mineral density correlations with T_2^* time were calculated.
Results. Correlation factors between T_2^* relaxation times and measured bone density parameters (BMD, vBMD and TrD) were found to range between $r = -0.58$ ($P<0.05$) to $r = -0.87$ ($P<0.05$) for both MRI scanners. Additionally, the T_2^* relaxation time correlated with the age of the examined women, $r = 0.59$ to 0.67 ($P <0.05$), especially for the region of the tibia.
Conclusion. T_2^* measurements can assess changes in bone status related to bone mineral density and age, between premenopausal and postmenopausal women with osteoporosis.

Inter – comparison of resolution assessment methods and their effect in image quality parameters

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Keywords: MTF, DQE, CMOS, Gd_2O_2S:Pr,Ce.F

The aim of the present study was to examine the influence of image quality software on the resolution assessment and subsequently the calculation of the Detective Quantum Efficiency (DQE) and the Information Capacity (IC) of digital imaging detectors. For the purposes of this study, three image quality software tools were used to assess the Modulation Transfer Function (MTF) of a CMOS digital imaging optical sensor coupled to custom made gadolinium oxysulfide powder scintillators, doped with praseodymium, cerium and fluorine (Gd_2O_2S:Pr,Ce,F). The screens, with coating thicknesses 35.7 and 71.2 mg/cm^2, were prepared in our laboratory from Gd_2O_2S:Pr,Ce,F powder (Phosphor Technology, Ltd) by sedimentation on silica substrates and were placed in direct contact with the optical sensor. Furthermore image quality was also determined through single index (Information capacity) and spatial frequency dependent (Detective Quantum Efficiency) parameters, through the MTF and the Normalized Noise Power Spectrum (NNPS). The MTF was measured using the slanted-edge method. The CMOS sensor/Gd_2O_2S:Pr,Ce,F screens combinations were irradiated under the RQA-5 (IEC 62220-1) beam quality. The detector response function was linear for the exposure range under investigation. Under the RQA-5 conditions, at 70 kVp, discrepancies in the MTF values, in the region from 1 to 4 cycles/mm, were observed for the 35.7 mg/cm^2 screen/CMOS combination. For the second configuration (71.2 mg/cm^2/CMOS combination), systematic discrepancies, for spatial frequencies up to 5 cycles/mm were observed, which may be due the screen non-uniformities. DQE of the 35.7 mg/cm^2 screen/CMOS combination was found to maximize in the medium spatial frequency range and drop thereafter.

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Authors wish to thank Dr. Stratos David for his contribution in the assembly of the scintillator and pixel value uniformity of the detector.

Dose Area Product to Effective Dose conversion factors for Vertebroplasty performed at a 3D Rotational Angiographic Unit and a Conventional Angiographic unit

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Keywords: Vertebroplasty

Vertebroplasty (VP) is a minimally invasive technique for treating vertebral body fractures. During the procedure fluoroscopic guidance is required which is associated with significant radiation exposure. This study aims at extracting dose-area-product (DAP) to effective dose (ED) conversion factors for VP performed with a 3D rotational angiographic unit (3D-RA) and a 2D conventional angiographic unit. Procedure outcome verification is achieved by 3D rotational acquisition and abdomen- pelvis CT, respectively.

Thermoluminescent dosimeters (TLDs) were placed in positions corresponding to critical organs of the RANDO male phantom which was irradiated at a 3D-RA fluoroscopy unit and at a conventional angiographic unit, under conditions simulating VP. During the procedure, lateral and antero-posterior (AP) projections were acquired and DAP values were registered. DAP to ED conversion factors were calculated after deriving ED according to ICRP103.

The DAP to ED conversion factor estimated from the phantom irradiation, was 0.356 $\frac{mSv}{Gy.cm^2}$ *for lateral and AP projections and 0.225* $\frac{mSv}{Gy.cm^2}$ *for 3D acquisition, at the 3D-RA unit. At the conventional angiographic unit, the conversion factor for the lateral and AP projections was 0.168* $\frac{mSv}{Gy.cm^2}$ *.*

Patient ED associated with VP can be estimated using the extracted conversion factors, whilst the ED related to the verification CT can be estimated using published k-factors.

Peptide receptor radionuclide therapy (PRRT) in patients with metastatic neuroendocrine tumors efficacy – safety issues

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Keywords: Peptide receptor radionuclide therapy, neuroendocrine tumors.

Purpose: Treatment with radiolabelled somatostatin analogues, ^{90}Y-DOTATOC or177 Lu-DOTATATE, is a valuable tool for the therapy of metastatic or inoperable neuroendocrine tumors (NETs) as it can lead to an effective reduction of the severe symptoms of these tumors (such as diarrhea, vomiting and flushing) and tumor regression. The aim of this study is to evaluate the clinical, radiological and biochemical response, as well as the safety of peptide receptor radionuclide therapy (PRRT).

Material and Methods: The study evaluated 19 patients (14 patients with gastroenteropangreatic tumors - GEP-NETs, 3 patients with lung carcinoid and 2 patients with medullary thyroid carcinoma) with histologically-proven well differentiated metastatic or inoperable NETs, somatostatin receptor scintigraphy positive lesions, measurable on CT or MRI, at a follow up time of 3-36months. 13 patients were treated with ^{90}Y-DOTATOC (total dose of 13.3 GBq) and 6 patients were treated with ^{177}Lu-DOTATATE (total dose of 29.6GBq). The co-administration of amino acids was given to all patients for renal protection.

Results: Clinical response occurred in 63%. Radiological response was achieved in 42%. Biochemical partial response was observed in 37%. Toxicity occurred in 3 patients of ^{90}Y-DOTATOC treatment.

Conclusions: This therapy is well-tolerated and induces clinical improvement and tumor regression.

Assessment of the contrast to noise ratio (CNR) in Positron Emission Tomography scanners with Monte Carlo methods

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Keywords: PET; CNR; image quality; Monte Carlo

The aim of the present study was to assess the contrast to noise ratio (CNR) of PET scanners through a thin layer chromatography (TLC) plane source. The source was simulated using a previously validated Monte Carlo model. The model was developed by using the GATE MC package and reconstructed images obtained with the STIR software for tomographic image reconstruction. The PET scanner simulated was the GE DiscoveryST. A plane source consisted of a TLC plate, was simulated by a layer of silica gel on aluminum (Al) foil substrates, immersed in 18F-FDG bath solution (1MBq). Image quality was assessed in terms of the CNR. CNR were estimated from coronal reconstructed images of the plane source. Images were reconstructed by the maximum likelihood estimation (MLE)-OSMAPOSL. OSMAPOSL reconstruction was assessed by using various subsets (3, 15 and 21) and various iterations (2 to 20). CNR values were found to decrease with increasing iterations and subsets. The simulated PET evaluation method, based on the TLC plane source, can be useful in image quality assessment of PET scanners.

Development of the RF front – end for a multi-channel microwave radiometer for internal body temperature measurements

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Keywords: RF Frond-End, Radiometer, Dicke Radiometer, Microwave Thermograph.

Microwave Thermograph (MT) is based on measuring the electromagnetic field spontaneously emitted by a body in micro-wave frequency range. In microwave radiometers, temperature measurement is made by measuring the thermal noise power. The primary module that is used for detecting this thermal noise power is the RF-Front, which must meet very challenging requirements in terms of accuracy for measuring the noise power at the input of the receiver. The work that will be presented here will exhibit the design approaches and specifications as well as the tradeoffs and performance criteria towards the development and prototyping of the RF-front End for a Multi-Channel Microwave Radiometer for internal body temperature measurements in the 1-4GHz frequency bands. The RF-front End is intended to be integrated and be a part of a full Microwave Radiometer device that targets early detection of malignant tumours. The latter relate with the increase of temperature in cancerous cells and the precise detection of the temperature difference is the goal of the radiometer.

The work can be presented as Oral or Poster, depending on the organizers' decision, but a poster demonstration is preferred.

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Estimation of the scattered energy spectra reaching the eye lens of the medical staff during interventional radiology: A Monte Carlo simulation study

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Introduction: In 2012, the International Commission on Radiological Protection has recommended a reduction of the dose limits to the lens of the eyes for occupational exposure. Recent studies showed that in interventional rooms is possible to reach these limits especially without using protective equipment. The aim of this study is to calculate scattered energy spectra distribution at the level of the operator's head.

Materials and Methods: An in-house developed Monte Carlo-based computer simulation code was used to design computational phantoms (patient and operator), the geometry of irradiation as well as to simulate the photon transport through the designed system. The computational phantoms were designed by simple geometrical primitives. Elemental compositions of the tissues for all the phantoms as well as their dimensions were adapted from ICRP 110. The initial spectra from 70 kV tube voltages and different filtrations were calculated according to the IPEM Report 78. Incident exposure was set to all data processing and visualizations were realized with Matlab 8.1.

Results: The scattered radiation distribution for 70 kV tube voltage and different filtrations of the X-Ray unit, typical for clinical conditions was recorded and compared to the initial spectra. Some of the results are shown in figure 1 for a total filtration of 3 mm Al and additional 0.9 mm Cu (figure 1a) and 3 mm Al and 0.3 mm Cu (figure 1b). Mean and effective energies for these scattered spectra were 37.5 keV and 30 keV for the case with 0.9 mm Cu, and 35.9 keV and 29 keV for the case of 0.3 mm Cu, respectively.

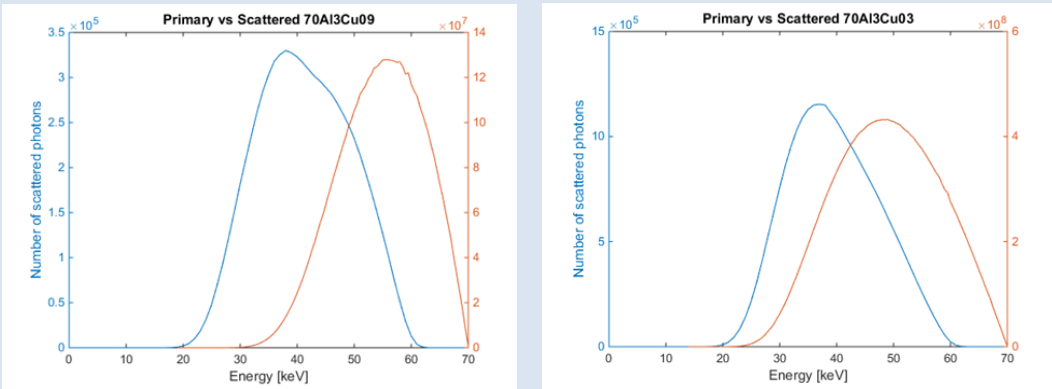

Figure 1: Comparison of primary and scattered at the level of the operator's head photon fluence for (a) 70 kV tube voltage and filtration of 3 mm Al and 0.9 mm Cu, while (b) 70 kV tube voltage and filtration of 3 mm Al and 0.3 mm Cu.

Discussion: The radiation fields in practice are complex and depend on equipment characteristics. The defining a scattered energy distribution in practice is difficult task. At the other hand knowledge of the quality of scattered radiation is important for radiation protection and practical occupational dosimetry of medical staff.

MARK1 – Early stage detection of melanoma through a smartphone compatible designed decision support application

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Keywords: melanoma, skin cancer, pattern recognition, MARK1

Malignant melanoma is the most deathful skin cancer in which melanocytes in the epidermis undergo malignant transformation. The main cause of melanoma is due to a long exposition to ultraviolet radiations, although skin type or other genetic factors can influence too. The most effective treatment is an immediate extirpation, but just when the melanoma had been detected in early phases. MARK1 project is a co-funded GREECE-ISRAEL research cooperation that aims in developing a self-examination platform/application able to adjust in commercial smartphone or handheld devices for facilitating early stage detection of melanoma. MARK1 will incorporate image processing, image analysis and pattern recognition techniques for mole identification, analysis and classification. The application will be linked with the medical specialist who will be able to advice regarding the urgency for a medical examination. In this way, MARK1 aims in early and accurate screening of melanoma by an easy to use technology accessible by general public, in order to enable fast, offline supervision of suspected moles by the health care specialist for detecting the disease at its early stages, when it is more vulnerable to available treatments.

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A Graphical User Interface for Mapping and Modeling of a Single-Channel Passive Microwave Radiometry Imaging

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Keywords: Microwave radiometer imaging, Graphical User Interface, Temperature map

Passive Microwave Radiometry (PMR) measures the electromagnetic field spontaneously emitted by the human body in the microwave frequency range. The radiation intensity is proportional to tissue temperature, thus, rendering the measurement of internal human tissue temperature plausible. In the present study, a computer software has been designed for modeling single-channel PMR imaging. The software employs Graphical User Interface (GUI) to handle major modules for communication, data management, processing and analysis. The communication module is responsible for data exchange with the radiometer via a Universal Serial Bus connection. The data management module provides capabilities for saving incoming data and related images through a database infrastructure. The processing and analysis module is responsible for computations related to brightness temperature reconstruction and visualization. The latter provides the ability to view the reconstructed temperature distribution in one, two, or three dimensions, to display multiplanar reconstructions in sagittal, coronal, or transverse planes, and to map temperature isosurfaces. The developed PMR-imaging simulation software was employed to reconstruct and map temperature distribution of a breast model with a lesion. Different scenarios were considered for detecting the existence of lesion concerning lesion size and site in the breast, PMR-detector position, number of PMR measurements involved in temperature reconstruction, and different noise levels.

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Pediatric chest HRCT using the iDOSE hybrid iterative reconstruction algorithm: which iDOSE level to choose?

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Keywords: iDose, iterative reconstruction, image quality, chronic bronchitis, HRCT, children

Purpose: To determine the appropriate iterative reconstruction (IR) algorithm level that combines image quality and diagnostic confidence, for pediatric patients undergoing high-resolution computed tomography (HRCT).

Materials and Methods: During the last 2 years, a total number of 20 children up to 10 years old with a clinical presentation of chronic bronchitis underwent HRCT in our department's 64-detector row CT scanner using the iDose IR algorithm, with similar image settings (80kVp, 40-50 mAs). CT images were reconstructed with all iDose levels (level 1 to 7) as well as with filtered-back projection (FBP) algorithm. Subjective image quality was evaluated by 2 experienced radiologists in terms of image noise, sharpness, contrast and diagnostic acceptability using a 5-point scale (1=excellent image, 5=non-acceptable image). Artifacts existance was also pointed out.

Results: All mean scores from both radiologists corresponded to satisfactory image quality (score ≤3), even with the FBP algorithm use. Almost excellent (score <2) overall image quality was achieved with iDose levels 5 to 7, but oversmoothing artifacts appearing with iDose levels 6 and 7 affected somehow the diagnostic confidence.

Conclusion: iDose level 5 enables almost excellent image quality without considerable artifacts affecting the diagnosis. Further evaluation is needed in order to draw more precise conclusions.

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Protein mass spectrometry analysis for prostate cancer biomarkers identification

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Keywords: prostate cancer, mass spectrometry, pattern recognition, PROSPECTRA

Prostate cancer is the second leading cause of cancer deaths in United States and Canada. The most widely used method for prostate cancer detection is the measurement of the prostate specific antigen (PSA). The PSA diagnostic test exhibits high sensitivity. However, its low specificity confines its use as an early detection biomarker. Mass Spectrometry (MS) data analysis helps on understanding the correlation between proteins/peptides and various diseases as well as the early cancer diagnosis. In most recent studies the correct classification rate between normal and cancerous MS cases is high; however, the identification of the protein subgroup, as they appear in MS spectrum, that provides the maximum separation and, at the same time, is connected to prostate cancer, so it could be used as a reliable biomarker for the specific disease, is still an open research field. PROSPECTRA is a research funded project organized in the Department of Biomedical Engineering of the Technological Educational Institute of Athens, Greece, that introduces new methods to solve problems related to MS biosignals processing, using publicly available data by means of a pattern recognition system that is being developed for the classification between of normal and cancerous prostate MS spectra, in order to estimate the possibility of locating possible biomarkers for prostate cancer.

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Implementation of a control system in Laser induced fluorescence (LIF) measurements of skin tissue samples and screen phosphors

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Keywords: LIF, fluorescence, clinical spectroscopy

Laser Induced Fluorescence (LIF) is a spectroscopic method, widely and successfully used as optical complementary techniques in medicine, in order to characterize chemical, physical and optical properties in skin tissue and to investigate changes for diagnostic purposes. The non-invasiveness of this method is a key advantage, making it an important tool in research and early diagnosis of skin lesions in screening tests with which a medical decision can be greatly facilitated. In this work, we present representative and characteristic LIF spectra of skin samples in situ, with a developed improved control system. This system is based on a RISC microcontroller technology, which was programmed to regulate the trigger between the laser pulse and spectrometer readings, adjust parameters like time delays, pulse intensity, energy etc accordingly and control the probe head. This developed microcontroller system provides a relative low-cost tool for LIF spectroscopy purposes, and it is a forerunner for the development and the composition of a mobile, clinical spectroscopic apparatus.

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X-ray dual energy spectra optimization for bone Calcium/Phosphorus mass ratio estimation

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Keywords: Ca/P ratio, dual energy, osteoporosis

Calcium (Ca) and Phosphorus (P) bone mass ratio has been identified as an important, yet underutilized, risk factor in osteoporosis diagnosis. The purpose of this simulation study is to investigate the use of effective or mean mass attenuation coefficient in Ca/P mass ratio estimation with the use of dual-energy method. The investigation was based on the minimization of the accuracy of Ca/P ratio, with respect to the Coefficient of Variation of the ratio. Different set-ups were examined, based on K-edge filtering technique and single X-ray exposure. The modified X-ray output was attenuated by various Ca/P mass ratios resulting in nine calibration points, while keeping constant the total bone thickness. The simulated data were obtained considering a photon counting energy discriminating detector. The standard deviation of the residuals was used to compare and evaluate the accuracy between the different dual energy set-ups. The optimum mass attenuation coefficient for the Ca/P mass ratio estimation was the effective coefficient in all the examined set-ups. The variation of the residuals between the different set-ups was not significant.

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The role of near infrared fluorescence imaging in minimally invasive surgery a systematic review

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Keywords: near infrared fluorescence imaging, minimally invasive surgery, anatomy identification, tumor localisation

Aim:Intraoperative imaging using infrared fluorescence light (NIRF) is a novel technique with putative applications in minimally invasive surgery. This systematic review aimed to investigate the role of this imaging modality in conventional laparoscopic and robotic-assisted surgery. Methods: Electronic databases were searched with the keywords 'NIRF, minimally invasive surgery, laparoscopic surgery, robotic-assisted surgery', for the time period up to and including March 2015. Inclusion criteria: Full publications providing evidence on the possible applications of NIRF in minimally invasive surgery. Results: Initially, sixty possibly relevant articles were identified. Abstracts were reviewed and finally nineteen papers met inclusion criteria and were retrieved in full text. Eight papers were experimental studies and the rest were small clinical studies, case series or case reports. NIRF contrast agents used were indocyanine green and methylene blue. Possible applications of NIRF include: vascular and biliary anatomy visualization, ureter visualization, intraoperative tumor identification and demarkation, sentinel lymph node mapping. Conclusions NIRF imaging could improve the safety of minimally invasive surgery through anatomy delineation. NIRF imaging could improve the oncological outcome of minimally invasive surgery enabling the radical resection of primary tumors, lymph nodes and metastatic lesions. However, further research is needed for the standardization of the technique, invention of contrast agents, validation of efficacy and safety.