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Image registration methodology to quantify ROIS' volume transform accuracy

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Introduction Medical images registration is the process of superimposing two or more images of the same scene taken at different times, from different points of view, and / or by different sensors. This geometrically aligns two images, the reference one and the detected (mobile) image. In radiotherapy, the clinical evaluation of a treatment plan is performed by various methods, such as image analysis or patient's clinical condition, among others. At the Radiotherapy Department of Hospital Oncologico Cordoba - Argentina, a rather recurrent problem is a noticeable change in patient's anatomy during the normal course of his radiant treatment. This situation requires a new CT scan to go through a second or third stage in the treatment planning. Consequently, there are differences between the sets of tomographic images captured at different moments due to the discrepancies in conditions of imaging, either because of difficulties in reproducing the original positioning of the patient or because of the obvious change in some of its structures. Image registration plays a fundamental role in all medical image analysis tasks. From the TPS it is possible carry out a visual analysis of the images, and in some cases the volumes of the regions of interest (ROIs), structures that are linked to the tomography, are observed. This analysis is subjective and qualitative compared to the treatment planning topographies'. Then, three goals are to be achieved: 1. to obtain suitable reference frames to merge tomographic images obtained in different stages and / or positions; 2. to find a correlation between the volumes of organs at risk from both sets of tomographic images through the use of co-registration and image fusion methods; 3. to obtain a systematized tool that allows to make this comparison of volumes involved.

Materials and methods This work was carried out using a computer-based tool of free accessibility, known as 3D-Slicer, which is able to perform co-registrations by different methods: for instance, Mutual Information, co-registration based on structures delineated by the physician, or Self-segmentation, fiducial registration, Landmarks, etc. Thus, an analysis of the recorded images and their delineated structures (ROIs) is obtained. Then, by calculating the percentage error in structures' volume of organs at risk (EV%), it is possible to quantify the discrepancies committed in the delineation of the structures of interest between tomographic images with and without registration. The transformation after registration is considered to induce deformation, but not a change in the volume of structures of organs at risk. In addition it is possible to quantify the change in the volume of ROIs generated by the transformations after the registration has been applied.

Results Some image registration algorithms are sensitive to the deformations induced by the applied transformations, such as the General Registration (BRAINS), semi-automatic register and Affin Transformation, which were discarded for being unreliable. The search for a systematized co-registration tool capable to quantify errors leads us to answer the questions raised in each objective proposed, and the use of the Fiducial Registry and the EV% calculation method to quantify the accuracy of the registry and its precision, respectively. A measure of quantification in the co-registration of medical images was obtained using the structures related to the tomography as reference frame. Analyzing its deformation and its volume change after the registration, an accuracy assessment was obtained by means of the RMS error provided by the fiducial record, which gives us an idea of exactly how the method used, by the strategic location of Landmarks on bone or anatomical landmarks at tomography. Using the EV% calculation method as a versatile and simple tool for the quantification of the accuracy of the registration process and its transformation, it is possible to contrast the results obtained in unexpected volume changes (ROIs) in the transformations, and also in the selection of the chosen registry: Fiducial and Surface Registration (with Rigid and Similarity transformations).

Conclusions It was possible to obtain the reference'frames and quantify the

accuracy of the probable measurement as well as the precision of a registration algorithm and its transformations, from the study of structures of organs at risk. The results obtained could open the way of subsequent analyzes linked to Dose Volume Histograms (DVH), dosimetric validation by measurements and the use of other software to verify the reproducibility of the results.

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