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Meeting abstract

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1099 Fully automated segmentation of the left and right ventricles: validation with a large clinical trial

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Introduction

Segmentation of the left (LV) and right (RV) ventricles is required for clinical and research studies of cardiac function. Manual analysis by experts is time consuming and also susceptible to intra- and inter-observer variability. Automated segmentation of the LV and RV from SSFP images would remove these problems and allow powerful image segmentation algorithms to process the data prior to presentation to the clinician. Present segmentation techniques for cardiac MR images typically require user interaction or do not cater well for the RV.

Purpose

To develop a mathematical model based method to automatically segment the LV and RV endocardium and epi-

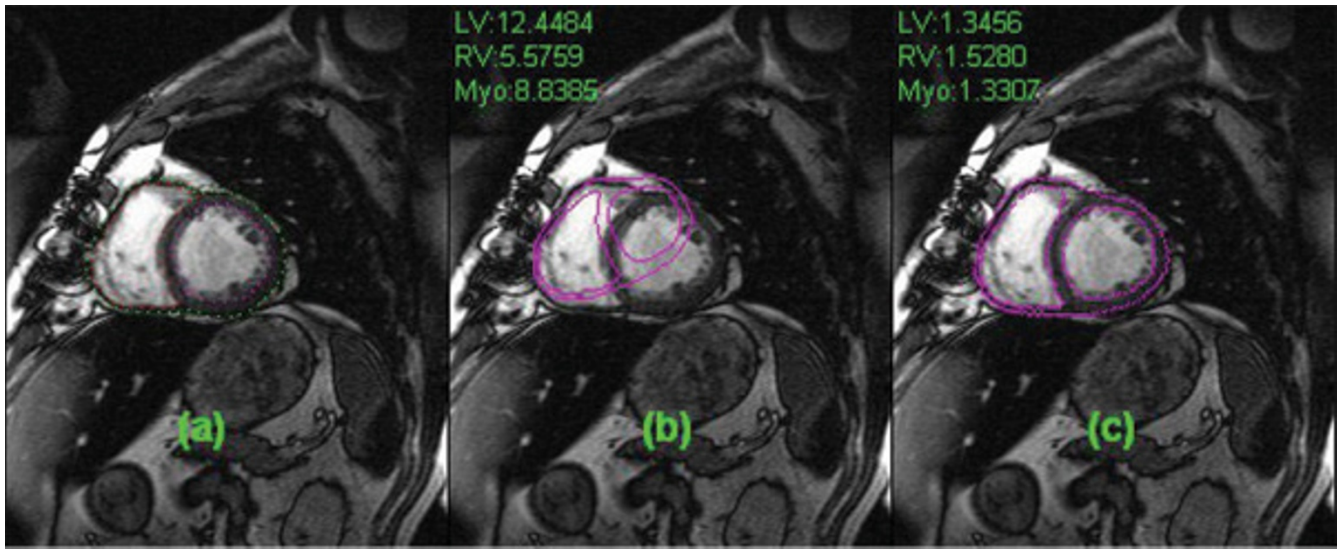

Figure 1
An example of middle SA slice fitting: (a) manual ground truth, (b) contour from initial model, (c) contour after atlas-based registration.

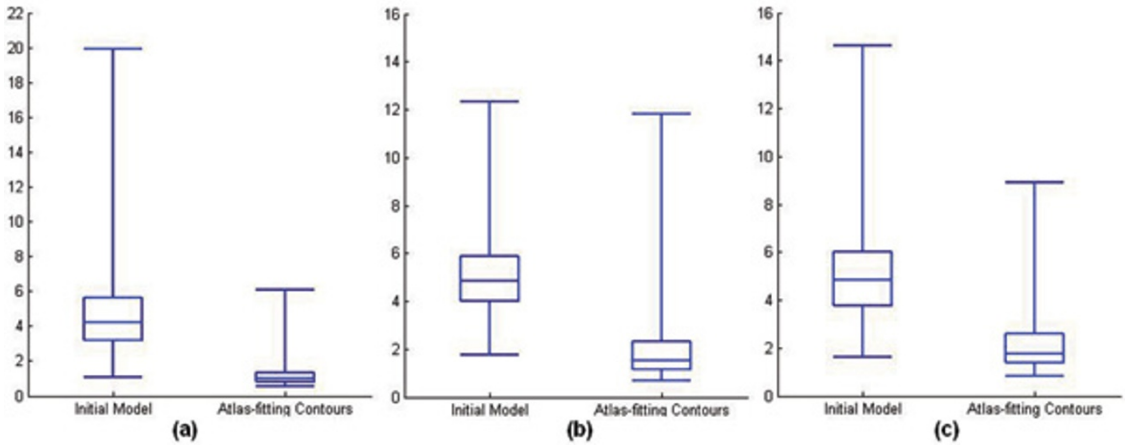

Figure 2
Box plot of the modified Hausdorff distance between automatic and ground truth contours in pixel units: (a) LV, (b) RV, (c) myocardium.

cardium in the middle short axis (SA) slice, and to validate the method in a large clinical trial.

Methods

A mathematical model of the LV, RV and myocardium at the mid-ventricular level was manually constructed from a randomly selected healthy volunteer. This was then automatically initialized and customized to the MR image data of each case. The method was applied to 330 high risk patients with vascular disease, enrolled in the ONTARGET Cardiac MRI substudy [1]. Studies were obtained at sites in six countries using a range of scanner manufacturers. Patient history included coronary artery disease (89%), hypertension (61%), myocardial infarction (58%), stroke (14%) and diabetes (34%). RV and LV contours were manually identified on all mid-ventricular slices to provide ground truth comparisons for validation. The fully automated segmentation methodology proceeded as follows: (1) The Fourier transform was calculated for each pixel through time and images representing the first harmonic (H1) at the frequency of the cardiac cycle were created for each of the short axis slices. The model was automatically located to its initial position based on the center and first eigenvector of the H1 volume [2]. (2) The middle SA slice was chosen and contours of the model endocardium and epicardium of the LV and RV obtained (Fig 1b). A new atlas-based registration framework was developed to integrate intensity, boundary and anatomical information into one system for contour refinement (Fig 1c).

Results

The method correctly identified the RV and myocardium in 327/330 cases, and correctly identified the LV in 328/330 cases. Figure 2 shows a quantitative comparison relative to the manually generated ground truth contours (Fig 1a) using the modified Hausdorff distances [3]. The results show the success of the localization of the initial position (mean +/- std: LV 4.68 +/- 2.42; RV 5.08 +/- 1.63; myocardium 5.07 +/- 1.82) and the improvement from the atlas-based registration step (mean +/- std: LV 1.17 +/- 0.58; RV 2.08 +/- 1.63; myocardium 2.21 +/- 1.35).

Conclusion

An efficient fully-automated method for the segmentation of the LV and RV endocardium and epicardium in the middle SA slice is proposed and has been validated using a large clinical dataset. Application of the method to other slices will be investigated in the future.

References

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