Automatic segmentation of the atrial region using a competitive deformable model approach

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1. Introduction

Multiple strategies have been proposed to segment the cardiac chambers. Nevertheless, accurate segmentation of the mid thin atrial walls is typically not achieved, limiting their application for biomechanical simulation and planning of inter-atrial interventions.

2. Materials and Methods

A competitive deformable approach was proposed to segment the atrial region (i.e. left atrium [LA], right atrium [RA] and aortic tract [AO]) [1]. The method starts by automatically initialize a set of contours (one for each chamber) through a fast and global atlas-based approach, being then refined to the patient anatomy based on image descriptors, namely edge and intensity transitions. In order to refine the contours' result in the thin mid atrial walls, a competitive strategy was applied. Specifically, when the distance between two contours is lower than a pre-defined threshold (expected wall thickness), a penalization force is applied to prevent fast contour evolution steps. The magnitude of the penalization force is adapted based on the distance between the contours. If the distance is high, a low penalization is applied, allowing the refinement to the anatomy. Otherwise, when the distance is too small, a high penalization is applied to prevent the overlapping of the contours.

The method was tested on a clinical database with 20 datasets. The automatic results were compared with manual contours delineated by one expert and the errors were assessed in terms of point-to-surface (P2S) distance. The advantages of the competitive approach were corroborated by comparing against the free evolution approach (i.e. without competitive strategy).

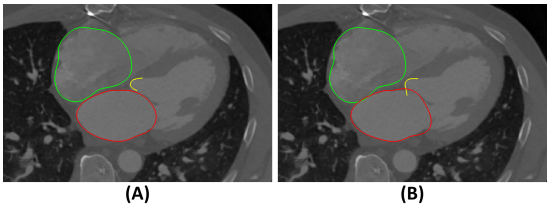

Figure 1: Segmentation result using the (A) Competitive approach and (B) free evolution strategy (Red – LA, Green – RA, Yellow – AO).

3. Results

A P2S error of 1.0±0.2|1.1±0.2 mm (LA), 1.7±0.4|2.1±0.7 mm (RA) and 0.8±0.5|0.9±0.5 mm (AO) was obtained by the competitive|free-evolution approaches. Figure 1 illustrates the advantages of the competitive approach when compared with the free-evolution approach.

4. Discussion and Conclusions

The competitive approach proved its added-value for the segmentation of the atrial region. It obtained a performance superior to the free-evolution approach, mainly at the thin mid atrial walls. The current solution shows potential to improve other methods for the planning of inter-atrial cardiac interventions or for their biomechanical simulation.

5. References

1. Morais et al., Medical Image Analysis 42:102-116 (2017).

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