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AN EFFICIENT VIEW CLASSIFICATION OF ECHOCARDIOGRAM USING MORPHOLOGICAL OPERATIONS

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ABSTRACT

In this paper an efficient cardiac view classification of echocardiogram is proposed. A cardiac cycle consists of two phases systolic and diastolic. The systolic is the contraction and diastolic is relaxation and filling. From the given video sequences only the diastolic frames are extracted and it is utilized for determining the view of the echocardiogram. The Echocardiogram image are first prepared to reduce noise and to enhance the contrast of the image then mathematical morphology is used to highlight the cardiac cavity before segmentation using Connected Components Labeling (CCL) is carried out. We classify three standard cardiac views namely parasternal short axis (PSAX), apical two chamber (A2C) and four chamber (A4C) views. Experiments over 200 echocardiogram images show that the proposed method ascertains 94.56% of accuracy in cardiac view classification.

Keywords: *Connected Components Labeling (CCL), Apical two Chamber (A2C), Apical 4 Chamber (A4C) and Parasternal Short Axis (PSAX).*

I. INTRODUCTION

The human heart is a four-chambered muscular organ. It is shaped like a cone and sized roughly like a person's closed fist. It is normally situated slightly to the left of the middle of the thorax, underneath the sternum, and it is surrounded by the lungs. About two-thirds of the mass of the heart lies to the left of the body's midline [1]. The pointed end of the heart is the apex directed anteriorly, inferiorly, and to the left. The broad portion of the heart is the base, which is directed posteriorly, superiorly, and to the right. The two upper chambers are the atria, and the two lower chambers are the ventricles. The left and right chambers are separated by an extension of the heart wall called the septum. Blood flows from the atria to the ventricles in one direction. The de-oxygenated blood is collected by the right side of the heart from the right atrium and pumps it to lungs through right ventricle where the oxygen is picked up. The oxygenated blood in the lungs is collected by left atrium in the left side of the heart. Blood moves from left atrium to the left ventricle which pumps it out to the body as shown in Fig. 1. Due to improper blood flow heart failure occurs [2].

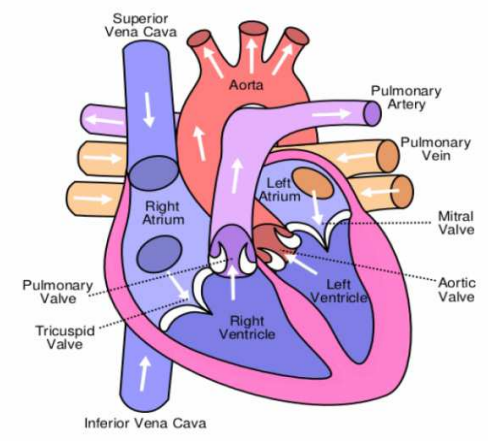

Fig: 1. Blood Circulation Through The Heart

The cardiac cycle has two phases:

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1. A phase during which the ventricles are relaxed, called the diastole.

2. A phase during which the ventricles are contracted, called the systole.

Towards the end of the diastole the atria contract, squeezing additional blood into the ventricles. During the diastole the pressure in the ventricles will always be less than that in the arteries, and the aortic and pulmonary valves will be closed [3]. So in this work only diastolic frames are considered for classification. If systolic frames are taken the aorta and pulmonary valves will be open which will make it difficult to segment the individual chambers.

Echocardiogram is used in the diagnosis and management of heart diseases. It involves processing and display of echocardiographic information to answer specific questions regarding the size, motion, and structural and functional characteristics of the heart. Parasternal Short Axis (PSAX), Parasternal Long Axis (PLAX), Apical and Subcostal views are the standard views in echocardiography. Currently we are focusing on four standard cardiac views Parasternal Short Axis (PSAX), Apical two Chamber (A2C) and Apical four Chamber (A4C) views. Fig 2. shows the echocardiogram images and their corresponding heart structures.

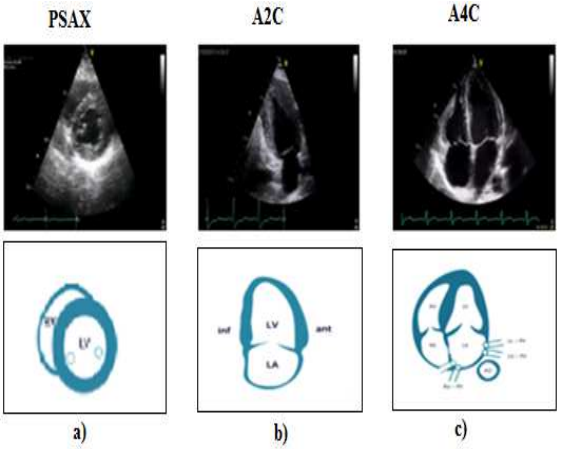

Fig: 2. Various Echocardiogram Images And Its Corresponding Heart Structure.

2. PREVIOUS WORK

Detection of heart chambers in echocardiogram images using cardiac cavity algorithm is proposed in [4]. The view classification is represented by the constellation of the detected heart chambers, which is coded as Markov Random Fields (MRF) [5]. Part based representation approach for recognizing the cardiac view is proposed in [6]. A novel algorithm to tackle cardiac view classification using multi-class object detection approach is proposed in [7]. The work in [8] uses two-level hierarchical classification approach combined with a simple dimensionality deduction approach. In our previous work calculation of Ejection fraction from segmented Left Ventricle is proposed [9]. Active contour model combined with the K-Means clustering algorithm for segmentation and boundary detection was proposed in [10]. Automating the segmentation of left ventricular chamber is proposed in [11]

3. METHODOLOGY

In this work an attempt has been carried out to classify the echocardiogram images based on three standard cardiac views namely parasternal short axis views (PSAX), apical two chamber view (A2C) and apical four chamber. The overview of the proposed system is shown in Fig.3. The diastolic frames extracted from the Echocardiogram videos are given as input to the proposed system. The first step is preprocessing which involves in denoising and contrast enhancement. Kuwahara filter and adaptive histogram equalization are applied in order to remove noise and enhance the contrast.

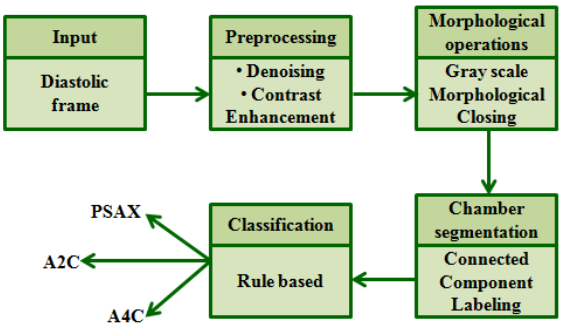

Fig: 3. Proposed System

The Kuwahara filter is used for smoothing the image while preserving the edges which helps in accurate segmentation. The adaptive histogram equalization is suitable for improving the local contrast of an image and bringing out more detail. Here the intensity difference between the cavity pixels and the

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muscle valve pixels is highlighted. Fig 4.shows the sample of original and preprocessed frames of each views taken.

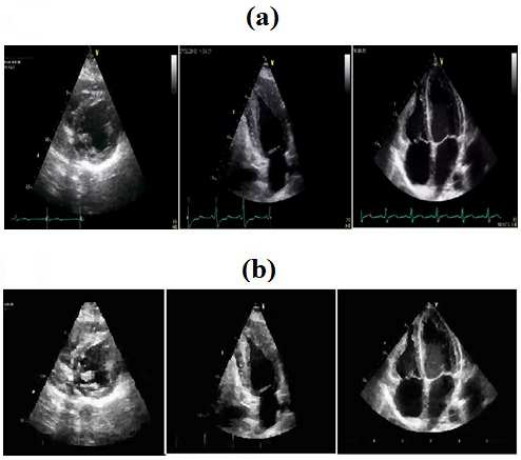

Fig: 4. a) Sample original images, b) Sample preprocessed images

To obtain the cardiac cavities morphological grayscale closing is applied on the preprocessed image which is binarised and then labeled by connected components labeling. Fig 5. shows sample preprocessed images after applying morphological closing and Fig 6 shows the labeled images after morphological closing and binarizing.

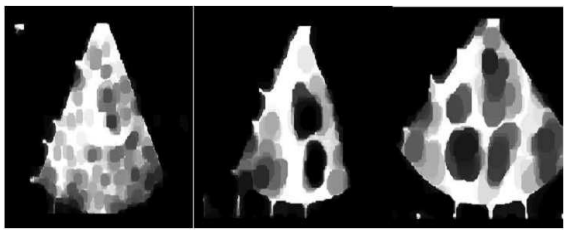

Fig: 5. Sample Preprocessed Images After Applying Morphological Grayscale Closing.

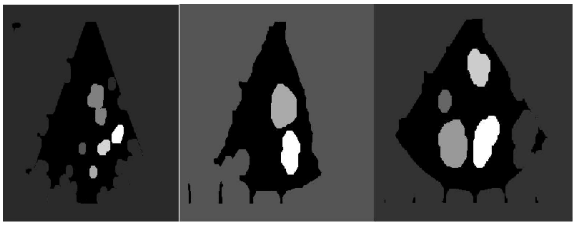

Fig: 6. Connected component labeling

The candidate region that is the cardiac chambers is obtained by discarding those components less than 4000 pixels and greater than 65000 pixels. These values were found empirically and this works fine for all short axis and apical echocardiogram images. The detected cardiac chambers are shown in Fig 7. If the number of chambers detected is 1 the image is classified as Parasternal short axis. If the number of chambers are 2 it is classified as Apical two chamber. If the number of chambers is 4 then the image is classified as apical four chamber view.

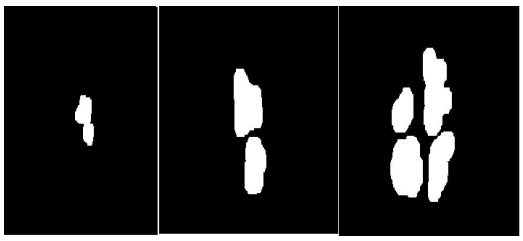

Fig 7. Segmented Chambers

200 Echocardiogram images (70 PSAX, 50 A2C, and 80 A4C) were taken up for this study to ascertain the efficiency of the proposed method. Table 1 gives the confusion matrix obtained. The accuracy is greater for PSAX view when compared to apical views.

Table 1: Confusion Matrix Of Cardiac View Classification

Test Image	PSAX	A2C	A4C
PSAX (70)	96.5%	2.1%	1.1%
A2C (50)	3.2%	93.4%	3.4%
A4C (80)	3.1%	3.1%	93.8%

4. CONCLUSION

In this paper an efficient cardiac view classification of echocardiogram is proposed. Using mathematical morphological operations and connected component labeling the cardiac chambers are detected based on which three standard views PSAX, A2C and A4C are classified. The proposed method performs very well on all the three standard views. Further exaction of diastolic frames can be automated and more views like Parasternal Long Axis, Subcostal views etc. can be added for classification.

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