High Intensity Focused Ultrasound Therapy Guidance System by Image-based Registration for Patients with Cardiac Fibrillation

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Transesophageal high intensity focused ultrasound (HIFU) energy can be used to treat cardiac arrhythmia efficiently and non-invasively. Since the esophagus is located just behind the heart, it offers a perfect acoustic window so that HIFU can be directed toward the heart to perform ablation. In a previous study a HIFU probe with one 2D-US image perpendicular to the esophagus axis for guidance purpose has been proposed. A new dual-mode HIFU probe with two perpendicular 2D-US imagining plane is now under development. In this paper we propose a therapy guidance system, based on an intensity-based registration of the two perpendicular 2D-US to preoperative 3D-CT. As a proof of concept we developed the following evaluation framework on a numerical phantom: 1) because the probe is under development we define a ground truth (GT) initial pose inside a CT volume and simulated two perpendicular US images from the CT data; 2) we run the registration framework from 55 randomly defined pose initialization around the initial GT pose; and 3) we estimated the accuracy of the registration by (a) the transformation parameter estimation errors (translation error and quaternion distance for rotation) and (b) Target Registration Error (TRE) on 8 features. The accuracy of the registration using two US plane has been compared to this of previous work with only one US plane. An improvement was observed when using two US planes with regards to the previous one US plane version. The median translation error is reduced from 1,5 to 0.7 mm, the rotation error reduced from 3.2° to 2.1° and the mean TRE reduced from 2.5 mm to 1.76 mm. Our future work aims at include phantom and real-patients data to evaluate the contribution of the registration scheme for the therapy guidance.