Journal of Cardiovascular Magnetic Resonance

Poster presentation

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Automated segmentation of left ventricle in cine cardiac mr images

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from 13th Annual SCMR Scientific Sessions
Phoenix, AZ, USA. 21-24 January 2010

Published: 21 January 2010

Journal of Cardiovascular Magnetic Resonance 2010, **12**(Suppl 1):P238 doi:10.1186/1532-429X-12-S1-P238

This abstract is available from: http://jcmr-online.com/content/12/S1/P238

Introduction

To quantitatively analyze global and regional cardiac function from MR, clinical parameters such as ejection fraction (EF) and volumes are required. These depend upon accurate delineation of endo- and epicardial contours of the left ventricle (LV). Accurate LV segmentation is acknowledged as a difficult problem because of the overlap between the intensity distributions within the cardiac regions, the lack of edge information, and the inter-subject variability. A novel method for the robust, accurate and fully automatic LV segmentation from short axis (SA) cine MR images is presented in this study.

Materials and methods

Imaging data (N = 153, 40 ischemic heart failure, 34 non-ischemic heart failure, 39 LV hypertrophy and 40 normals) were acquired from a 1.5 T scanner (GE CV/i Excite) with IR-SSFP SA cine MR. The segmentation algorithm consists of three stages for each data set. First, the LV centre is localized on a mid-ventricular slice image in the end-diastolic phase (starting image) by a roundness metric (Fig. 1). Second, the endocardial contour is detected by determining an optimal threshold and binary blood pool image, then the endocardial contour is smoothed by applying the fast Fourier transform (Fig. 2). Third, the epicardial contour is detected by mapping the pixels from Cartesian to polar coordinates, then region growing is used to get the contour. The contour is then smoothed by the fast Fourier transform (Fig. 3).

Results

The accuracy of LV location is 94.1%(144/153). The average computation time of LV location is 0.085 ± 0.013 s per subject. The average perpendicular distance (APD) between the detected and the manually drawn expert contours and Dice metric (DM) over slices and ES and ED phases are shown in Table 1. The average computation time of the segmentation is about 0.8 s per image for these 153 exams.

Discussion and conclusion

In summary, the proposed fully automated segmentation technique is fast, accurate and robust and should be of benefit for quantification of cine cardiac MR in clinical practice.

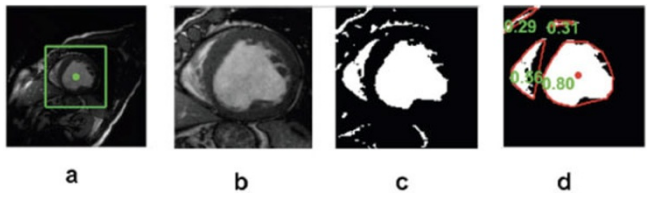

Figure 1
LV location procedure. A. Target images with rectangular ROI (green box and image center (green point), b. ROI image, c. Binary image, d. Surviving objects' convex hulls (red) and the corresponding roundness metric (green). The detected LV blood pool centroid is labelled as a red point.

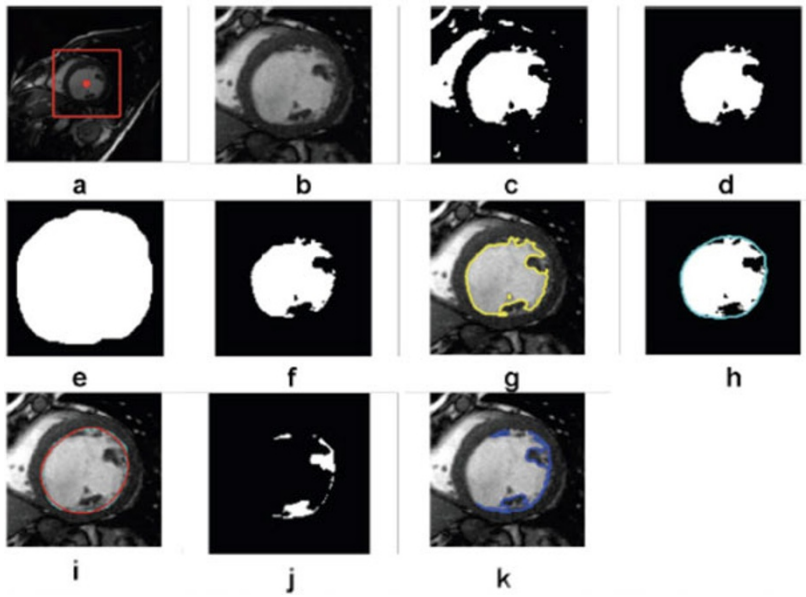

Figure 2
LV contour calculation procedure. A. Image with rectangular ROI and previously identified LV blood pool centroid (red), b. ROI image, c, Binary image, d, Coarse LV blood pool, e. Dilated mask, f. Refined LV blood pool, g. LV blood pool contour, h. Convex hull of the LV blood pool (cyan), i. Smoothed endocardia contour (red), j. Papillary muscles and trabeculations' mask, k. Papillary muscles and trabeculations' contours (blue)

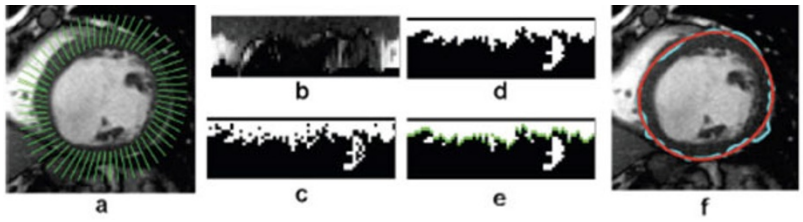

Figure 3
LV segmentation procedure for epicardial contour. A. Scan lines for mapping the pixels from Cartesian to polar coordinates. B. Results of image transform, c. Region growing binary image, d. imaged after filling holes, e. Edge points (geren), f. Epicardial contour before (blue) and after FFT smoothing (red).

Table 1:

	APD AND DM			
	APD (average perpendicular distance)		**DM (DICE METRIC)**	
	IC (MM)	**OC (MM)**	**IC**	**OC**
MEAN	2.11	1.9	0.89	0.94
STANDARD DEVIATION	2.34	1.42	0.05	0.02
	IC: INNER CONTOUR	OC: OUTER CONTOUR		