SPECTRUM-BASED AUTOMATIC LOCALIZATION OF LEFT VENTRICLE FROM CARDIAC MAGNETIC RESONANCE IMAGING

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Introduction: To identify the boundary of left ventricle (LV), i.e. segmentation is critically significant for medical imaging analysis. Localizing the position of LV in the image could not only improve the accuracy of segmentation result but also decrease the computational load. Existing localization methods are partially dependent on the assumption that left ventricle is at the center of image [1-2]. We have recently proposed a new method for precise LV localization based on spectrum analysis, which outperforms earlier methods [3].

Theory: Given a cine cardiac MR image of size $M \times N \times L$, it could be thought of as a $M \times N$ combination of discrete time series of length L. Discrete Fourier transform (DFT) is conducted to each time series and the frequency components are separated. The $M \times N$ image of the i-th order frequency component is defined as the i-th harmonic image. We found two facts concerning LV and right ventricle (RV). (1) In all order harmonic images, RV presents a higher intensity than LV; (2) as the harmonic order increases, the superiority of RV to LV increases as well (Figure 1).

Methods: The proposed method was experimented on 17 subjects, 13 males and 4 females, mean age 37 years old, range from 19 to 64 years old. The cine MR images were acquired on a 1.5T Siemens scanner with conventional ECG gating. The slice thickness is 8 mm. The pixel spacing is between 1.25 mm to 1.87mm, typically 1.71 mm. The TR/TE/flip angle is typically 63.84/1.13/70º. A cine image slice contains 22 time frames over a cardiac cycle. Based on the two facts of cardiac harmonic images, the first and fifth order harmonic images, H1 and H5, are utilized in LV localization procedure. The gradient maps and edge maps of H_1 and H_5 are generated [4-5], ∇H_1, ∇H_5, e_1 and e_5. e_1 and e_5 are then utilized in a modified circle Hough detection. e_1 votes with positive weights into the parameter space, while e_5 with negative weights.

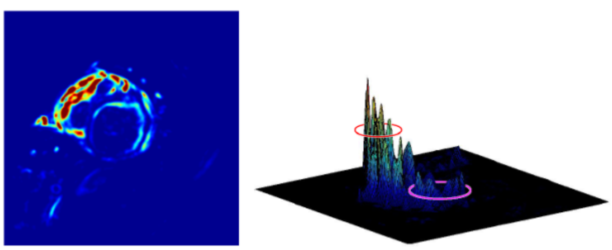

Figure 1: the first harmonic image and surface plot

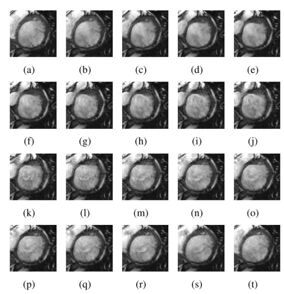

Figure 2: Cropped image for all frames in a cine MRI

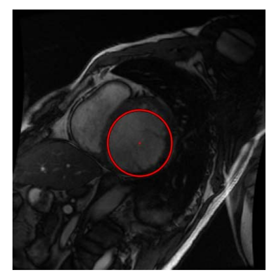

Figure 3: LV detection

Results: The cropped ROI of all cases contains the left ventricle, which is visually inspected (Figure 2). The size ratio of the cropped ROI to the whole image ranges from 0.15 to 0.26, average is 0.2. If we increase the expanding ratio from 1.7 to 2 for more proof reason, the average cropped ratio is 0.28, which is still a large reduction for the computation load. Figure 3 shows the more precise LV detection result.

Conclusion: A novel automatic left ventricle localization method is proposed based on spectrum analysis in cine MRI. Using the observed fact that right ventricle occupying most portion in the high harmonic image, two harmonic images are utilized in an anisotropic weighted circle Hough transform. The interruption from right ventricle is largely suppressed, leading to a more precise localization of left ventricle, which is useful to auto segmentation in cardiac cine MRI.

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