Multimodal Imaging for PET Attenuation Correction

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***Abstract*—In this study different methods of medical imaging are considered along with the possibility of combining information offered by them. One of the techniques of special interest is positron emission tomography (PET). This medical imaging technique gives information about metabolic processes in the human body. One of the main defiance of this method is attenuation of gamma photon in interaction with tissues and organs inside the body. This phenomenon can be fixed by the attenuation correction factor. The factor can be obtained using Computerized tomography (CT) imaging with aim to map PET image with linear attenuation coefficient. The PET and CT images are matched using image registration technique which provides determination of attenuation coefficient space distribution. Using the attenuation coefficient the pixels intensity of PET image can be scaled by the reciprocal value of attenuation coefficient with propose of attenuation correction.**

I. Introduction

The medical imaging is a basic technique in diagnostics and decision making in medicine. The medical imaging methods based on the obtained information about human body primarily use electromagnetic radiation. The large progress in medical diagnostic has been made with the development of nuclear medicine. The nuclear medicine is based on using radio nuclide which emits product of nuclear decay, usually gamma quant, which can be detected by the detectors. PET is an important imaging method in nuclear medicine area [1]. This technique uses positron annihilation process for detecting some metabolic processes in human body. This method, when the radiation source is positioned into the patient body, is one of the emission techniques. A radiation technique uses radiation source outside the human body. Emitted radiation interacts with tissues and organs and its attenuation can be obtained by detector. CT imaging is the most common radiation technique where the radiation source is X-ray tube [2]. The Magnetic Resonance Imaging (MRI) is technique complementary to CT which gives information of tissue structures using external magnetic field and radio frequency radiation [3]. Using only one medical imaging technique in many cases can not give sufficient data for medical decision support. This fact causes the need for using multimodal imaging method.

II. Multimodal Medicine Imaging

The multimodal imaging means the combination of the different methods of medical imaging with the aim to obtain more quality information of the human body.

A. Computerized tomography (CT)

Computer tomography is a standard radiology method for 3D object scanning 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 [4].

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 techniques. All of these techniques are 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. Attenuation of X-ray radiation in the homogenous media with linear attenuation μ is given by relation:

$$I = I_0 e^{-\mu \cdot d} \tag{1}$$

where I_0 is intensity of initial radiation, I is final intensity radiation after path length d in tissue with linear attenuation coefficient μ. If there are multiple materials, the equation becomes:

$$I = I_0 e^{-\sum_i \mu_i d_i} \quad . \tag{2}$$

Linear attenuation coefficient depends on X-photon energy; due to equations 1 and 2 are satisfied only for monochromatic beam.

If a polychromatic X-ray source is used, taking into account the fact that the attenuation coefficient is a strong function of X-ray energy, the complete solution would require solving the equation over the range of the X-ray energy (E) spectrum utilized:

$$I = \int I_0(E) e^{-\mu(E) \cdot d} dE \tag{3}$$

In CT practice examination the CT numbers also known as the Hounsfield units are used. The CT numbers are proportional to mean linear attenuation coefficient [5]. The CT number is defined as