Modeling of radiation dose of human head during CT scanning using neural networks

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Abstract — **In this study the authors present the method for determination of exposure dose on human head during computer tomography (CT) scanning procedure. The method is based on the use of the feed-forward neural network (FFNN) model to predict the exposure dose on human head. The neural network with Levenberg–Marquardt learning is constructed. The training data are obtained using the Monte Carlo method simulation. The simulation is performed by generating random numbers for determination of photon direction and for quantification of interaction between X-ray photon and head tissue. Spectra of photon energy is used for 3DCT scanner, X-ray tube Model XRS-125-7K-P. The FFNN predicted values are in accordance with the values obtained by the simulation with correlation coefficient around 0.99.**

I. Introduction

COMPUTED tomography (CT) scans contribute to (35-45) % of the total radiation dose to the patient population [1,2].

Further research into the complex relationship between radiation exposure, image quality, and diagnostic accuracy should be encouraged, in order to establish the minimum radiation dose necessary to provide adequate diagnostic information [3].

Protection of patients during scanning procedure is the main requirement during imaging procedure and design of CT devices. The one way to minimize radiation dose is to better understand mechanisms of dose absorption and factor like construction of X-ray device, CT detector characteristics and patient tissue properties. Dose reduction can be achieved using appropriate filterers [4,5] suitable reconstruction algorithms [6,7] or special mode of X-ray source operation [7].

The main goal of our previous research is estimation of the absorbed radiation dose using Monte Carlo simulation of X-photon transport in head tissue of the patient [8]. For simulation we have created geometrical model from CT images. The model is divided into a number of regions with realistic dimensions and attenuation coefficients obtained from spectra data and grayscale level of images being used.

The Monte Carlo method consumes a lot of computation time and one way to avoid this problem is application of machine learning techniques [8]. Artificial intelligence techniques have been recognized as a powerful tool which is tolerant of long computational time, imprecision and uncertainty.

In [9], [10] the radiation dose is determined using the Artificial Neural Networks (ANN).

In this paper the radiation dose of CT scanner is obtained using the Feed-Forwarded Perception Neural Networks. The training database is generated using Monte Carlo simulation of interaction between photons and head tissue. The head tissue is approximated by the ellipsoid with corresponding semi-principal axes length as input data. Output data of neural network is radiation dose given as the number of absorbed photons in tissue.

II. Computer Tomography

A. Basic Relation

Computer tomography (CT) is a non-destructive method for characterizing 3D objects by using X-ray radiation. This method is based on the differences in attenuation coefficient of X-ray beams for various materials and tissues. The final result is a grey level CT image where corresponding grey level is proportional to attenuation coefficient.

CT medical imaging includes exposure of the object of radiation at one side and detecting attenuated radiation at the other side of the object and this procedure is repeated from more than one direction. The next step is image reconstruction from the projection by using a number of algorithms. These techniques are mainly based on solving systems of integral equations which are formed as a result of total attenuation of the radiation beam from the source to the detector. Monochromatic X-ray reduction for homogenous materials is given by the relation

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