Study of CT/MRI Mutual Information Based Registration Applied in Brachytherapy

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The present work aims to include magnetic resonance imaging (MRI) in a Medical Image-based Graphical platfOrm - Brachytherapy module (AMIGOBrachy) which coupled to the Monte Carlo N-Particle (MCNP6) code allows absorbed dose calculations. Computed tomography (CT) and MRI images were registered using mutual information algorithms to improve tissue segmentation potentially leading to a more accurate treatment planning system.

Keywords — **Brachytherapy, CT, Image Register, MRI, Mutual Information**

Brachytherapy (BT) is an advanced cancer treatment technique in which radioactive sources are placed in, or near, the tumor itself. This allows a high radiation dose in the tumor and reduces healthy tissues radiation exposure. The accuracy of the treatment plan depends on physical models and computer programs, which are directly related with the patient outcome. Recently, model-based dose calculations algorithms (MBDCAs) [1] have been made available. These are capable to handle tissue compositions/densities and other treatments complexities leading to more accurate dose distributions. Monte Carlo (MC) simulations have been proposed as an alternative to the implementation of MBCDAs due to their ability of achieve accurate radiation transport in realistic geometries. AMIGOBrachy is an MBDCA developed at *Instituto de Pesquisas Energéticas Nucleares*. It has been designed to create an user-friendly interface to integrate clinical treatment plans with MCNP6 [2]. This software provides the main resources required to process and edit images, import and edit treatment plans, set simulation parameters and analyze the results obtained.

Currently, CT-based patient geometry allows the assignment of interaction cross sections to each voxel using density-Hounsfield units (HU) calibrations curves. However, due to the limited soft tissue contrast and image artefacts (high-density materials in a scanned object can lead to streaking artefacts) proper tissue segmentation may not be possible only through CT images [3]. MRI images introduce several additional imaging benefits, especially because of the superior soft-tissue contrast compared with CT. Many studies have investigated MRI and CT registration [4]. In this context, the purpose of this work is to study CT-MRI mutual information (MI) based registration [4,5] to improve future modelling in AMIGOBrachy using accurate anatomical representations (CT images) and excellent tissue contrast (MRI images).

Image registration was performed using in-house algorithms developed using MATLAB software (Mathworks Inc., Natick, MA), version R2015. CT images were adopted as reference and MRI images as sensed [5]. The developed algorithm uses a two-step method. First, segmentation techniques are applied, such as: Thresholding, Growing Region and Resize. Then, transformation functions (rotation and translation) are used and a probabilistic approach based on voxel similarity (mutual entropy). Two images of the same patient were used in this study. The images were acquired in *Instituto de Câncer do Estado de São Paulo* (ICESP) for a gynaecologic treatment and were obtained immediately after inserting the applicator. The MI was determined for each translation and rotation in both x-axis and y-axis. The MI maximum value corresponds to the best fit between the images.

The initial results allow a qualitative study of anatomical representation and improve target volume and structure delineation in AMIGOBrachy. The registration of the images shows geometric differences between CT and MRI due to geometrical deformation (inherent to the MRI images). The next step of this study is to obtain tissue composition and density from MRI images and implement an image module in AMIGOBrachy software. These improvements will significantly expand AMIGOBrachy software capabilities contributing to a more accurate treatment planning system.

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