IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661, p- ISSN: 2278-8727Volume 16, Issue 2, Ver. III (Mar-Apr. 2014), PP 33-38
www.iosrjournals.org

Analysis for Diagnosing Myocardial Ischemia by Detecting the Boundary of Left Ventricle in Echocardiography Sequences using GVF snake

N.Sameena,MPhil,[1]DR.A.R.Mohamed Shanavas,Ph.D,[2]
[1](*Department of Computer Science, Jamal Mohamed College, India.)*
[2](*Department of Computer Science, Jamal Mohamed College, India.)*

Abstract: *Left ventricular performance, one of the hallmarks of coronary artery disease, can be detected by echocardiography. Coronary artery disease (CAD) also known as myocardial ischemic heart disease (MIHD), is the most common type of heart disease and cause of heart attacks or heart failure. Heart failure (HF) can result from any structural or functional cardiac disorder that impairs the ability of the ventricle to fill with or eject blood. Echocardiography represents "the gold standard" in the assessment of left ventricle LV systolic and diastolic dysfunction. Left ventricular dimensions, volumes and wall thicknesses are measured from systolic and diastolic movements that are widely used in clinical practice and research. To obtain accurate linear measurements from the echocardiography accurate segmentation of the LV is essential. This paper proposes a method to segment left ventricle to detect the systolic and diastole movements which is obtained by extracting the frames from the video of echocardiogram which is further processed to detect systolic and diastole movements so that movement of heart can be clear to the cardiologist to visualize the left ventricle. The obtained results are efficient and can be utilized for the purpose of detecting abnormal heart wall motion so that many heart problems can be detected in echocardiography instead of using advanced diagnosis like angiogram which may have risk.*

Keywords: *Echocardiogram, Left ventricle, GVF snake, boundary detection.*

I. Introduction

Echocardiography images of heart using standard ultrasound. The human heart is an organ that provides continuous blood circulation to the entire body through the cardiac cycle and is one of the most vital organs in the human body. The heart is divided into four main chambers: the two upper chambers are called the left and right atria and two lower chambers are called the right and left ventricles. The left ventricle [LV] receives oxygenated blood from the left atrium via the mitral valve, and pumps it into the aorta via the aortic valve .For healthy functioning of the heart the LV should relax very rapidly after each contraction so as to fill rapidly with oxygenated blood flowing from the lung veins. One cardiac cycle of left ventricle is 0.8secs with of systole of 0.27 secs and diastole of 0.53 secs. The echocardiogram allows doctors to diagnose, evaluate, and monitor heart related problems. An echocardiogram is a test that uses sound waves to create a moving picture of the heart. The picture is much more detailed than a plain x-ray image and involves no radiation exposure. An echocardiogram allows doctors to see the heart beating, and to see the heart valves and other structures of the heart. Myocardial Ischemia is also called as Hear Failure. The word 'Myocardial' means 'heart' and 'Ischemia' means 'loss of blood supply'. When there is block there will be no blood supply which causes systole and diastole to be improper. Here the problem is the cardiac cycle is so speed in terms of milliseconds the doctor cannot analyze that, whether the systole and diastole is proper or improper. Thus, LV segmentation in echocardiogram is desirable because here we focus mainly to predict the movements of heart that is the systole and diastole. The purpose is to slow down the systole and diastole movements so that the doctor can view it cleary.If systole and diastole movements are normal the functioning of heart is normal other wise it is abnormal. In this paper it is proposed to segment the LV in parasternal short-axis view of the echocardiogram video without any manual intervention.

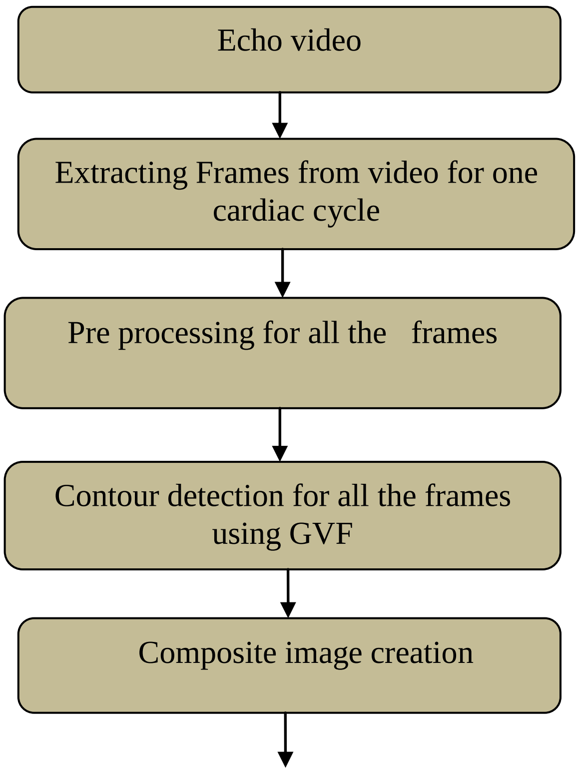
GVF snake is an extension of active contour model(snake).The active contour that uses the GVF field as its external force which is called a GVF snake. Particular advantages of the GVF snake over a traditional snake are its insensitivity to initialization and ability to move into concave boundary regions .Gradient vector flow (GVF) field begins with the calculation of a field of forces, called the GVF forces, over the image domain. The GVF forces are used to derive the boundary contour, modelled as a physical object having a resistance to both stretching and bending, towards the boundaries of the object.

II. Related Work

Accurate LV segmentation is quite difficult due to the presence of noise and due to the low contrast of echocardiographic image. Hence preprocessing of echocardiographic images is very important before the actual segmentation of LV. The work in [1] presented a wavelet-based thresholding scheme for noise suppression in ultrasound images. In [2] the image is filtered by convolving with a 3X3 Gaussian low pass filter followed by thresholding and to eliminate the noise morphological dilation and erosion have been applied. Adaptive weighted median filter (AWMF) for reducing speckle noise in ultrasound images is presented in [3] which is based on the weighted median. By adjusting the weight coefficients and consequently the smoothing characteristics of the filter according to the local statistics around each point of the image, it is possible to suppress noise while edges and other important features are preserved. The work in [4] combines image processing techniques with radial search to detect the left ventricular borders from echocardiograph images. The fuzzy reasoning employed in [5] defines edges by local image characteristics computed based on local statistics of the image. In this work to reduce the noise and to enhance the contrast of the image high boost filtering followed by LoG filter is carried out. The literature shows different methods for segmentation of LV in short axis views. The work in [6] uses the gray level information along with user defined initial contours to extract the boundary in the images. The method in [7] implements a probabilistic deformable model considering the boundary as two-dimensional deformable object using maximum posteriori estimate. The work in [8] reports an interesting approach to detect LV boundary of short axis echocardiographic sequences using a multiple active contour model which is an extension to the original model proposed in [9]. A Hough transform technique is used in [10] to find an initial approximation of the object boundary at the first frame of the sequence then, an active-contour model is used in a coarse-to-fine framework, for the estimation of a noisy LV (Left Ventricle) boundary. A texture segmentation algorithm based on the multi-channel filtering theory, is presented in [11]. The work in [12] presents a technique that incorporates the information on pixel velocities (optical flow) into the estimate of initial contour to enable tracking of fast-moving objects. Watershed transform and morphological operation to locate the region containing the LV which then performs snake deformation with a multi-scale directional edge map for the detection of the endocardial boundary of the LV is proposed in [13].A novel approach of combining the K-Means clustering algorithm for segmentation and active contour model for boundary detection was proposed in [14]. More recently mathematical morphology and connected component labeling are used to segment the LV in short axis view echocardiography [15].In this work, gradient vector flow is used for boundary detection to segment the LV in short axis view echocardiography.

III. Methodology

The block diagram of the proposed work is shown in Figure1.The Echocardiogram video is given as input to the system and is converted to frames which are then subjected to further processing.



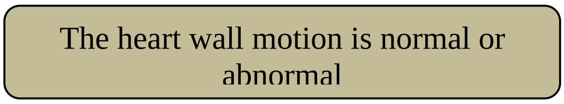


Figure 1 shows the method of the proposed work

When a patient Echo video is divided into frames, required images from the frames for one cardiac cycle will be extracted, and image pre-processing is performed for all the images that is extracted and the LV boundary is detected by using GVF snake model .The boundary obtained for the entire echo image which is used to create a composite motion (CM) image that consist of boundary detected systole and diastole movements. Then, finally it is concluded that if the systole and diastole movements are normal then it is a normal heart else it is abnormal and there is a block. Hence these methods are used to classify the heart wall abnormality. These stages are detailed in the following sections.

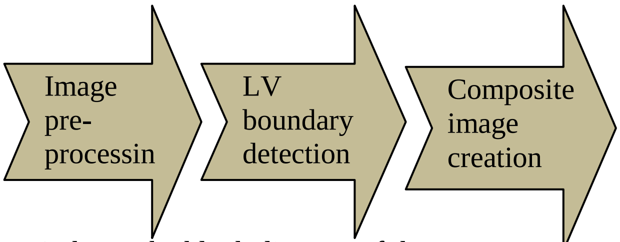


Figure 2 shows the block diagram of the stages

Image pre-processing

An average filtering process is performed on the approximations. A mean based smoothing is performed to all the details, which is defined for an image I(x, y) as,

$$I(x,y) = \begin{cases} I(x,y) & \text{if } |I(x,y)| \leq N \\ N & \text{if } |I(x,y)| > N \end{cases}$$

where N is the trimmed mean value of row of the pixel I(x, y) and x, y are the pixel coordinates. The trimmed mean of a data X with n values, is the mean calculated by excluding the highest and lowest k data values, where k=n*(p/100)/2 and where p is the percentage to be trimmed. Here 25 % of the outliers are trimmed from the data. However, if the data is all from the same probability distribution, then the trimmed mean is less efficient than the sample mean as an estimator of the location of the data. This operation is used to smooth the sudden changes of coefficient values. Then the image is reconstructed using all the modified sub bands to get the noise reduced image. Figure 2(a) shows the noisy image (speckle noise variance=0.5) and 2(b) shows the speckle noise reduced image.

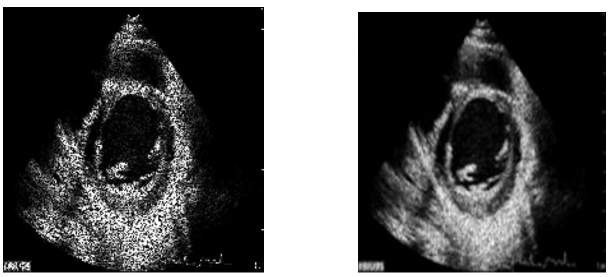


Figure 3 (a) Original image of Echo in parasternal short axis view (b) Speckle noise reduced image of Echo in parasternal short axis view

LV boundary detection

The left ventricle boundary is detected by using Gradient vector flow.

GRADIENT VECTOR FLOW SNAKE

Using a force balance condition as a starting point, the GVF field replaces the potential force field

In defining a new snake, called the GVF snake. The GVF field points toward the object boundary when it is very near to the boundary, but varies smoothly over homogeneous image regions, extending to the image border. The main advantages of the GVF field are that it can capture from either side of the object boundary and can force it into concave regions.
Contour is said to **possess energy** (***E_{snake}***) which is defined as the sum of the three energy terms.

$$E_{GVF} = E_{INTERNAL} + E_{EXTERNAL}$$

The internal energy, Einternal is the energy of curve and the image energy, Eexternal possess a GVF field as external energy; and the constraint energy, *Econ*,allows higher level information to control the curve.

Internal Energy

The internal energy is further given by sum of elastic energy and bending energy.

Elastic Energy ($E_{elastic}$)

The curve is treated as an elastic rubber band possessing elastic potential energy.It discourages stretching by introducing tension. Weight $\alpha(s)$ allows us to control elastic energy along different parts of the contour. Considered to be constant α for many applications. Responsible for shrinking of the contour.

$$E_{elastic} = \frac{1}{2}\int_{s} \alpha(s)\,|v_s|^2\, ds$$

Bending Energy ($E_{bending}$)

The snake is also considered to behave like a thin metal strip giving rise to bending energy. It is defined as sum of squared curvature of the contour.

β(s) plays a similar role to **α(s).** Bending energy is minimum for a circle.

$$E_{bending} = \frac{1}{2}\int_{s} \beta(s)\,|v_{ss}|^2\, ds$$

Total internal energy of the snake can be defined as

$$E_{\text{int}} = E_{elastic} + E_{bending} = \int_{s} \frac{1}{2}(\alpha\,|v_s|^2 + \beta\,|v_{ss}|^2)ds$$

External energy of the contour (E_{ext})

GVF snake algorithm possess Gradient Vector Field as external energy. The GVF field is defined to be a vector field V(x,y)

Force equation of GVF snake:

$$\alpha v_{ss} - \beta v_{ssss} + V = 0$$

αVss is the bending force of the internal energy, βVssss is the elastic energy of the internal energy and V is the energy external which is defined as GVF field.V(x,y) is defined such that it minimizes the energy functional.

$$V(x, y) = (u(x, y)\ v(x, y))$$

GVF field can be obtained by solving following equations,

$$\mu\nabla^2 u - (u - f_x)(f_x^2 + f_y^2) = 0$$

$$\mu\nabla^2 v - (v - f_y)(f_x^2 + f_y^2) = 0$$

derivative of u and v.∇^2 Is the Laplacian operator.

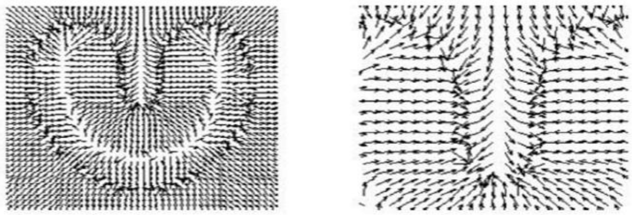
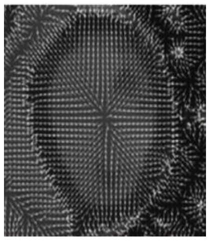


Figure 4(a) GVF Field for a U shaped image and (b) Close up of GVF field showing concavity



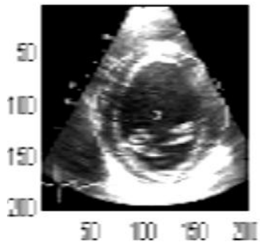
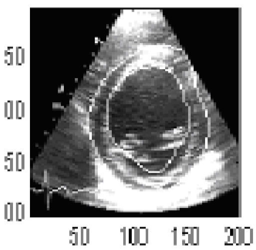


Figure 5(a) Original image. (b) GVF field (c) Initial Contour



(d) Final Contour

Figure 5 (a) shows a original image,(b) is a gradient vector flow field, depending on the GVF field initial contour and final contours are made(c) is a initial contour for the image using GVF snake,(d) is a final contour for the image using GVF snake

Composite Image Creation

The wall position at contracted phase and relaxed phase of the LV chamber is significant in estimating information on the contractility of the heart wall. The movement of the inner heart wall is used by experts to identify the wall motion abnormality. Hence, the LV wall boundaries are detected for each frame and the edges obtained for all the frames between the end-systole and the end-diastole are used to create a composite motion image. The extracted inner wall boundaries for all the frames are placed into a composite image to show the movement of the heart wall from the contracted phase to the relaxed phase. This image is referred as the composite motion image.

The figure (a) is a composite image of a normal heart wall motion and (b) is a composite image of a abnormal heart wall motion.

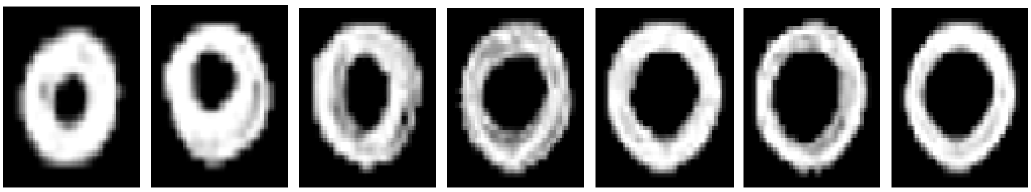
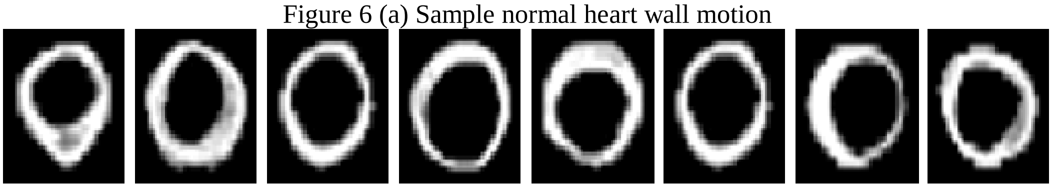


Figure 6 (a) Sample normal heart wall motion



(b) Sample abnormal heart wall motion

IV. Conclusion

In this paper a method for border detection in left ventricle was proposed using GVF snake for diagnosis of myocardial ischemia.The heart wall boundaries extracted by using the GVF snake to analyse the heart wall to identify the heart wall abnormality. The left ventricular motion over a complete cardiac cycle was provided by the proposed algorithm. The accuracy of the proposed method was useful to the cardiologist. Hence the proposed method can be very effectively used to detect myocardial ischemia.

References

[1] S.Sudha, G.R.Suresh and R.Sukanesh Speckle Noise Reduction in Ultrasound Images by Wavelet Thresholding based on Weighted Variance, International Journal of Computer Theory and Engineering, Vol. 1, No.1, April 2009.

[2] A. Mishra, P. K. Dutta, and M. K. Ghosh, A GA based approach for boundary detection of left ventricle with echocardiographic image sequences. Image Vis. Compute., vol. 21, pp. 967-976, 2003.

[3] T. Loupas, W. N. Mcdicken, and P. L. Allan. An Adaptive Weighted Median Filter for Speckle Suppression in Medical Ultrasonic Images OO98-4094/89/01OO-012901 .01 989 IEEE.

[4] Saulo Guerreiro Lacerda, Adson F. da Rocha, Daniel F. Vasconcelos,Joo L. A. de Carvalho, Iwens G. Sene Jr. and Juliana F. Camapum Left Ventricle Segmentation in Echocardiography Using a Radial-Search-Based Image Processing Algorithm. IEEE 2008.

[5] Sheila Chan, Gopalakrishnan Sainarayanan, Fuzzy-based boundary enhancement for echocardiogram using local image characteristics. Malaysian Journal of Computer Science, Vol. 19(2), 2006.

[6] Chu, C. H., Delp, E. J., and Buda, A. J. (1988). Detecting left ventricular endocardial and epicardial boundaries by digital two dimensional echocardiography. IEEE Transactions on Medical Imaging.

[7] Staib, L. H., and Duncan, J. S. (1992). Boundary finding with parametrically deformable models. IEEE Transactions on Pattern Analys is and Machine Intelligence.

[8] Chalana, V., Linker, D. T., Haynor, D. R., and Kim, Y. (1996).A multiple active contour model for cardiac boundary detection one echocardiographic sequences.IEEE Transactions on Medical Imaging,15, 290298.

[9] Kass M., Witkin A., and Terzopoulos D. (1988). Snakes: Active contour models. International Journal of Computer Vision, 1, 321331.

[10] Antonio Fernandez-Caballero, Jose M. Vega-Riesco. Determining heart parameters through left ventricular automatic segmentation for heart disease diagnosis. Expert Systems with Applications 36 (2009) 223422492007ElsevierLtd.All rights reserved doi:10.1016/j.eswa.2007.12.045.

[11] A Bosnjak, G Montilla, V Torrealba, Medical Images Segmentation using Gabor Filters applied to Echocardiographic Images0276-6547/981998 IEEE.

[12] IvanaMikic,* Slawomir Krucinski, and James D. Thomas, Segmentation and Tracking in Echocardiographic Sequences: Active Contours Guided by Optical Flow Estimates S 0278-0062(98)04883-6. 1998 IEEE.

[13] Jierong Cheng, Say Wei Foo, and Shankar M. Krishnan Watershed Presegmented Snake for Boundary Detection and Tracking of Left ventricle in Echocardiographic Images IEEE transactions on informationtechnology in biomedicine, vol. 10, no. 2, April 2006. *IJCATM :*

[14] S. Nandagopalan, C. Dhanalakshmi, Dr. B. S. Adiga N. Deepak, Automatic Segmentation and Ventricular Border Detection of 2DEchocardiographic Images Combining K-Means Clustering and Active Contour Model. IEEE 2010.

[15] G.N.Balaji,Dr.T.S.Subashini,Automatic Border Detection of the Left Ventricle in Parasternal Short Axis View of Echocardiogram using mathematical morphology International Journal of Computer Application.September 2013.