Automatic Segmentation in Dobutamine Stress Magnetic Resonance

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Introduction

In dobutamine stress magnetic resonance (DSMR), short-axis (SA) cine Cardiac MR (CMR) scans are made at different levels of pharmacologically induced stress. Comprehensive analysis of these scans is currently done visually, but would preferably consist of quantification of ventricular function and wall motion at all stress levels, which requires delineation of the myocardium in all acquired images. We have developed a dedicated analysis application that allows complete quantitative analysis of DSMR exams. The application includes an automatic segmentation algorithm, which exploits the close relation between the images from the scans at the different stress levels, to overcome the burden of time consuming manual delineation of all images.

Methods

Our new segmentation algorithm computes the cardiac contours for all stress scans given the cardiac contours at rest. The cardiac contours at rest can be obtained fast and accurately using the contour propagation algorithm described and validated in [1], such that only ED slices at rest need to be delineated manually. The new method consists of three steps. First, affine registration between the images from the different stress levels is performed. Next, contours are propagated from one stress level to another using active contours [1]. Then the resulting end diastolic cardiac contours are propagated from phase to phase. The result of this propagation over time is averaged with the result from propagation over the stress levels using the Repeated Averaging Algorithm (RAA) [3] to obtain coherent cardiac contours over time.

The accuracy of the resulting cardiac contours depends on the parameter settings used for registration and propagation. To obtain the most accurate parameter settings we analyzed the relation between the parameters using full factorial experiments and the Analysis of Variances (ANOVA). Our method was optimized and technically validated using images from DSMR exams from 10 patients. Cine CMR imaging with retrospective ECG triggering was used to acquire 25 phases for 3 SA slices at 3-6 levels of cardiac stress. All images were 256x256 in size and covered a field of view of 380x380 – 400x400mm. Golden standard delineations for all images were obtained by averaging four delineations from two experts using RAA (root-mean-square (RMS) inter-observer variance 1.11 ± 0.66 mm).

Results

The accuracy of the resulting cardiac contours after each step was measured in Root Mean Square (RMS) positioning errors (see table 1). Point correspondence was established using RAA [3]. The results of the complete algorithm have been split up for the separate cardiac contours in table 2. Examples of the resulting cardiac contours are given in figure 1.

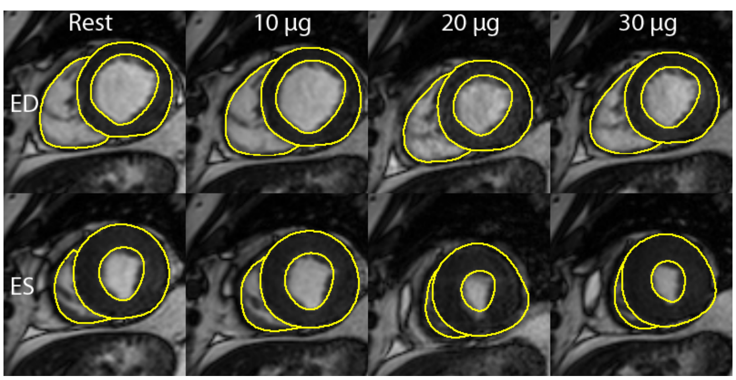

Figure 1: Examples of resulting cardiac contours for different levels of stress at ED and ES

	RMS Error (mm)
Transformation	6.13 ± 4.03
Registration	2.76 ± 1.97
Propagation (Levels)	1.41 ± 0.91
Propagation (Phases)	1.33 ± 0.92

Table 1: Average RMS errors for all cardiac contours after each step of the algorithm

	RMS Error (mm)
LV Endocardium	1.43 ± 0.97
LV Epicardium	0.94 ± 0.47
RV Endocardium	1.08 ± 0.59

Table 2: Average RMS errors for the cardiac contours

Conclusion

We have developed a new automatic segmentation algorithm for cardiac contours in DSMR exams. The RMS positioning errors of the resulting cardiac contours are within pixel dimensions.

References

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