Comparison of Discrete and Continuous Wavelet in Cardiac Cycle Phase Detection using Echocardiography Images and ANN

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ABSTRACT
The cardiac diseases have been increasing a lot in recent years. As the heart is the important part of a human body, the functioning of the heart is very important to be in regular. The functioning of the heart is called as cardiac cycle. The cardiac cycle is the combination of two phases of the heart i.e. the actions that happen in between the pumping of the heart. This could also be said as two main states of heart, "diastole and systole". The diastole is the process of blood filled into a chamber of the heart and the systole is the process of blood flowing out from the chamber of the heart. The aim here is to identify the states of the heart and the volume during the cardiac cycle function occurs. In this paper the left ventricle is considered for the project. The feature extraction extracts the information about the given image and also differentiates them under the two categories either the heart left ventricle is in the diastolic state or under the systole state. The image here consists of noise and is removed by using the median filter as the first scenario and wavelet transform for the edge detection in the second scenario. To extract the data from the image is the third scenario, the mean and SD has been calculated here. To classify the two states of the heart, the Artificial Neural Network (ANN) is used. This is fourth scenario. By training the Neural network classifiers the heart images are classified as diastole and systole.

Index Terms
Cardiac cycle, Diastole, Systole, Echocardiography images, Pathology, Median Filter, Wavelet, Anatomical information, ANN, Classifiers

1. INTRODUCTION
THE life of a person is conformed with the heart beat, heart is located in between the lungs. This is the important organ in the body due to is importance of making all parts of the body to function with the pure blood and collect the impure blood from those organs [2]. The cardiac heart failure is the most commonly affecting problem in the human body due to various reasons like, blood pressure, cholesterol, diabetes, obesity, etc,. The global cause of death among all people is now-a-days is due to the cardiovascular diseases, than others causes the most of the people die due to this diseases. Some of the cardiovascular diseases that appear in body are: coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatic heart disease, congenital heart disease, deep vein thrombosis and pulmonary embolism. In the year of 2008 17.3 million people were died due to cardiovascular diseases, which represent 30% of all global disease. Of estimated these diseases 7.3 million were due to the coronary heart disease and the 6.2 million were due to the heart attack (stroke).As the World Health Organisation record say in the Media Centre: Low and the middle class income countries are affected over 80% of the cardiovascular disease and it was equally affected both the genders, the male and the female. The most common disease that make to the cardiovascular disease is the heart attack (stroke) and the percentage will increase to 23.3 million by the year 2030, this vulnerable cardiac disease projected to remain the only single leading cause of the death. The one of the reason which is due to the blood pressure which causes 9.4 million deaths each year or is the 16.5%. This which includes the 51% of the death is due to the strokes and where due to the coronary heart disease [3]. The heart failure is the major clinical problem in the world, which strived to work on the project. The heart is viewed as in the simplest term, the heart consists of four chambers with the blood network of arteries and veins. The arteries always take the oxygenated blood (pure blood) and veins carry the deoxygenated blood (impure blood). Echocardiography represents a non- invasive procedure to examine the heart and the surrounding blood vessels [10]. This case changes in the heart, here the pulmonary artery carries the deoxygenated blood (impure blood) to the lungs to purify the blood and the purified blood from the lungs is taken to the atrium of the heart [4][5][6]. The four chambers of the heart is views as 1) Left Article 2) Left Ventricle 3) Right Article 4) Right Ventricle.

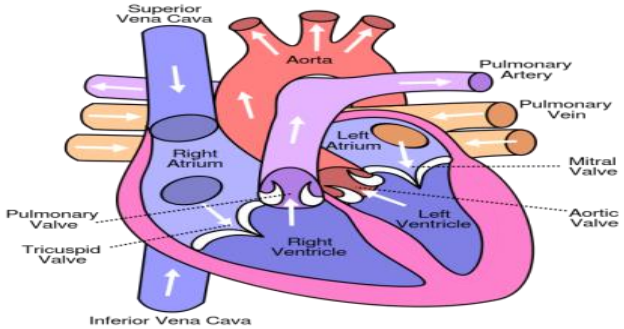

Fig.1. Heart

Commonly the atrium collects the blood and the ventricle transmits the blood. The Left article collects the impure blood from the all parts of the body through the superior vena cava and sends it to the ventricle through the tricuspid valve which further transmits the impure blood to the lungs through

pulmonary artery. The right article collects pure blood from the lungs and gives it to the left ventricle through the mitral value, now the left ventricle transmits the blood to the all parts of the body through the aorta. Thus pure blood is transmitted through the mitral value from atrium to ventricle so that all parts of the body get the pure blood. Due to this importance the mitral valve is taken for the analysis, as the main and important part of the heart. This is the basic part to be functioned well else there will be some existence of some dysfunction in the heart. There are also the two states of the heart in the cardiac cycle: 1) Diastole 2) Systole. The cardiac cycle for an normal person will take place for about 60-100/min. The Diastolic function is the process, where a chamber fills with the blood. Systolic is the function, where the filled chamber pumps out the blood. Thus the ventricle images and the cardiac cycle phase estimation are great importance to the cardiac research and the valuable tool to clinically assess cardiac health. For the estimation of the heart and find the possible disease the first step is the automatic detection of the states of the heart. Moreover the echocardiography also allows the detection of automatic and semiautomatic states of the heart depending on the image features. [1]. As said in [7] by W.H. Gaasch and R.m Zile showed that the with the clinical examination only cannot distinguish between the diastolic heart failure, thus the proposed paper concentrate on the part of identifying the states as the first step. This paper mainly focused on the left ventricle cardiac chamber of the heart and the mitral valve position of the heart. The purpose of the paper to develop is the increase the recognition of the states and reduces the doctor's time in identifying whether there is a problem in the heart and in identifying does the basic function is performing periodically and regularly and to also correctly distinguish between the diastole and systole state of the heart. The detail of the heart and the position of the valve are extracted using the combined methods and the techniques. Those are the reading the image, de-noising the image, detecting the edges of the image, extracting the required information from the image, classifying the image into two category.

Reason for the study

The main reason of underlying this study is, if the bicuspid valve or the mitral valve annulus fails to function properly then the functioning of the heart will be compromised in resulting in the heart attack, which is the main reason of the occurrence of the cardiovascular disease [maximum reason for the cause of the death], Heart failure, Endocarditis, Rheumatic fever, Stenosis, Infective endocarditis.[8]. This paper has been organized as sections follows: Section2 dissipates the data flow diagram and the datasets of the paper. Section3 provides the methods and techniques used in this paper, section4 provides the results and analysis of that have been got during the process. Finally, the conclusion and the future work to be carried out from this paper are dissipated in the section5.

2. DATA FLOW DIAGRAM AND DATASETS

This flowchart represents the proposed algorithm. This algorithm consists of major three divisions or the three parts. The first part of the algorithm is the "pre-processing". This pre-processing step consists of de-noising, gray scale conversion, binarization, and the edge detection. A set of images is collected from the Apollo hospital, Madurai and from those images the needed data is alone extracted in the second part of the algorithm. This step involves the extracting the data from an image. The final part of the algorithm is classifier; the Artificial Neural Network is used, for the classification of the image. The input data to the classifier is the data with the mean and the standard deviation value. Based on the given input image to the classifier, the image is compared with the existing image in the database and produces the result.

In order to effectively work on the project, the mitral valve position of the heart is taken under the study. These images are the frames of the ultrasound images of the heart of the patients were used for the case. The dataset of 130 images were used, in which the both normal and abnormal cases of the images were also taken under consideration. Mostly the image with the infract pathology has been chosen as because it will cause the mitral value to not close properly and make the mitral valve regurgitation. Also the dead tissue will show the compromise of the mitral valve position and the process.

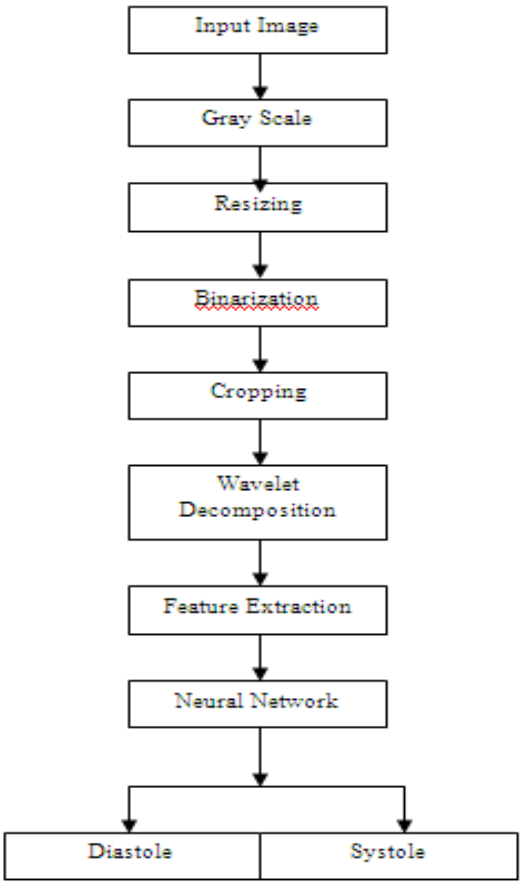

Fig.2. Flowchart of the algorithm

The Dataset here is collected with the image of 64*64 was taken and the decomposition of the image has been done. The hardware of the experiment is done on the Intel (R) Core(TM) i5-2450M CPU @ 2.50GHz 2.50 GHz with windows 7, with 64 bit OS and 4.00 GB RAM. The operating toolbox with the wavelet 2D toolbox in MATLAB 7.

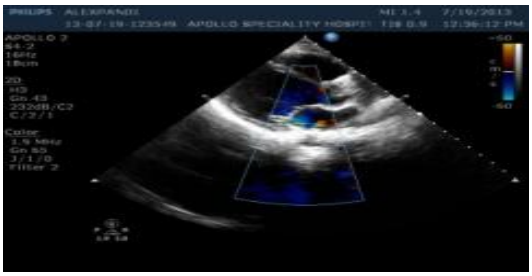

Fig.3. Systolic Phase of the LV1

Fig.4. Systolic phase of the LV2

Fig.5. Diastole phase of LV 1

Fig.6. Diastole phase of LV2

Table I. PSNR Value comparision

FILTER	TIME TAKEN	PSNR
MEDIAN	6.2 Sec	32
GAUSSIAN	8.9 Sec	29

3. METHODS AND TECHNIQUES

The techniques used here are, denoising, binarization, edge detection, feature extraction, Artificial Neural Network.

3.1 Image De-Noising

Image de-noising is task is very important step. There are many ways for denoising an image, the most common way is the use of Gaussian filter, but the time of execution and the accuracy has been got satisfied while detecting the edge while using the median filter. Thus the median filter is used for denoising the cardiac image.1) the image loaded is added with the salt and pepper noise, 2) then by using the median filter the added noise along with existing noise were removed.

In further proceedings with the median filter the edges of the input image has been got clearly, so the median filter is used here.

$$Y[m,n] = \text{median}\{x[i,j],(i,j)\ \text{Ɛ}\ w\} \quad (1)$$

This gives the median value for an image and the noise existence is thus removed from the data input image and the de-noised image, as an output has been received.

3.2 Binarization Methods

For binarizing the image the default threshold value has been calculated using the "graythresh" function in the MATLAB. To perform this operation the image which is in rgb is converted to gray scale image. Now using this threshold value the binary image is obtained using the generated threshold value.

3.3 Edge Detection

The edge detection is the main part, where the edges of the cardiac images are obtained. The Wavelet edge detection is used to identify the edges. The wavelet was used, as its accuracy of detecting the edges was high. Thus using the wavelet the image data are obtained in a high accurate result. As referred in [9] for the analysis of singularities, the Fourier transform and the wavelets are the mathematical tool. But the Fourier transform is too global to adapt and analyze on local singularities, which makes the identification of location and spatial distribution difficult. This problem here is overcome by the wavelet transform, which is the local analyzer.

$$\boldsymbol{\psi^1}(x,y)=\frac{\partial \boldsymbol{\theta}(x,y)}{\partial x} \text{ and } \boldsymbol{\psi^2}(x,y)=\frac{\partial \boldsymbol{\theta}(x,y)}{\partial y} \quad (2)$$

3.4 Wavelet Decomposition

The wavelet decomposition is merely done for the lossless reduction of the size of an image. The resizing i.e. the image is here decomposed such that the data of the image is preserved. The wavelet used here is discrete wavelet, as the continuous wavelet is used for the signal processing and discrete wavelet transform is used for the image processing mainly. Some of the wavelet families are: Beylkin, BNC Wavelets, Coiflet, Cohen-Daubechies-Feauveau wavelet, Daubechies Wavelet, Binomial-QMF, Haar Wavelet, Mathieu Wavelet, Legendre Wavelet, Villasenor Wavelet, Symlet. The levels of wavelet are from 1-5. Here the accuracy of the image is maintained till the 3rd level of the decomposition. This wavelet decomposition is here done to reduce the image size and proceed the process. This will lead to save time with maintain the accuracy of the process. Thus the wavelets are used at most of the time. The commonly used wavelet is Haar and daubchies. The same wavelets are also used in this paper. The decomposition is done as:

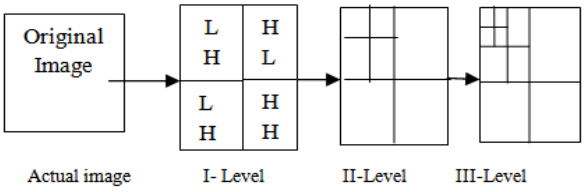

Fig.7. Decomposition Levels

The four divisions in the image was the same in all level of the decomposition, instead the levels are the iteration. This four divisions are 1) LL – Smoothing image of the original image, 2) LH - Preserves horizontal edge details, 3) HL – Preserves vertical edge details, 4) HH – Preserves diagonal edge.

3.5 Feature Extraction

The feature extraction as the name means the extracting the data, especially the required data from the image. This consists of various methods and methodologies applicable in current technology. One of the techniques used in this paper was identifying the mean and the standard deviation of the image.

- Standard Deviation

$$S= (\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2)^{1/2} \quad (3)$$

$$S= (\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2)^{1/2} \quad (4)$$

- Mean

The sum of all the pixels and its average is mean. By calculating the mean and the SD a normal value is calculated and kept. This value is kept as a condition the values are segregated separately and the images are viewed. These images gave 99.79 % of output when the threshold value is low. This value was used in the Neural Network to train it. The mean and standard deviation value could be adjusted based on the project need, as because the wavelet has been used.

3.6 Artificial Neural Network

The Neural Network is the network of nodes which is used as a classifier. It is same like neurons, which gives the output or response based on the input or the stimulus. It has various layers where the first layer is the input layer and followed with some of the hidden layer and the output layers interconnected to each of them. The 'r' input to the system M= $\{m_1, m_2, m_3, \ldots\ldots\ldots\ldots, m_r\}$, the features of vector W=$\{w_{1,1}, w_{1,2}, w_{1,3}, \ldots\ldots\ldots\ldots, w_{1,r}\}$

The artificial neural network is often defined by the three parameters.

- Interconnection pattern between the neurons.
- Learning process in order to update the weight of the interconnections.
- The activation function.

The activation function will convert the input as to the output of activation.

4. RESULTS AND DISCUSSION

The results for all the methods got in the process are displayed.

4.1 The Original Image

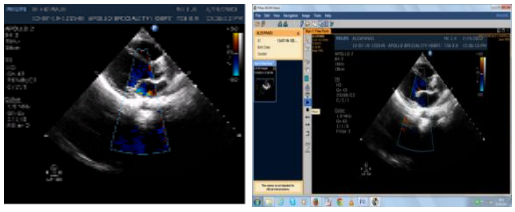

Fig.8.a) Diastole **Fig.8.b) Systole**

These are the original images used for the identification of the cardiac cycle phases.

4.2 The Grayscale Image

Fig.9. Gray scaled image

4.3 The De-noised image: Noise and Noise Removed

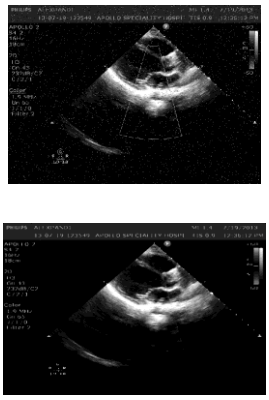

Fig.10. Ventricle diastole and systole

The noise is added using the salt and pepper noise and then removed using the median filter**.**

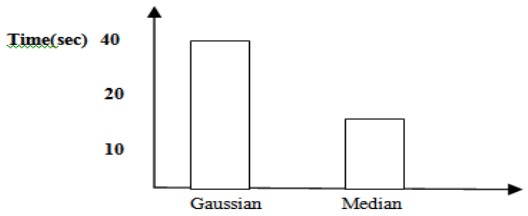

Fig.11. The Elapsed time comparison for Gaussian and the median filter

4.4 Binary Image and the Resized Image

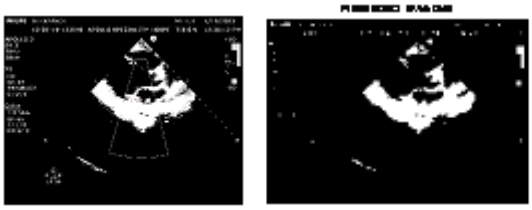

Fig.12. Binarized Image

4.5 Edge Detection

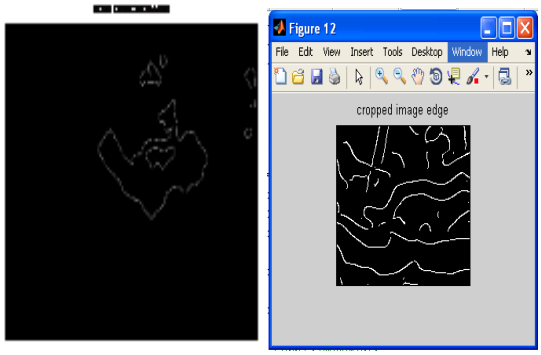

Fig: 13 a) edge detected image. ***b)*** **Cropped image**

4.6 Wavelet Edge Detection

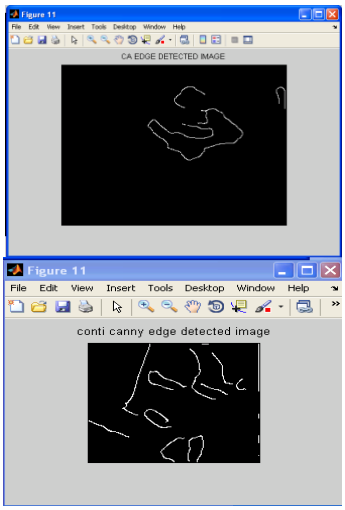

Fig:14 a) Discrete wavelet edge detection b)Continuous Edge Detection

4.7 Wavelet Decomposition

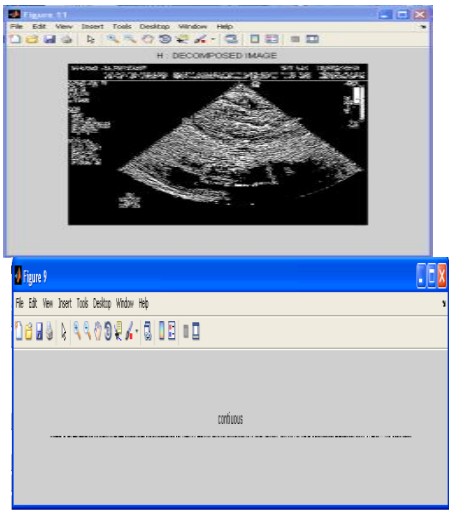

Fig.15.a)Haar Wavelet – H b) Continuous- Haar

4.8 Feature Extraction

The features extracetd here are mean and the standard deviation. This features extracted here for the edge detection image. This extracted feature and the result of the Artificial Neural Network are analysied mannualy by the specialist.

Table II. Features and its classification, mean:24.72 SD 69.33 Discrete Wavelet

No	Diastole			systole		
	Mean	SD	Classification	Mean	SD	Classification
1	16.3	55.7	Diastole	26.3	71.4	systole
2	18.5	58.3	Diastole	23.1	70.9	systole
3	16.1	60.1	Diastole	24.7	74.5	systole
4	15.8	68.3	Diastole	25.3	71.2	systole

Table III. Features and its classification, mean:3.777 SD26.5 continuous Wavelet

No	Diastole			systole		
	Mean	SD	Classification	Mean	SD	Classification
1	3.06	16.3	Diastole	4.6	26.7	systole
2	3.56	18	Diastole	3.87	23.9	systole
3	3.7	17.6	Diastole	3.98	23.9	systole
4	3.75	15.8	Diastole	4.63	25.6	systole

4.9 ANN Classifier

The mean and SD calculated value is used for thhe classifier for classification. The values lesser than that of the calculated value are the diastole state and the rest of the image are in the systolic state.During testing the images were distinguished correctly.

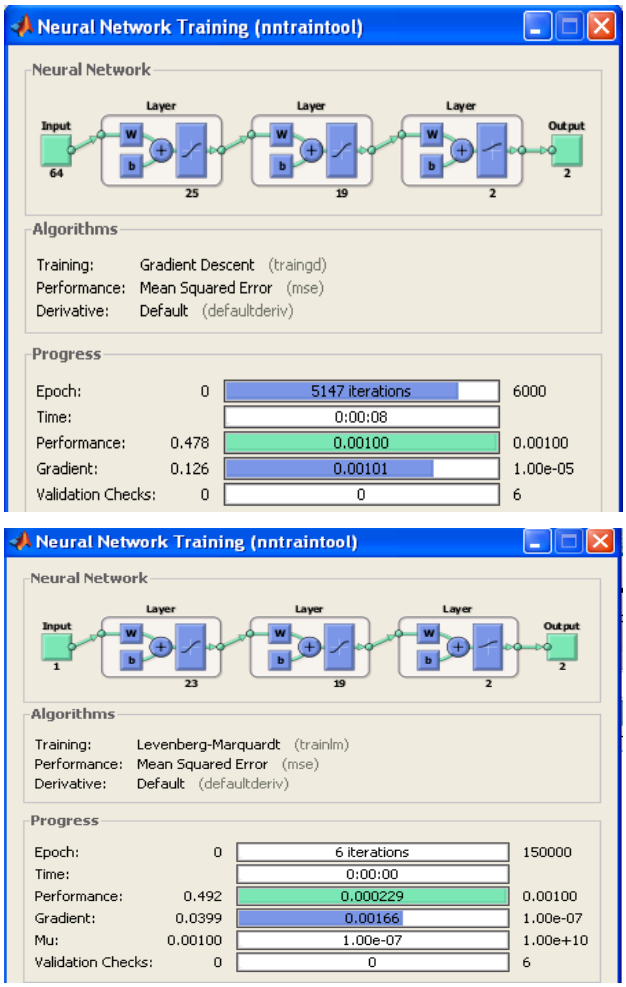

Fig.16. a)Discrete Wavelet ANN b) Continuous Wavelet ANN

5. CONCLUSION

With the existing methodology and the techniques the cardiac cycle has been differentiated. This mainly helps in saving the time of the doctors. The images of the person could be got from the echocardiography machine and sent as the input to system, it will identify the differences between the occurrence of the diastolic and the systolic function. Such that this result could be printed and analyzed by the doctor. So that the doctors need not check all the type of suspecting one but could go with the suspected analysis for the possible occurrence of the disease. This technique is itself removes the available noise and provides the sufficient results for doing the work. Finally, the future work is estimating the thickness of the ventricle valve during each phase of the cardiac cycle.

6. ACKNOWLEDGMENT

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