An Efficient and Robust Method to determine Cardiac Contours in Time-Series MRI Images

G. Gang[1,2], P. W. Cockshott[1], T. N. Martin[2], J. E. Foster[2], H. Dargie[2], A. Elliott[2], B. A. Groenning[2]

[1]Department of Computing Science, Glasgow University, Glasgow, Scotland, United Kingdom, [2]Glasgow Cardiac Magnetic Resonance Unit, Glasgow University, Glasgow, Scotland, United Kingdom

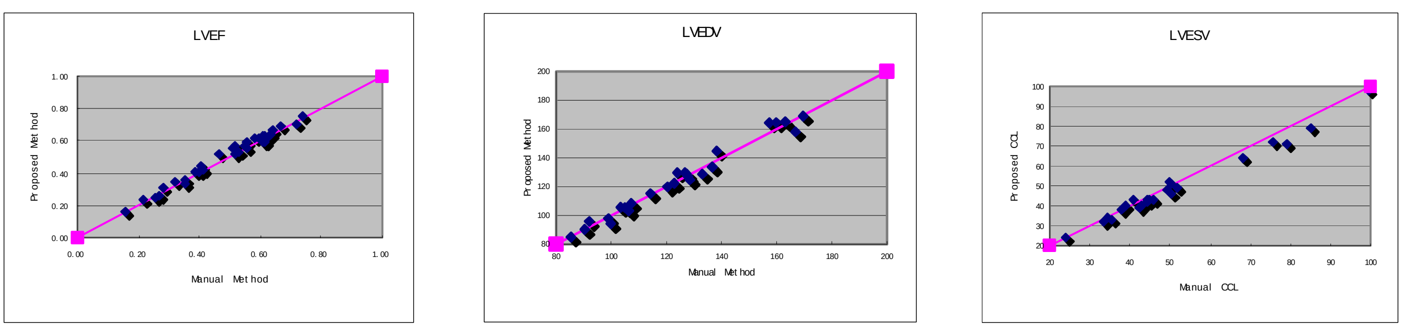
Introduction. Cardiac cine MRI images can be analyzed to provide assessment of cardiac disease. The accuracy of the results depends on reliable cardiac contour determination, which is time consuming and error probe. Normally, clinicians define cardiac contours in the end diastole and the end systole, linearly estimating cardiac parameters such as stroke volume, ejection fraction, etc. We present a method, which propagates a pre-defined cardiac contour through the cardiac cycle. This produces non-linear data, allowing new cardiac studies, for example, the studies of ejection rate and filling rate.

Methods. 34 subjects (20 normal volunteers and 14 heart failure patients) were recruited. An MRI study was performed on a Siemens Sonata 1.5T system using a phased array chest coil. Left ventricular (LV) dimensions were evaluated by a stack of CINE trueFISP breath-hold slices (thickness=10mm, TR=47.4ms). The matrix size is 208 x 256. Our method builds on a multiple scale signal matcher (MSSM) developed by the Turing Institute, Glasgow University. MSSM has proven very successful in areas including, 3D modeling and medical image analysis [1][2]. For each short axis stack, we define a reference image. In the reference image, we define 10-15 control points manually along the cardiac boundaries, from which smooth cardiac contours can be formed using a cubic spline. MSSM algorithm uses the maximization of correlations to produce motion fields mapping the reference image to the others. Using these, the control points are propagated from the reference image to the other images. The MSSM algorithm can also be used to track the motion of RV and papillary muscles.

Results. Cardiac contours were defined manually and by the proposed algorithm. Reference images are chosen between the end diastole and the end systole. Mean (SD) LV end diastolic volume in each of the scans was measured by planimetry (manual/proposed)=177.31/176.55ml, p=0.48. Mean (SD) LV end systolic volume (manual/proposed) =82.10/84.32ml, p=0.33. Mean (SD) LV ejection fraction (manual/proposed)=0.48/ 0.48, p=0.25 (figure 1).

Discussion. We introduce a robust and efficient algorithm to define cardiac contours automatically through cardiac cycle. Our method greatly reduces analysis time, which allows for the use of short capture times and thin slice thicknesses to acquire more information on cardiac structure and function. In addition, more complex cardiac MRI studies, such as studies on the filling rate of the LV can greatly benefit from the non-linear data produced by our method.

Conclusion. A novel and efficient method to track cardiac contours on MR images is proposed. We have shown that there are no significant differences in LV volumes and LV ejection fraction between manually and automatically defined contours. The method therefore appears to be promising as an accurate cardiac boundary tracking tool.



(a) (b) (c)

Figure 1. The proposed algorithm versus the manual contour definition. (a). LVEF; (b). LVEDV; (c). LVESV

Reference.

[1]. Nebel, J.C., Rodriguez-Miguel F.J., Cockshott, W.P., “Stroboscopic stereo rangefinder”, 3DIM2001, May 28 – June 1, 2001, Quebec City, Canada

[2]. Gao G., Cockshott P, Martin T., Groenning B, “A normal method for viability assessment by cine and LE MRI”, accepted by SCMR’04, Feb. 14 2004, Barcelona, Spain