A FULLY AUTOMATED REGISTRATION-BASED TECHNIQUE FOR SEGMENTATION OF THE LEFT VENTRICLE FROM CARDIAC MRI

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Background: Current techniques for computer-based left ventricular (LV) contour detection on cardiac MRI often require tedious manual contour initialization and editing. We aimed to develop a fully automatic and novel segmentation method for cine cardiac MRI based on cardiac motion detection and contour-to-image registration.

Materials and Methods: 20 cine MRI studies acquired with Fast Spoiled Gradient Echo (FSGPR/20) (GE, CVMR) and another 20 cases acquired with True-FISP (Siemens, Sonata) were considered. Short-Axis (SA) slice thickness was 6 mm on FSGPR and 10 mm on True-FISP images. Images contained 16 cardiac phases on FSGPR and 20 phases on True-FISP images. Mid-ventricular two-chamber (2-CH) and four-chamber (4-CH) cine images were also acquired and utilized for contour detection. Images were pre-segmented by heart localization based on cardiac motion as detected by voxel analysis of cardiac phases, optimal thresholding and 3D intersection of the SA, 2-CH and 4-CH views. The blood pool and endocardial contours were automatically identified by seeded region-growing with adaptive iterative thresholding. The epicardial contours were found with a novel contour-to-image registration technique that uses elastic hermite curves. Control points of the Hermite curves are initialized by expanding the endocardial borders and subsequently registered to the SA, 2-CH, and 4-CH cine-images using iterative simplex minimization of the global contour-image fit function. The cost function is based on spatio-temporal intensity constraints for the myocardium and assumptions about the LV shape and size. Hermite curves were created with 4 control points (16 parameters) for SA images and 3 control points (12 parameters) for 2-CH and 4-CH images. Initial tangent values and search ranges for the Hermite curves were initialized with the expected curvature based on the position of the control points and slice orientation. The SA control points were further constrained by the contours determined from the 2-CH and 4-CH views.

Results: The fully automatic segmentation was performed in 44 sec per study on a 2GHz PC computer. The average number of simplex of iterations per slice was 535 during the search of the optimal epicardial curve. The average difference between the manually and automatically determined end diastolic volumes was 15.3+-6.8 ml and between end systolic volumes was 4.6+-2.6 ml. Results of the segmentation are shown in Figure 1.

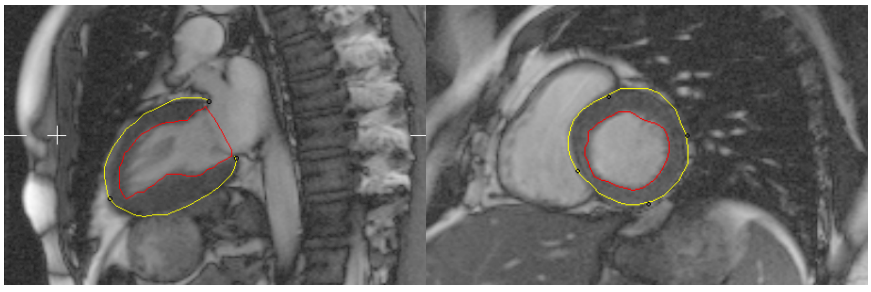

Fig 1. Results of epicardial (yellow) and endocardial segmentation on 2CH (left) and SA images (right). Black points show control points for Hermite curves.

Conclusion: Fully automated segmentation of the left ventricle from the cardiac MRI data using a motion detection and novel Hermite contour-to-image registration technique has been developed.