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Thresholding Based Edge Detection of 2D Echocardiographic Videos

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Abstract—Medical image analysis is a primarily complicated problem because the natural characteristics of these images. It includes low contrast, speckle noise, signal dropouts and complex anatomical structures an accurate analysis of wall motion in Two-dimensional echocardiography images is essential clinical diagnosis parameter for many cardiovascular diseases. Difficult challenge for most researchers is how to speed up the clinical decisions and how to reduce human error of estimating precisely the true wall movement's boundaries. If it can be done automatically will be a useful tool for assessing these diseases qualitatively and quantitatively. Echocardiography imaging is one of the most widely used diagnostic tests for cardiovascular diseases. It allows direct visualization of cardiac structure and ventricles wall motion of boundaries. It can also provide information regarding the size and shape of the heart. An accurate method for edge detection of ventricle wall motion is still vital clinical diagnosis tool. The proposed technique involves three stages: First, the pre-processing stage for contrast enhancement and to reduce speckle-noise. In second stage, segmentation process applied using thresholding technique by considering a mean value of pixels intensity as a threshold value to distinct image features (e.g., Background and object). After thresholding achievement, mathematical morphology operators 'erosion' and 'dilation' are applied to improve the efficiency of the wall boundary detection process. Finally in third stage, Subel's operator is used as edge detector to identify the wall boundaries.

Keywords— Echocardiography image, edge detection, threshold value, mathematical morphology operators, wall motion, proposed method, Sobel's operator.

I. INTRODUCTION

1.1 Overview

Echocardiography is a powerful tool for the diagnosis most of heart diseases that allow a qualitative understanding for heart morphology and function by direct visual observation of cardiac structure and movement. It could be a useful diagnostic tool for assessing the abnormality of regional ventricular systolic function which based on the myocardial wall movements. The basic goal is to detect true boundaries through the complete cardiac cycle in order to assist the specialist in the assessment of common cardiac diseases. Echocardiogram or cardiac ultrasound is a sonogram of the heart. The heart diseases can be diagnosed using ultrasound frequency of 2MHz to 5MHz. Two-dimensional echocardiography is a powerful tool for the diagnosis most of heart diseases that allow a qualitative understanding for heart morphology and function by direct visual observation of cardiac structure and movement.

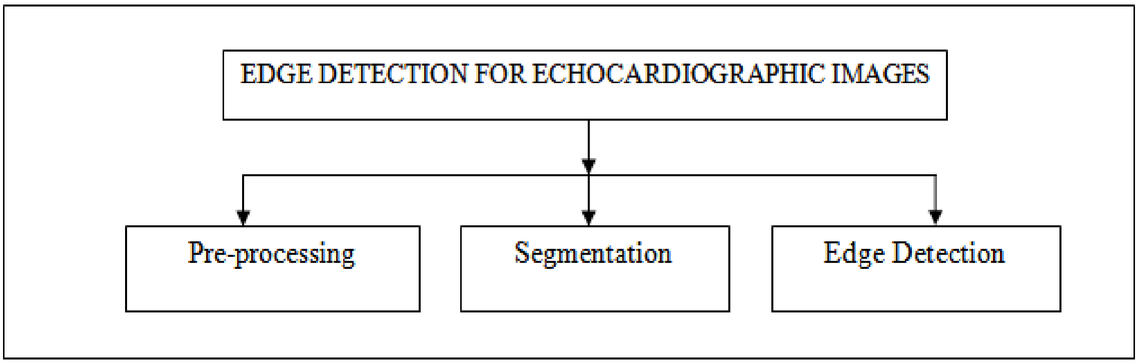

Figure 1.1: Edge detection processes.

Main goal in our work is to detect true boundaries of the heart wall movements automatically through the complete cardiac cycle in order to assist the specialist in the assessment of common cardiac diseases. In particular, some clinical parameters can be evaluated qualitatively and quantitatively measurements of Left Ventricle (LV), Right Ventricle (RV), Left Atrium (LA), Right Atrium (RA), Valve size. The aim of the proposed method is to develop boundary detection process for wall motion automatically by segmenting the image into distinct regions (i.e., blood and myocardial). The segmentation process is based on a threshold value which equals to average value of image pixels intensities. This step is a basic key of our work because it's applied automatically for all data unlike other methods as they need to test threshold value many times visually and then select the desired one which gives a good result.

1.2 PRE-PROCESSING:

Due to complex anatomical structure of echocardiography image, it causes two major problems; low contrast and speckle noise. Thus, two steps of preprocessing are needed for contrast enhancement and noise reduction to solve these problems without losing image features. Image enhancement techniques are used to highlight certain features of interest in an image. Two important examples of image enhancement are: (i) increasing the contrast, and (ii) changing the brightness level of an image so that the image looks better. It is a subjective area of image processing. On the other hand, image restoration is very much objective.. The actual solution to a specific problem still requires a significant research and development.

1.2.1 Speckle noise reduction: In 2D-echocardiographic image is used to enhance the visual quality by removing the noise from image with keeping the important features like myocardial wall tissue. In general, speckle texture could be a form of multiplicative noise that depends on the structure of the imaged tissue and various parameters concerning echocardiography imaging characteristics. There are a number of investigative research projects into the field of medical image analysis that present several methods for reducing the speckle-noise from an image based on a noise model. Most of noise modeling is affected by the acquisition instrument, data transmission media, image quantization and discrete source of radiation

a) Mean filter is a linear technique which is often used to performs spatial filtering and is applied as a smoother to average the speckles in each individual pixel in an image using grey-level values in a square window size (i.e. 3x3 , 5x5 or 7x7) surrounding each pixel. Practically, all pixels are filtered by replacing each pixel intensity value in the image with the mean ('average') value of its neighbors, including itself. However, this filter has the effect of potentially blurring the speckled image.

1.2.2 Contrast enhancement: Is essential in cases where substandard quality images are acquired. Contrast of an image is determined by its dynamic range, which is defined as the ratio between the brightest and the darkest pixel intensities. Contrast enhancement techniques have various application areas for enhancing visual quality of low contrast images.

a) Histogram equalization (HE): is a very popular technique for enhancing the contrast of an image. Its basic idea lies on mapping the gray levels based on the probability distribution of the input gray levels. It flattens and stretches the dynamics range of the image's histogram, resulting in overall contrast improvement.HE has been applied in various fields such as medical image processing and radar image.

b) Contrast Stretching: The most popular methods for contrast enhancement include histogram adjustment, unsharp masking, homomorphism processing and adaptive modification of the local contrast and local luminance mean. Histogram adjustment and unsharp masking are conceptually and computationally simple techniques, which can often provide significant improvement in image quality or intelligibility to the human observer and are therefore used routinely in many image processing applications. However, these methods also enhance the noise that is present within the image.

c) Correlation: The performance of the proposed algorithm has been compared against four other methods for image enhancement. We use correlation technique for contrast enhancement. It has combine features of histogram equalization and contrast enhancement. We do not stretch the colors because these are grey level images or we use pseudo colors. By using this technique contrast enhancement is done and image frames are further used for segmentation.

1.3 SEGMENTATION:

The basic goal of segmentation process in echocardiography is to identify boundary points between blood and myocardial tissue.

1.3.1 Thresholding: is the simplest form of regional segmentation for converting a multilevel (grey scale) image into a binary image, to separate the foreground object(s) from the image background. In our proposed method, the implementation to this purpose is determined by a single parameter known as the intensity threshold which equals to average value of image pixels intensities. In a single pass, each pixel in grayscale image is compared with this threshold. There are a number of investigative research projects in the field of medical image analysis that present several ventricle segmentation methods.

1.3.2 Mathematical Morphology: Two most common operators 'erosion' and 'dilation' are used to smooth the object's border by removing small dark regions around the object and set all of the neighbours within 3 pixels of object's to white. A process of erosion followed by dilation names the opening operation was found to be successful in determining object's region (i.e. Regional Ventricular Wall Motion). In this proposed method, a series of image processing stages is presented in an accurate and a reliable manner.

a) Erosion: is used to shrink the wall boundaries of echocardiographic images, So we can detect true wall boundaries which help diagnostics to take decisions.

b) Dilation: Dilation is used to fill the broken regions that are created by erosion. Both help us to provide true wall boundaries.

1.4 EDGE DETECTION:

In this step our proposed method that used to detect sharp transition calls 'edges' and to connect these edges to outline the desired boundaries. One of the gradient edge detectors that we use is operator which is based on the form of most differential operators. It is a simple and quick way to compute for highlights regions of high spatial gradient that often corresponds to edges. We use Sobel's operator for edge detection. Edge detection is a process that detects the presence and location of edges constituted by sharp changes in intensity (or brightness) of an image.

II. RELATED WORK

Rehmat et. al. (2012) in this paper boundary detection of echocardiographic videos given. This paper presents the different methods for the edge detection of medical images. In this automatic boundary detection is used to detect wall motion of echocardiograohic images based on thresholding value. In this after pre processing segmentation of image is done based on thresholding value and then edge detection techniques and mathematical morphological operators are applied.

Pradeepa and Vennila (2012) in this paper introduced the theory of mutual information and its application in the medical image registration field. Two experiments based on optimization gives a vivid idea of sampling methods that can be chosen based on the applications.

Economopoulos et. al. (2010) in the paper, "Contrast enhancement of images using Partitioned Iterated Function Systems", have proposed implementation of PIFS for contrast enhancement that divide the image in overlapping and non-overlapping blocks and then apply gray level enhancement while transformation to original form. The contrast-enhanced image is obtained by adding the difference of the original image with its lowpass version, to the original image itself. The proposed algorithm uses a predefined constant value for the gray level parameter.

Luo and Konofagou (2010) in this paper developed a time-efficient sum-table method was implemented in the field of ultrasound-based motion estimation to rapidly calculate the normalized cross-correlation (NCC). By taking advantage of the exhaustive search and high overlap between windows required for high-quality imaging, this method can avoid redundant calculation in motion estimation and thereby significantly reduce the computational cost. This method allows for the use of RF signals, together with large window sizes and high window overlaps, for high-quality motion estimation at low computational cost, without the multiple associated tradeoffs in conventional methods between accuracy, spatial resolution, and computational cost.

Kumar et al. (2009) in the paper "Contrast enhancement for medical images based on histogram equalization followed by median filter ", has proposed a method of image enhancement in which enhancement is performed by MMBEBHE based on a modified contrast stretching manipulation. While the image is enhanced, the impulse noises present in the images are also enhanced. To avoid this effect, the enhanced image has been passed through a median filter and got better results.

Roshnivs and DrkRevathy (2008) in this paper the theory of mutual information. Image registration based on mutual information in conjunction with Powell method has been presented. The proposed method requires neither segmentation nor any ad-hoc assumptions about the nature of the imaging modalities. In addition to being effective and efficient, the technique is quite general. The performance results have been compared to the use of normalized mutual information and cross-correlation as metrics.

Zieai et al. (2008) in their paper "A Novel Approach for Contrast Enhancement in Biomedical Images Based on Histogram Equalization" presented a new technique to increase the quality of medical images based on Histogram Equalization. In the proposed method firstly a noise reduction method has been applied and then some suitable preprocessing on histogram of the medical images and after that histogram equalization has been applied on the new histogram. Results for the proposed approach have been verified & validated on the basis of mathematical criteria.

Stefan et. al. (2007) provided a comparison of eight optimization methods for non-rigid registration based on the maximization of mutual information, in combination with a deformation field parameterized by cubic B-splines.

Hong and Zhang (2007) in this paper has proposed a new image registration algorithm based on wavelet multiresolution feature extraction techniques. It combines a discrete wavelet transform (decimate mode) and redundant wavelet transform ("à trous") into one image registration process. The discrete wavelet transform with decimate mode is used to generate a pyramid structure and locate feature points in each level, the "à trous" wavelet is used to obtain the feature points at highest level, and to keep the shift invariant property of the feature points while it is a problem using discrete wavelet transform with decimate mode. Normalized cross-correlation and probability relaxation matching techniques are used to find similarity between feature points in the reference image and sensed image The proposed method can resolve the following problems existing in the registration of high resolution images: (1) manually selecting a large number of control point pairs; (2) high volume data; (3) local distortion existing in different sensors and different temporal images.

Jafar and Ying (2007) in the paper, "A New Method for Image Contrast Enhancement Based on Automatic Specification of Local Histograms" proposed a new method, Automatic Local Histogram Specification (ALHS) that automatically provide the optimal contrast enhancement with minimal distortion in the image appearance. The 'ALHS' method automatically defines the Histogram such that it is the closest to the uniform distribution as in the Histogram Equalization method, and at the same time has a mean brightness with minimum deviation from the mean brightness of the original block.

III. THE PROPOSED ALGORITHM

We proposed algorithm for edge detection of echocardiographic images. In this video is converted in to frames and then algorithm applied on frames for boundary detection. After converting video into frames, our main motive is to detect sharp boundaries of edges. Which are helpful for the experts or diagnostics to detect the diseases.

3.1 Phases In Development:

Our research will start with study of accurate analysis of wall motion in Two-dimensional echocardiography images to find the best techniques with better reliable components.

Phase 1: In our First phase acquire the echocardiographic image frame from echocardiograph video using MATLAB framework.

Phase 2: In Second phase enhance image quality by increasing contrast and reducing the noise in each frame.

Phase 3: In Third phase thresholding based segmentation process to be applied on image to convert it into foreground and background.

Phase 4: In this phase morphological operations are to be performed on the image for texture improvement and for the edge detection.

Phase 5: Detect the wall boundaries of the image using sobel's edge detector.

Phase 6: In final phase display the extracted boundaries.

3.2 Models for Present Work

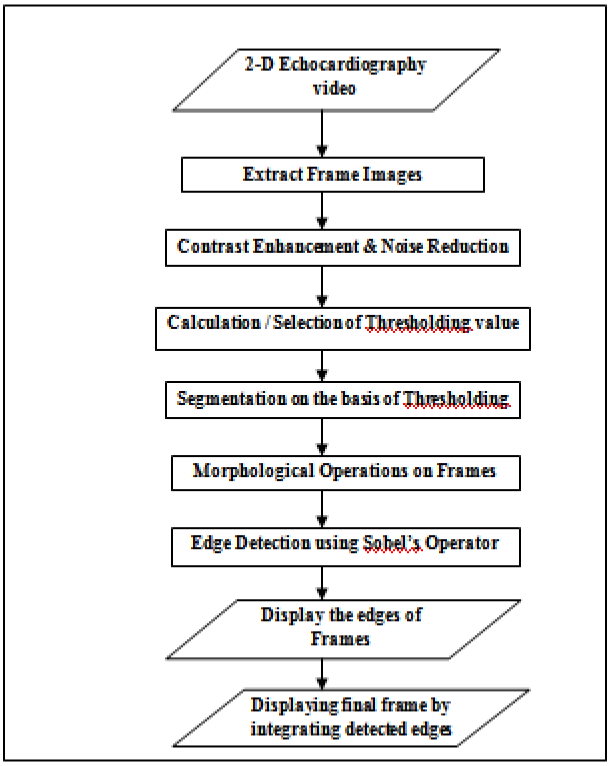

Figure 3.2: Flow chart of proposed algorithm.

3.3 Proposed Algorithm

Step1: Take 2D echocardiography video.

Step2: Extract frame images from video.

Step3: Now apply contrast enhancement and noise reduction on frame images.

Contrast enhancement is done with correlation of contrast stretching and histogram.

Noise reduction is done by using mean filter.

Step4: Calculate threshold value by separating the image into foreground and background.

With the help of grey level images threshold value is calculated.

Step5: Segmentation is on the basis of threshold value.

Each value is compared with threshold value for border detection.

Step6: Apply morphological operations on frame images.

Basically erosion and dilation morphological operators are applied.

Step7: Edge detection using Sobel's operator.

Step8: Display the edges of frames.

Step9: Displaying final frame by integrating detected edges.

Figure 3.3: Proposed Algorithm

IV. EXPERIMENTAL RESULTS

This section provides information regarding results, interpretation of results and comparison ofproposed technique using Pratt's figure of merit tool. We conclude several experimental results with this procedure on several echocardiographic videos.

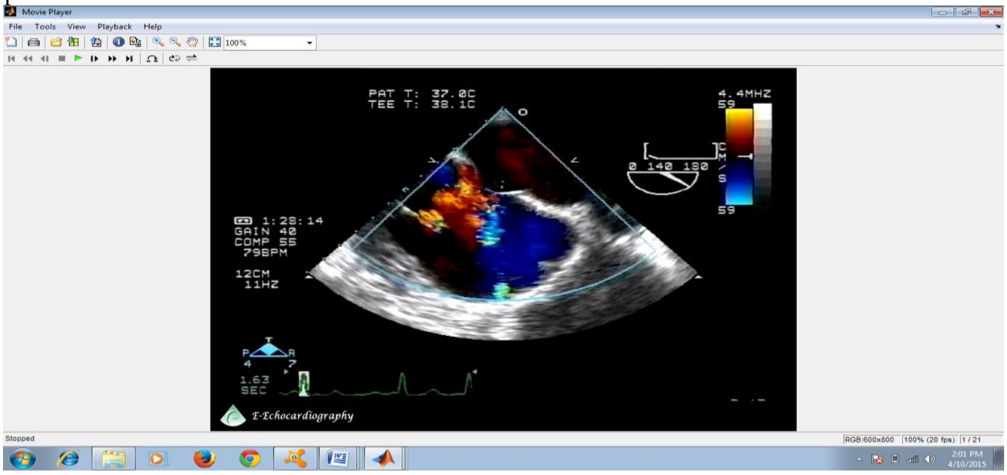

Figure 4.1: Starting Window of Purposed Work.

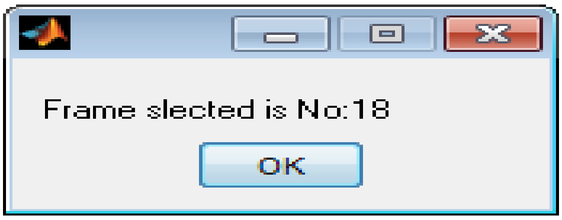

Figure 4.2: Frame is selected with best FOM value.

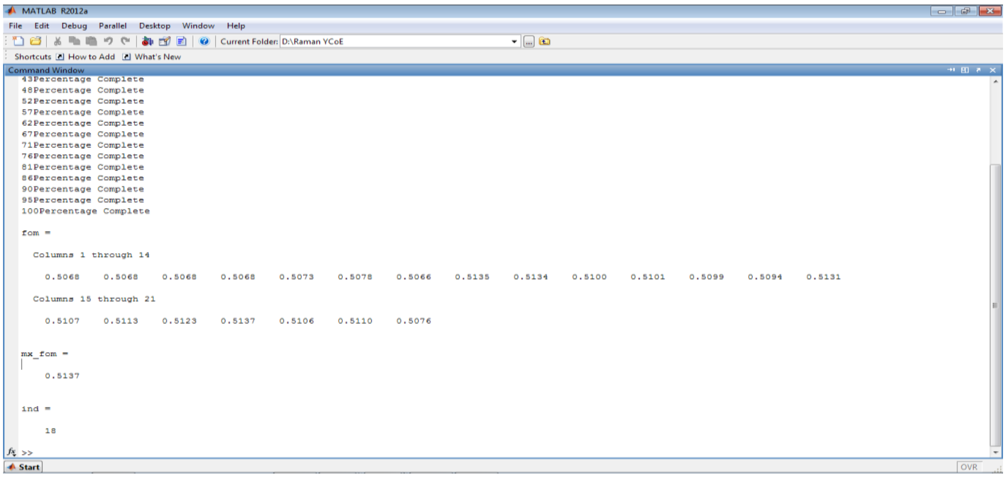

Figure 4.3: FOM value for all the frames.

Figure 4.4: After edge detection frame with wall boundaries.

4.5 Parameters of Edge Detection

In order to evaluate the accuracy of the proposed method quantitatively, Pratt's Figure Of Merit (FOM) metric were used for the results comparison process. FOM returns a number between 0 and 1 based upon the quality of edge detection, with 1 being the ideal. These measured computations are based on the desired edges that are generated from complete border option that is obtained from our proposed method. To do this computation, we need to separate the desired edge and then saved as new image after converted to binary. This process has been done by subtracting each pixel's intensity in the original image from corresponding pixel intensity in complete border image.

Table 1: The comparison of our proposed method with others using FOM tool.

2D Echo videos	**FOM average of our proposed method**	**FOM average of Existing Method**
V1	0.5130	0.3974
V2	0.4738	0.4133
V3	0.5259	0.4343
V4	0.4887	0.3694
V5	0.5057	0.5238
V6	0.5200	0.5203
V7	0.4955	0.4803

4.6 Comparison of Proposed work with Existing work.

The results are compared with existing method values. We have enhanced our work from existing work by using Pratt's Figure of Merit as a tool for the calculation of our results for both techniques. In figure 6.7 it is clear that results obtained by our purposed method are better than with existing results. So, if we do the comparison our purposed method yields better results which help diagnostics to take accurate and quick decisions.

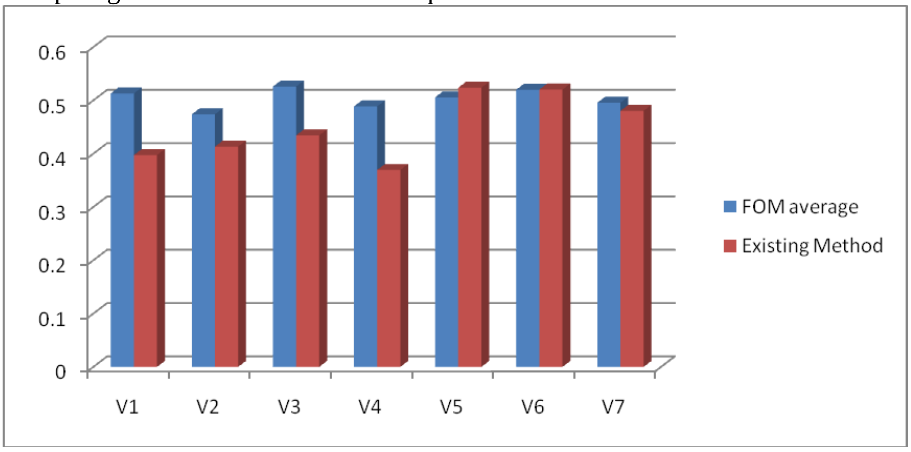

Figure 4.6: The comparison of FOM average measurement and existing method value.

V. CONCLUSIONS

For accuracy measurement, the experimental results of our Proposed Method have been compared with results that obtained from existing method qualitatively and quantitatively. Qualitative comparisons process is done by visual subjective observation of the specialist to make his decision according to the performance of results. This decision is represented as a score which is given as follows: 1: Purposed Method is worse than existing method, 2: Purposed Method is similar to existing method, 3: Purposed Method is more acceptable than existing method and 4: Purposed Method is better than existing method. Table 3 shows the qualitative validation for all data set. The results have shown the performance accuracy of our proposed method has more acceptable and better than existing method results. In order to evaluate the accuracy of the proposed method quantitatively, Pratt's Figure of Merit (FOM) metric were used for the results comparison process. FOM returns a number between 0 and 1 based upon the quality of edge detection, with 1 being the ideal. In our purposed method we try to compute the results that are close to ideal figure of merit values. As we compute ideal results it gives assistance to the experts for the better boundary detection of echocardiography images.

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