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Hybrid Algorithm for Segmentation of Left Ventricle in Cardiac MRI

R.Sreemathy[1], Rekha S. Patil[2], Priyanka Shirude[3]

Pune Institute of Computer Technology, Pune, India[1,3]
Dr. D. Y. Patil Technical Campus,Talsande, Kolhapur[2]

Abstract- According to estimates from the American Heart Association, each year 17 million people die of cardiovascular disease (CVD). More than 30% of all deaths in world are due to cardiovascular disease. Hybrid algorithm using k-means clustering and level- set is proposed in this paper in order to improve the efficiency of segmentation. K-means algorithm is used to initially locate the position of left ventricle and the accurate segmentation has been achieved with the help of level set algorithm. Preprocessing has been carried out with the help of 5*5 kernel median filter and speckles inside the heart region are faded. The preprocessing has sufficiently reduced speckle noise and preserved the LV edges.

Index Terms- K-means clustering, speckle noise, level set, CVD

I. Introduction

Generally cardiac examination involves assessing a combination of the four following physiological measures: cardiac structure, function, perfusion and myocardial viability. Different imaging modalities, including Ultrasound (US), single-photon emission computer tomography (SPECT), computed tomography (CT), and magnetic resonance imaging (MRI) are used in performing cardiac examinations. Among existing methods, cardiac MRI [7](CMR) has attracted significant interest in the research community, as a single imaging technique capable of retrieving all cardiac measures appropriately.

More specifically the aim for this work is to segment the left ventricle in the heart using cardiac MRI and to find out various clinical parameters. Currently, medical practitioners are using manual segmentation which is very tedious task. This automated segmentation will reduce the burden on medical practitioners.

Automated segmentation is important for assessment of LV filling because cavity volumes must be measured on hundreds of short-axis cine images, making manual tracing impractical for widespread clinical application [3]. Figure 1 shows that the left ventricle shape and its endo-cardial and epi-cardial contours. We can note that the shape of heart changes from apex to bottom and each heart is having slightly different position. So to detect the exact location of left ventricle in individual person is a dynamic process.

So it is very difficult to have a global algorithm which can be able to detect left ventricle.

We need to address the following challenges to develop an automatic LV detection system.

1. The position and orientation of the LV is unconstrained in an image.
2. A 2D image loses a lot of useful information about a 3D object.
3. The LV shape changes significantly in a cardiac cycle.
4. There are large variations in the image intensity.

Figure 1 includes various levels approximately 8-10 levels for patients and each level consist of approximately 20 frames.

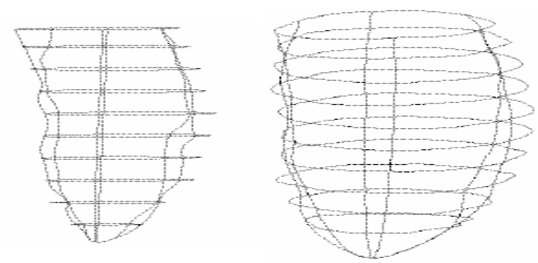

Figure 1: (a) LV endocardial contours (b) LV epicardial contours,

Data from MRI is more accurate than that derived from LV angiocardiography, where the calculation is based on the assumption that the LV is ellipsoidal in shape. Volume measurements by MRI are independent of cavity shape, with the area from contiguous slices integrated over the chamber of interest.

Here in this paper an attempt has been made to identify left ventricle by using k-means clustering algorithm [2] and a more precise segmentation of endocardium has been carried out with level set[5]. The area measured with this hybrid algorithm has been compared with the ground truth which is marked by experts in this field.

II. METHODOLOGY

Small variations in the magnetic field introduced by the radiofrequency (RF) system (the B1 field introduce slowly undulating (low frequency) in homogeneities in the image which can be visually distracting), can impact the textural significance of an area, and because they can substantially reduce the contrast in different image regions, is a barrier to using any kind of segmentation or region delineation tool which is based on thresholding.

Thresholding techniques produce segments having pixels with similar intensities. They can handle any underlying image model as long as each intensity is associated with the only one segment. [1]

The following steps are used in order to achieve the final segmentation

1). Median filtering
2) K-means clustering
3) Connected components finding
4) Centroid detection
5) Levelset algorithm

Figure 2 shows the methodology used for the implementation of hybrid algorithm for detection of left ventricle.

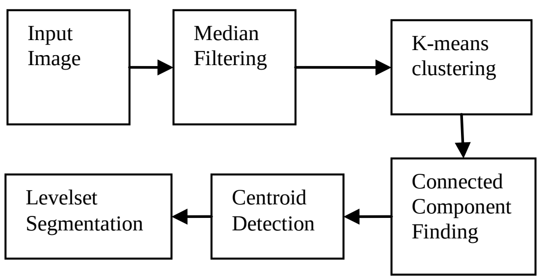

Figure 2: Block Diagram for automated segmentation

A. *Median filtering*

Median filter of size 5*5 kernel has been used on original image in order to reduce the noise and to sharpen the edges. The original input image is shown in Figure3 and the final median filtered image is shown in Figure4.

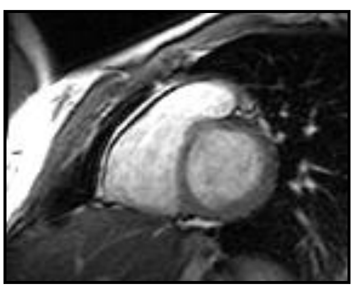

Figure 3: Original Image

Figure 4: Filtered Image

B. *K-means clustering*

K-means clustering [7] is an algorithm to classify or to group objects based on attributes/features into K number of group. K is positive integer number. The grouping is done by minimizing the sum of squares of distances between data and the corresponding cluster centroid. Thus, the purpose of K-mean clustering is to classify the data.

K-means algorithm is summarized as follow:

1. Choose k initial class means.
2. Assign each pixel to the class with the closest mean.
3. Reassign one pixel to a new class such that the move best reduces the overall sum of square distances criterion.
4. Recompute the class means using the new assignments.
5. If the criterion was improved, go to Step 3.

Figure5 shows the K-means clustered output on the filtered image.

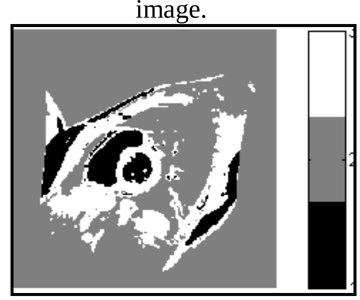

Figure 5: Clustered Image with 3 regions

C. *Connected components labeling*

Next step is to find the connected components in the clustered image and to select proper component containing left ventricle. Results of it are shown over Figure6.

Figure 6: connected components finding

D. *Centroid detection*

After rigorous study, it is found that the label of the left ventricle is found to be one. Now the centroid of this label is found. Thus we are able to locate a central point on left ventricle.

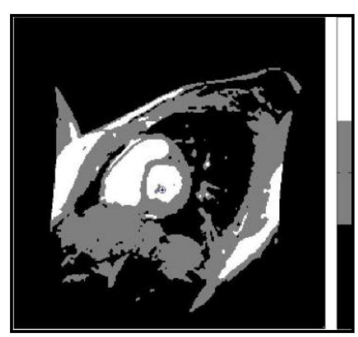

Figure 7: Centroid Detected

E. *Levelset segmentation*

The level-set method is one computational technique for tracking a propagating interface over time, which in many problems has proven more accurate in handling topological complexities such as corners and cusps, and in handling complexities in the evolving interface such as entropy conditions and weak solutions. It is a robust scheme that is relatively easy to implement.

The general idea behind the level-set method is to apply a function Φ (t) to the space the interface inhabits, where Φ is a point in that space, t a point in time. The function is initialized at t = 0, and then a scheme is used to approximate the value of Φ (t) over small time increments.

Levelset algorithm can be summarized as follows:

1. Introduce a co-ordinate system
2. Embed the interface in the x-y plane.
3. Invent the function z = Φ (x, y, t). This is level set function.

Using the centroid located in section D and with minimum radius of the left ventricle initial contour of the level set algorithm is drawn automatically with the centroid as center. Thus by detecting the centroid, the change in location of left ventricle is found easily. And hence the final segmentation is more accurate as we are able to change the position of the initial contour automatically and easily. Hence tracking the left ventricle with respect to various levels has become simplified.

Figure 8 shows final segmented left ventricle for one image of level1.

Figure 8: Level set segmented contour

III. RESULTS

The database used [8] has about 33 patients. The algorithm is tested by using above database. Accuracy of algorithm has been tested on sufficient number of images. The above mentioned algorithm has worked successfully on all levels starting from base to apex. The algorithm is working successfully in the base, middle and apical slices and the algorithm is able to locate a point successfully on the left ventricle which made the job of drawing initial contour simple.

A. *Result Analysis of k-means clustering*

While performing k-means clustering, endo-cardium and epicardium are merged with each other.

B. *Result analysis of centroid detection*

The centroid of first 5 levels is located exactly in left ventricle. But in apical levels centroid of left ventricle is getting shifted slightly. And because of the same reason for those levels we are facing problems in initializing the contour for level set. Here Figure 9 shows the bar chart for centroid detection against different levels, which shows that for 1st five levels, we are having 100% success rate and from 6th to 8th level we are having 80%-85% success rate.

Figure 10 shows the area segmented using the above proposed algorithm on one of the levels. The x-axis represents the frame number and y-axis represents the corresponding area of left ventricle

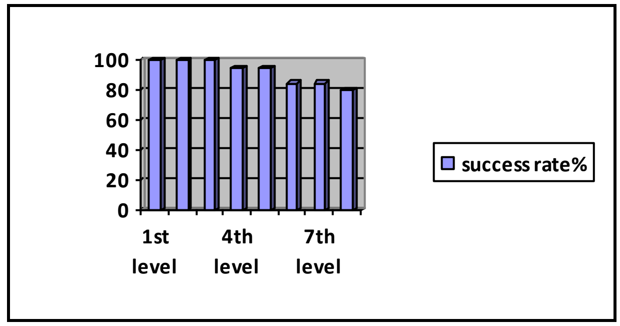

Figure 9: Bar chart for success rate on different levels

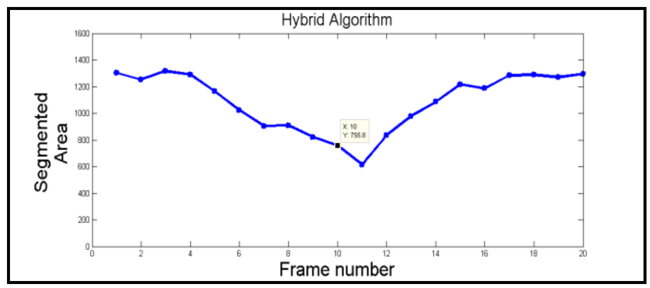

Figure 10: Graph of segmented area of left ventricle using hybrid algorithm

The mean area error between ground truth and the above algorithm is 0.5%.

IV. CONCLUSION

A new hybrid algorithm using k-means and level set algorithm has been proposed in this paper. K-means algorithm has been used as an initial tool to locate the left ventricular region. The k-means algorithm has made the segmentation task automatic as we are able to easily locate a point on the left ventricle. This point is used as initial seed for the final level set segmentation.

REFERENCES

[1] Salem Saleh Al-amri, N.V. Kalyankar and Khamitkar S.D "Image Segmentation by Using Thershold Techniques", journal of computing, volume 2, issue 5, May 2010, issn 2151-9617

[2] M. Lynch, O. Ghita, P.F.Whelan, "Automatic segmentation of the left ventricle cavity and myocardium in MRI data", Computers in Biology and Medicine 36 (2006) 389–407

[3] Si Yong Yeo, Liang Zhong, Yi Su, Ru San Tan, Dhanjoo N. Ghista, "Analysis of Left Ventricular Surface Deformation during Isovolumic Contraction", *Proceedings of the 29th Annual International Conference of the IEEE EMBS Cite International*, France, 2007

[4] Tapas Kanungo, David M. Mount, Nathan S. Netanyahu, Christine D. Piatko, Ruth Silverman, and Angela Y. Wu, "An Efficient k-Means Clustering Algorithm: Analysis and Implementation", *IEEE transactions on pattern analysis and machine intelligence*, vol. 24, no. 7, July 2002.

[5] Sethian, J. A., "*Level Set Mehods: Evolving interfaces in geometry, fluid mechanics, computer vision, and material science*", Cambridge University Press, 1996.

[6] M Puvaneswary, "*Cardiac MR Imaging*", JP brothers Medical Publishers(P) Ltd, 2005

[7] Kanungo, T.; Mount, D. M.; Netanyahu, N. S.; Piatko, C. D.; Silverman, R.; Wu, A. Y. 2002. "An efficient k-means clustering algorithm: Analysis and implementation". I*EEE Trans. Pattern Analysis and Machine Intelligence* 24, p. 881–892.

[8] Alexander Andreopoulos, John K. Tsotsos, "Efficient and Generalizable Statistical Models of Shape and Appearance for Analysis of Cardiac MRI", *Medical Image Analysis*, Volume 12, Issue 3, June 2008, Pages 335-357.

First Author – R. Sreemathy, ME(Electronics) and MS(Electronics and control), Pune Institute of Computer Technology. Email id - sreemathyr@yahoo.com.

Second Author – Rekha S. Patil, PhD (Electronics), Dr. D. Y. Patil Technical Campus. Email id - prekha46@yahoo.com.

Third Author – Priyanka B. Shirude, BE(E&TC), Pune Institute of Computer Technology. Email id - p.shirude2@gmail.com.