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ABSTRACT

Purpose: To evaluate four different, volume-based, automatic image registration algorithms from two commercially available treatment planning systems (Philips Syntegra, BrainLab BrainScan).
Methods and Materials: Philips Syntegra provides Cross Correlation (CC), Local Correlation (LC) and Normalized Mutual Information (NMI) as optimization metrics. BrainScan applies Mutual Information (BSMI) as an optimization metric. These algorithms were evaluated with: 1) synthesis images, i.e., the images obtained by applying known transformations to a set of original CT images, 2) CT and MR phantom images, and 3) CT and MR head images from 12 different patients with brain tumors.
Results: For synthesis images, the registration results were compared with known transformation parameters and all algorithms achieved sub-millimeter accuracy in translation and sub-degree accuracy in rotation. For phantom and patient images, the registration results were compared with those provided by manual registration. The mean and standard deviation of translation and rotation errors for the phantom study were 2.0±1.1 mm and 1.7±1.0 degree respectively. For the 12 sets of head images in this study, NMI algorithm, with registration accuracy within 1.5mm and 1 degree, performed better than other algorithms (p-value 0.005). CC and BSMI performed poorly with potential errors close to 4mm and 3 degrees. We also noticed that LC and CC algorithms were much less robust and may fail to register when large translation and rotation were required.
Conclusion: All algorithms themselves can achieve sub-voxel accuracy for CT to CT registration of synthesis images. For clinical MR and CT image registration, the accuracy is much reduced, probably due to the intensity and voxel size differences between those images. In addition, Normalized Mutual Information based model appears to outperform other algorithms for registering MR and CT images of the brain.