Automatic Detection of Mitral Valve Disorders using Artificial Neural Network

Ms. Anu Reeby John
S_3 M.Tech
Dept.ECE
AJCE
Kanjirapally, Kerala, India

Mr. Jose J Edathala
Asst.Professor
Dept.ECE
AJCE
Kanjirapally, Kerala, India

***Abstract*- This project proposes an approach for the automatic detection of the mitral valve disorders from 2-D echocardiographic images. A dataset of 100 images were collected from the hospital that included both normal and infarct cardiac pathologies. Detailed cavity geometry and the position of the mitral valve were accessed using de-noising, binarization and edge detection techniques. Feature extraction was done using Gray Level Co-occurence Matrix and intensity histogram techniques. Finally artificial neural network has been trained as a classifier for the automatic detection of the mitral valve disorders in the echocardiographic images. The accuracy of the result was tested with the help of an expert cardiologist. The main reason underlying this study arises from the finding that if the mitral valve annulus fails to properly connect with the leaflets, then the functioning of the heart may be compromised resulting in mitral valve regurgitation.**

Keywords – Mitral valve disorder, Artificial Neural Network, Echocardiographic Image.

I. INTRODUCTION

The cardiac diseases have been tremendously increasing in recent years. Heart is an important part of the human body so the functioning of the heart is very important to be in regular. The percentage of heart failure will increase to 23.3 million by the year 2030 [1]. Hence heart failure is a major clinical problem. The cardiac cycle is a combination of two phases of the heart which is the systole and the diastole. The diastole is the process of blood is filled into the chamber of the heart and the systole is the process of blood flowing out from the chamber of the heart. The aim is to identify the heart valve disorders particularly the mitral valve. Left ventricle is of prime importance since it pumps the oxygenated blood (pure blood) to all parts of the body. This is done by identifying the anatomical information of the heart with the dataset of both the normal and patients with mitral valve disorders.

The heart is a muscular organ which pumps blood through the blood vessels of the circulatory system. The blood provides the body with oxygen and nutrients, as well as removing metabolic wastes. The heart is divided into four chambers: upper left and right atria; and lower left and right ventricles. The right atrium and ventricle are referred to as the right heart and their left counterparts as the left heart. Due to heart valves, blood flows only one way which prevents backflow. The heart is enclosed in a protective sac called pericardium. A normal functioning valve allows blood to flow unimpeded from the left atrium to the left ventricle during diastole and prevents mitral valve regurgitation during systole.

Mitral valve function is dependent on the integrity of the underlying valvular structure and also on the adjacent myocardium. Detailed cavity geometry and the position of the mitral valve were accessed using de-noising, binarization and edge detection techniques. The de-noising scenario was being performed in the framework of Gaussian noise. Noise quality parameters were calculated. Feature extraction was done using Gray Level Co-occurrence Matrix (GLCM) and intensity histogram techniques. Artificial neural network was trained as a classifier for the effective investigation of mitral valve disorders.

II.PROPOSED METHODOLOGY

The flowchart of the proposed algorithm is shown in Figure 1.

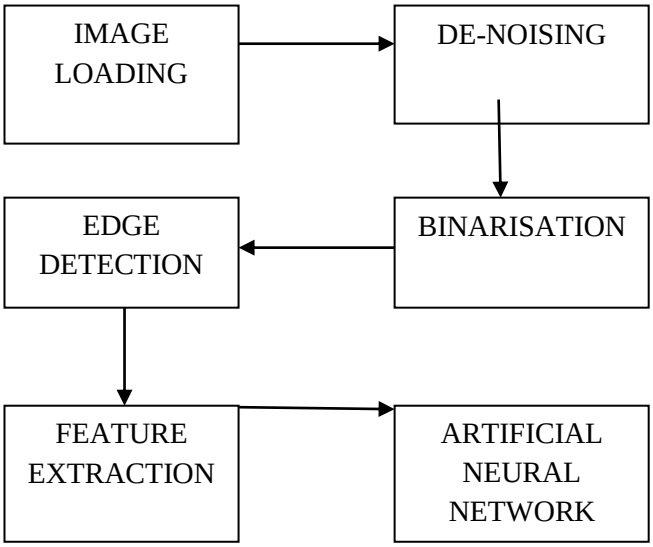

Figure 1: Flowchart of the algorithm

The algorithm consists of three main parts. In the first part images were denoised, binarized and edge detection techniques were applied. In the second part feature extraction was done followed by classification in the third part of the algorithm.

A. Image Loading

The image database is created by collecting images from the hospital. Images included both of healthy heart and with infarct cardiac pathology. The infarct pathological echocardiographic images were taken because it is the cause of mitral valve regurgitation.

B. De-Noising

Removal of the noise is an important step in the cardiac disease diagnosis. This is carried out using the following steps- Fourier transform was performed followed by filtering the frequency components using a Gaussian Low pass Filter. To reconvert the image back to spatial domain inverse Fourier transform was performed.

C. Binarisation

Otsu's global binarisation method was employed to obtain an optimal threshold. This technique divides the histogram of the image into two classes so that the intraclass variance will be minimal.

D. Edge Detection

Canny detector is used for the edge detection. It is computed using an algorithm comprising of five steps. The first step involves smoothing followed by finding the gradients, non maximum suppression, double thresholding and hysteresis. Canny edge detector checks for the intensity discontinuities and a threshold value is chosen depending on which the core boundary is held or discarded.

E. Feature Extraction

Gray-level co-occurrence matrix (GLCM) is the statistical method of examining the texture features. GLCM functions calculates how often pairs of pixel with specific values and in a specified spatial relationship occur in an image. The MATLAB function graycomatrix creates a gray-level co occurrence matrix (GLCM) by calculating how often a pixel with the intensity (gray-level) value i occurs in a specific spatial relationship to a pixel with the value j.

F. ARTIFICIAL NEURAL NETWORK

The artificial neuron is inspired from real biological neuron. Neuron outputs +1 when the net input reaches a threshold. By the supervised training of artificial neural network it can predict the output accurately. Once the artificial neuron is trained, the classification becomes fast.

III. RESULTS AND DISCUSSIONS

The experimental images were divided into two sets by one expert radiologist physician. The expert manually labelled the images. The experimental images came from a blend of healthy and cardiac patients that suffer from myocardial infarction. Input image is shown in Figure 2.

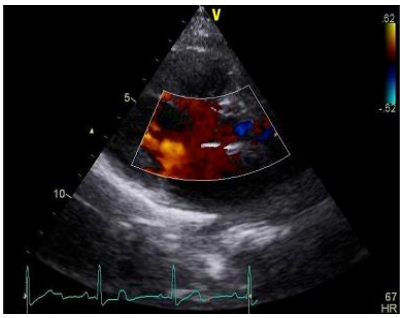

Figure 2: Input Image

This step is followed by image de-noising. Noise quality parameters were calculated. Higher values of Signal to Noise ratio (SNR) and Peak Signal to Noise Ratio (PSNR) indicates a good de-noising scenario. The denoised image is shown in Figure 4.

Figure 3: Image corrupted with Gaussian Noise

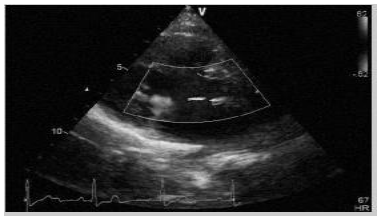

Figure 4:De-noised Image

Images are then binarised using Otsu's method. The binarisation produces satisfying results and the myocardium walls are optimally highlighted .The binarised image is shown in Figure 5.

Figure 5: Image after Binarisation

Edges are detected using canny method. Most of the major edges were detected. Edge detected image is shown in Figure 6.

Figure 6: Image after Edge Detection

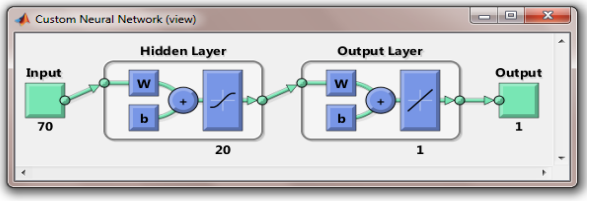

Figure 7: Network Model

trained, classification becomes very fast. Network model is displayed in Figure 7 and final output is displayed in Figure 8.

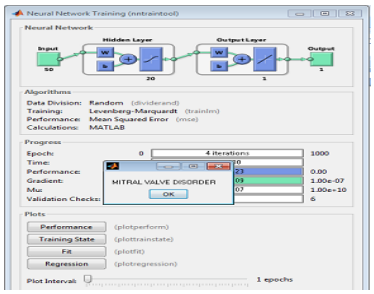

Figure 8: Final Output

GLCM and Intensity histogram techniques were used to extract the texture features. GLCM works well on medical images. Finally artificial neural network was trained such that it efficiently classifies the echocardiographic images. Once it is

IV. CONCLUSION

This method provides an efficient way of detecting mitral valve disorders by employing the texture features. Detailed cavity geometry and the position of the mitral valve were accessed using de-noising, binarization and edge detection techniques. Graphical User Interface environment was used in MATLAB for the analysis. By the supervised training of Artificial Neural Network, it classifies the echocardiopgraphic images with greater accuracy.

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