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Abstracts from the 36th Workshop Organized by the BSBPE

Modeling of tumor growth: Preliminary developments

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The aim of this work is modeling the growth of three-dimensional tissue lesions, whose models and X-ray images are of crucial interest in research activities dedicated to improving diagnostic imaging of the mammary gland. The starting point is to model a section of a human tissue as composed of cells with anatomically true dimensions and location. The modelled healthy tissue is initially visualized and then the user triggers the lesion growth. The focus of the software application is the growing process of the tumor formation modelled as a process of gradually conversion of neighboring healthy cells to abnormal such. As a consequence, the healthy cells undergo transformations and change their properties to abnormal ones. The geometrical primitives used to model the cells are spheres. The sphere is a quadric surface and is easily visualized by exploiting the OpenGL library. The program is written in the C++ programming language and run under Windows platform. The application starts with the initialization of a tissue segment, approximated as a parallelepiped with a size, set by the user and filled with healthy cells with a specific radius (6 μm). One of these cells is then randomly sampled to become abnormal and the abnormal process begins. The cells when turning their properties to cancerous are also visualized in the three-dimensional space where they can be examined closely. The modeled tumor formations are intended for use in X-ray imaging research. Both, computational models and images are dedicated for developing of CAD applications for cancer detection and characterising, for development of machine learning algorithms to classify human breast tissues, as well as to speed up the development and optimization of new diagnostic procedures based on X-rays.

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Realistic breast phantoms with segmented real tumour formations from tomographic images

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A common approach in the development and improvement of diagnostic imaging techniques is the use of anthropomorphic phantoms. These phantoms can be physical or computational. In this study the creation of computational breast phantoms with included pathological formations is presented. The creation of the realistic phantoms is achieved by utilizing real patient data in the form of tomographic images. The 3D tumour models are generated by segmenting the regions containing tumour formations in the patient images. The segmentation is performed with a developed software tool based on a semi-automatic algorithm, which makes use of a series of image processing and region growing techniques. The software tool also provides the user an opportunity for corrections after the automated segmentation. Then the acquired flat images are stacked in a 3D voxel matrix. Creation of the computational healthy breast model as well as the compression procedure is achieved with a software tool called *BreastSimulator*. The healthy breast model and the segmented tumour formation are then interactively combined with a software tool called *XRAYImagingSimulator*. While the user can select a location for the tumour formation, also an automatic software processing is applied for integration between the two computational models. The simulation procedure for acquiring tomographic images from the created realistic breast phantom with included tumour formation is performed with the *XRAYImagingSimulator* software tool. Finally, the acquired simulation images are reconstructed with a software tool called *FDKR*. The combination of mathematical models of the breast and tumour models segmented from real patient data leads to the creation of realistic breast phantoms, which can be used in X-ray imaging simulation studies. The presented approach gives an opportunity for generation of multiple cases of breast cancer; thus allowing for further progress in already existing software models and techniques in diagnostic imaging.

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Testing of lead clothing in X-ray department

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Purpose. To test and implement a simple approach for examination of the suitability of the lead clothing used for protection of the staff in X-ray departments.

Materials and methods. According to European and Bulgarian legislation each X-ray has to be equipped with enough protection clothing. Every year these clothing have to be examined for defects which could lead to over exposure of the staff. A simple method for testing and rejection of the clothing was presented from Brian Philips et al. This method comprises several steps for examination together with rejection criteria for lead apron, thyroid shield and Gauntlet.

Results. Because of the daily use in most of the clothes defects were observed. The size of some of the defects could cause overexposure and overrun of the year dose limit of 20 mSv. Therefore these clothes were rejected and replaced with new.

Conclusions. Examination of the lead clothing must be included in every quality assurance program. This will keep the occupational exposure below the year effective dose limit.

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Automated dose tracking in CT of the chest

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Purpose. To present a detailed optimization process of automated radiation dose tracking data in standard CT chest examination for multi detector computed tomography (MDCT). Tasks resulting from such a goal are related with correct processing of collected data, deep analysis and interpretation of the data, identification of incorrect clinical practice and to compare the results with another radiology department practice.

Materials and methods. A single retrospective study was conducted involving regular enrolled patients for routine CT chest examination in Acibadem City Clinic Tokuda Hospital. All MDCT exams were performed on a 64-detector row computed tomography (LightSpeed VCT, GEHC) without any iterative reconstructions. The tube voltage (kV), slice thickness (mm), rotation time (s/rot) and table speed (mm/s) were periodically altered parameters according to radiation dose reduction without compromising the quality of the image. In the course of the study a web-based dose management software was used (DoseWatch, GEHC) which allows all MDCT chest examinations to be properly tracked and radiation doses to be collected.

Results. After the step by step optimization the $CTDI_{vol}$ and DLP were decreased to 9,20 mGy and 373,77 mGy.cm respectively while maintaining good diagnostic image quality. In comparison with Acibadem City Clinic Cancer Centre (Optima CT660, SS40 ASIR, GEHC) these values are slightly higher which is explained by the fact that in Optima CT660 an iterative reconstruction algorithm was systematically used ($CTDI_{vol}$6,43 mGy and DLP 265,2 mGy·cm).

Conclusions. The CT chest radiation dose was reduced with 56% ($CTDI_{vol}$) and 63% (DLP) with preserving the diagnostic image quality. A significant CT chest dose reduction was achieved even without using any iterative reconstruction algorithm.

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An approach of modelling of irregular masses

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The goal of this study is to create and evaluate a methodology for generation of realistic 3D computational models of breast tumours with irregular shapes.

Methods. The methodology for the creation of breast masses consists of two steps: (a) creation of the initial diffusive tumour shape, by choosing Brownian motion or nearest neighbour random walk algorithm, (b) creation of a solid tumour shape by applying a set of 3D filters, and morphological operations. The initial models were smoothed by applying a set of image processing methods. Thereafter, projection images of these 3D lesions were generated by using an in–house developed software, capable to simulate the X-ray transport through the computational phantoms. Subsequently, a technique for embedding the simulated masses in patient mammography images was developed and applied.

Results. Thirty irregular masses with different sizes and shapes were generated, and projection images were simulated. The realism of the projected masses on patient images was evaluated by comparison of extracted features, such as the exponential parameter of the power spectrum, fractal dimension and other statistical parameters to these extracted from patient data. The obtained results confirmed that the methodology is capable of producing realistic 3D tumour models with user defined sizes and irregular shapes.

Conclusions. The methodology will be used to generate unique and realistic in shape and size computational models of breast adenoma, intraductal papilloma, cysts and duct hyperplasia. These computational models are stored in an open source database to be used by all professionals working toward the creation of new technologies for breast-screening and diagnosing.

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Breast awareness mobile application

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The main purpose of this work is to present the development of a mobile application to assist the women with breast cancer prevention. The mobile application is implemented using React Native - a JavaScript framework for building natively rendering mobile applications for iOS and Android. The RESTful API is implemented using Node.js - an open-source, asynchronous, event driven, cross-platform JavaScript run-time environment. MongoDB - a NoSQL, document-oriented database is used as a database. The platform starts with a questionnaire related to the user and her family. After the quiz, the application assesses the user's risk of breast cancer and provides advices how often a specialist should be visited. The questions, as well as all other information supplied by the application, are currently under review and evaluation by radiologists. Under development is as well a system for archiving the user's medical examination results. In addition, all the necessary information about prophylaxis, self-exam, symptoms, stages, risk factors, etc. is provided in an interactive way. For instance, there is a dedicated panel for implementing a breast self-exam, which is important action towards finding first signs of any breast abnormality. The provided drawings and running text assist the users to easily perform this