ECG SIGNAL ANALYSIS FOR ARRHYTHMIA USING BACKPROPAGATION NEURAL NETWORK ALGORITHM

Project report submitted in partial fulfillment of the requirements for the Degree

Of

BACHELOR OF TECHNOLOGY

BY

ASHISH SAINI-141045

ADITYA RAJ-141051

NITESH KUMAR -141099

UNDER THE GUIDANCE OF

Dr. SHRUTI JAIN

Department of Electronics and Communication Engineering

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

MAY-2018

DECLARATION BY THE SCHOLAR

I hereby declare that the work reported in the B-Tech project entitled **"ECG signal analysis for arrhythmia using backpropagation neural network algorithm"** submitted at **Jaypee University of Information Technology, Waknaghat** is authentic record of my work carried out under the supervision of **Dr. Shruti Jain.** I have not submitted this work elsewhere for any other degree or diploma.

Ashish Saini

Aditya Raj

Nitesh kumar

Department of Electronics and communication Engineering
Jaypee University of Information Technology, Waknaghat, India
Date:

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY
(Established by H.P. State Legislative vide Act No. 14 of 2002)
P.O. Waknaghat, Teh. Kandaghat, Distt. Solan - 173234 (H.P.) INDIA
Website: www.juit.ac.in
Phone No. (91) 01792-257999
Fax: +91-01792-245362

CERTIFICATE

This is to certify that the work reported in the B.Tech project report entitled **"ECG signal analysis for arrhythmia using backpropagation neural network algorithm "** which is being submitted by **Ashish Saini Aditya Raj Nitesh Kumar** in fulfillment for the award of Bachelor of Technology in Electronics and Communication Engineering by the Jaypee University of Information Technology, is the record of candidate's own work carried out by him/her under my supervision. This work is original and has not been submitted partially or fully anywhere else for any other degree or diploma.

Dr. Shruti Jain

Associate Professor
Department of Electronics & Communication Engineering
Jaypee University of Information Technology, Waknaghat,

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We would like to extend our sincere and heartfelt obligation towards all the people who have helped us in this endeavor.

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Thank you,

Ashish Saini
Aditya Raj
Nitesh Kumar

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ABSTRACT

ECGs are necessary medical specialty signals that are reflective of an electrical activity of the heart. Graphical record signals are one amongst the best-understood signals being at constant time a crucial supply of diagnostic info .Within the recent years there has been a gentle and intensive analysis with intent of developing economical and effective ways of process and analysis of graphical record signals. This methodology employs various filtering techniques to filter out the baseline wander noise embedded in the input ECG signal to the system. These noise are being removed by preprocessing of ECG signal. Next process is feature extraction in which wavelet transform is used after the preprocessing of signal. Wavelet transform remove the high frequency noise at different levels. After this various features have been extracted from the signal i.e. mean, median, rmse, variance etc. this data has been feed to the classifier block where the back propagation neural network algorithm has been used to classify the ECG signal in two classes. In first class there is arrhythmia whereas in second class there is no arrhythmia is present.

CHAPTER-1

INTRODUCTION

Electrocardiography (ECG or EKG) is that method of recording the electrical activity of the center over an amount of your time victimization electrodes placed on the skin. These electrodes observe the little electrical changes on the skin that arise from the center muscle's electrophysiological pattern of depolarizing and repolarizing throughout every heartbeat. It's a really usually performed medical specialty take a look at. The electrical activity of the center is caused by a sequence of fast ionic movements across cellmembranes ensuing1stin depolarisation (activation) so repolarization of the cardiac muscle cells. This process leads to sequential changes in the cellular membrane potential and is referred to as the action potential. In the normal heart, the electrical activity associated with each cardiac cycle originates in a specialized group of cells in the high right atrium known as the Sino atrial Node (SA Node). SA Nodal cells spontaneously depolarize at a rate that is dependent on the relative balance of sympathetic and parasympathetic tone . At rest, vagal (parasympathetic) tone predominates and the SA node spontaneously depolarizes, on average, 60-100 times per minute. During exercise, there is both increased sympathetic nervous system activity and withdrawal of vagal tone and the SA node may depolarize at a much faster rate, depending on age. From SA node the wave of depolarization propagates in an orderly timed fashion to the remaining atrial tissue, to the Atrioventricular Node (AV Node), the His-Purkinje system and then to the left and right ventricular myocardium (Fig:1). The AV node conducts relatively slowly, thereby allowing the atrium to fully contract before ventricular contraction starts. The His-Purkinje system (also named a specialized physical phenomenon system) consists of the most His Bundle and also the left and right bundle branches and also the diffuse fine network of bodily cavity Purkinje fibers. Relatively rapid conduction in the His-Purkinje system allows for synchronized contraction of the ventricles. The ECG waveform is shown in (Fig: 2)

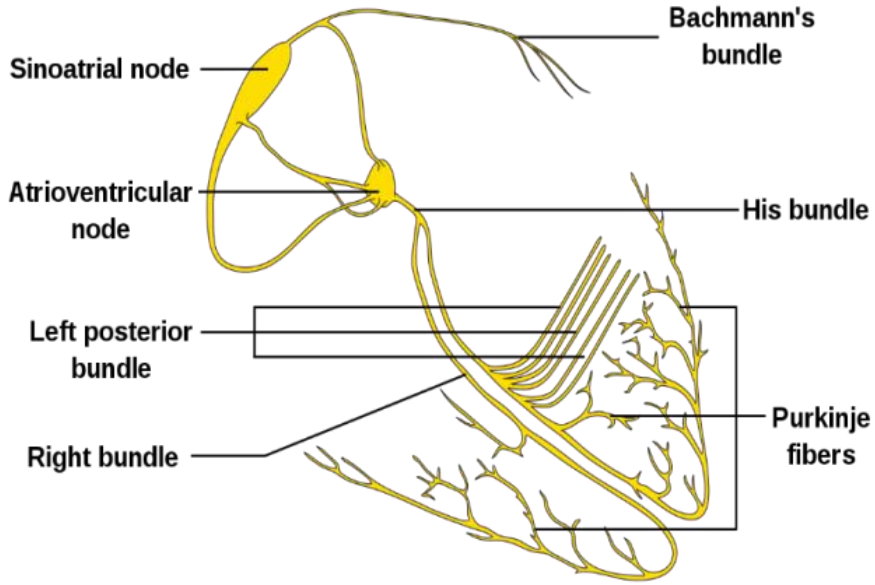

Fig 1: His-Purkinje system[3]

1.1 AMPLITUDE AND INTERVALS OF ECG WAVEFORM

P Wave

For ECG waveform P wave plays one of the most vital role. This P wave speaks to a trial depolarization or conduction of an impulse by atria. At the point when survey a P wave, appear to be specifically at its trademark, particularly its area, design, and redirection. An ordinary P wave has the accompanying attributes: The amplitude of P-wave comes out to be two to three millimeter high and time comes out to be 0.06 to 0.12 seconds where the QRS complex is being preceded by located P wave and the same can be depicted out from figure 2 during arrangement it is typically adjusted and smooth. For an instance if the P wave's setup and redirection is typical, if P wave is upright, un-lead, delicate and adjusted, and also if QRS complex comes after P wave then it can be expected that in sinoatrial hub (SA) the electrical inclination begins. It is true that in halfway only, through P wave the contraction of atria starts. It must be very well noted that only electrical activities are being taken into account by ECG [10-15].

Fluctuating P waves point towards that the impulse might originate from various locales, as with a meandering pace producer mood, bad tempered atrial tissue, or harm close to the SA hub. With functional rhythm other than SA hub drive start by tissue may be signified by P waves. At the point P wave does not precede the QRS complex, heart block may be present.

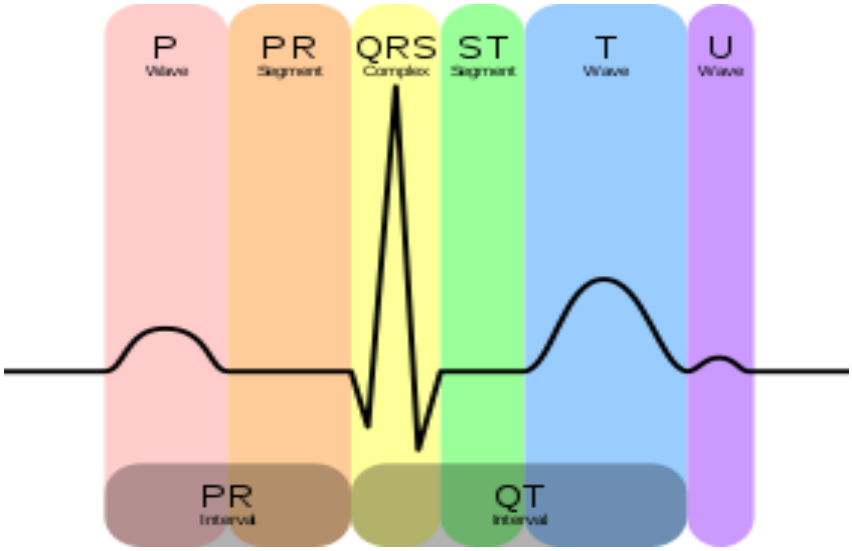

Fig 2: ECG signal waveform [2]

PR Interval

From artria through hub the atrial impulse is being taken after by PR interval, a person's heap and package branches of left and right, are some of the things which are being looked upon for analyzing the PR interval. There some progression happened in PR interval causes a changed impulse development or a conduction delay, as seen in above graph. The initial point of P wave is associated with the initial of the QRS complex for the PR interval and time interval for the same lies between 0.12 to 0.20 second.

QRS Complex

Ventricles and impulse conduction's depolarization are being represented and also the tracking of P wave is being done by QRS complex. QRS complex is being introduced as soon as the depolarization of ventricles occurs so that bonding between them can be done. A waveform is generated as the blood gets drained by the corridor, which comes out of the ventricles being launched because of the bonding being created. At whatever point the heart is being observed it must be recalled that the waveform is just the electrical mode of movement of heart. When there is an indiscreet compression of ventricular then frail in waveform or absence of electrical action of heartbeat occurs. In this way, earlier treat what the mood strip appears, check the patient. When evaluation of QRS complex is done then emphasis must be put on configuration and duration.

QRS complex wave takes after the PR interval and amplitude of QRS complex between 5to 30mm high; PR interval's half is equivalent to length of every heartbeat i.e. 0.06second to 0.10 second (From the initial of the Q wave or from the initial of R wave if there is an absence of Q wave to the end of S wave the duration is being measured).In depth, a patient is said to have myocardial necrosis if it is observed that the wave Q is wide. Therefore according to this situation the sufficiency of Q wave is almost equivalent to or greater than R wave's height also the Q wave's duration is found out to be almost greater than or equivalent to 0.04 seconds. A bundle branch block may be indicated by a notched R wave. AV block or ventricular halt may be demonstrated if there is an absence of QRS complex.

ST Segment

The segment that demonstrates the beginning of ventricular re-polarization or recuperating and also the end of the ventricular depolarization or conduction is the ST segment. J point can be defined as the point that is responsible for the grating of the initial of ST frame and the end of QRS complex. For more data about ST segment depict the accompanying attributes (amplitude, duration, and configuration are not observed) To the initial of T wave and diversion of ST segment usually isoelectric or on the baseline that may change from -0.5 to +1mmfrom S wave, the ST segment can be reached out.

T Wave

The re-polarization's comparative obstinate time or ventricular recovery are being represented or demonstrated by T wave's peak. While assessing a T wave, appear to the sufficiency, setup and diversion. ST segment is being followed by T wave with amplitude of normal lead to be 0.5 millimeter and pre-cardinal leads to be 10 millimeter. T wave has rounded and smooth shaped. The T wave peak representation relative recalcitrant time of ventricular re-polarization, a period while which cell is particularly powerless against additional stimulus. If there is a knocking in T wave then it can be said that T wave covers up P wave in it. So it can be said that the depolarization of atrial has occurred at that particular point and the same has been done at one of the ventricle's position.

QT Interval

The time being taken for the process of re-polarization or depolarization is said to be a QT interval. On the basis of heart rate the QT interval's length fluctuates. Durations must be closely marked when the evaluation of the QT interval is being carried out.

The extension from the initial of QRS complex to the final edge of T wave is being Accomplished by an ordinary QT interval and the interval's duration changes as indicated by the heart rate, age and gender; generally at the end from 0.34 to 0.45 second; should not be prominent than a large portion of the separation between two progressive R the rhythm is regular. During ECG signal recording in medical lab it is usually faulty by baseline due to an apnea, power supply, probes mismatch, and other muscle artifacts. Removal of these noise artifacts from ECG used different filter methods.

In ECG monitoring if signal is noisy, the PQRST points may be blurred and not easy to detect due to some common monitor problems. Here discussed the most commonly encountered monitor problems, their possible causes. Artifact (pulse interference) is a most common noise error occurred during ECG monitoring such as improper electrode application, dirty or messy connection, electric inference from other equipment in the room etc. Baseline wandering is another big noise problem while ECG monitoring. This noise element causes patient restlessness and electrodes mismatching.

1.2 MOTIVATION

The ECG signals are measured from the body surface thus it's simple to be contaminated by body and instruments. it's essential for doctors to diagnose the diseases accurately by analysis of ECG signals. Therefore, the noise or artifacts within the ECG signals will influence the doctors diagnosing which noise within the ECG ideally ought to be removed before doctors diagnosing. that's the explanation why we want ECG signal process.

1.3 OBJECTIVES

- To study various digital filter techniques for removal baseline wandering and noise artifact from ECG signal. Comparing various filter results on the basis of performance parameters such as SNR and PSD.
- To perform various signal processing methods in feature extraction block.
- To obtain the normal and abnormal ECG signal through classifier block which identifies the patient condition.

1.4 PROJECT OUTLINE

The project mainly focused on the analysis of ECG signal. Which include different filtering techniques. This analysis mainly contains 3 process denoising, feature extraction and classifier block.

In this chapter we include the introduction of ECG signal and its wave form explanation. Chapter 3 is the preprocessing which being done prior starting the research work. Chapter 4 is feature extraction of ECG signal using different wavelet transform and various features. Chapter 5 is classification of ECG signal.

CHAPTER-2

LITERATURE REVIEW

1. Osowski*et al* 2001 This paper shows the use of the fuzzy neural system for electrocardiographic (ECG) beat acknowledgment and characterization. The new arrangement calculation of the ECG beats, applying the fuzzy half and half neural system and the highlights drawn from the higher request measurements has been proposed in the paper. The consequences of trials have affirmed great effectiveness of the proposed approach. The acknowledgment of the ordinary and distinctive sorts of beats speaking to the arrhythmias have been finished with a decent precision. The consideration of the beats not utilized the learning procedure has lessened this effectiveness just marginally. These basic examinations demonstrate that the displayed technique may discover reasonable application in the acknowledgment of numerous more sorts of beats.[1]
2. Lera*et al* 2002 In spite of the fact that the Levenberg– Marquardt (LM) calculation has been widely connected as a neural-arrange preparing technique, it experiences being exceptionally costly, both in memory and number of operations required, when the system to be prepared has countless weights. In this paper, the conduct of an as of late proposed variety of this calculation is contemplated. In this work, an adjustment of the notable LM preparing technique in light of the meaning of neural neighborhoods is introduced. The conduct of the strategy for a few neighborhood sizes has been contemplated, contrasted and both backpropagation and LM strategies, demonstrating that great outcomes can be normal for neighborhoods of direct size .when the quantity of versatile weights is huge, it is conceivable to accomplish better execution with the NBLM calculation than with alternate techniques considered.[2]
3. Sadaphule *et al* 2007 This Paper tries build up a calculation to identify and group three sorts of electrocardiogram (ECG) flag beats including typical beats (N), right bundle branch block beats (R), left bundle branch block beats (L)using a neural system classifier. Different types of classfication algorithm have been implemented using Unsupervised Soft Competitive Learning (USCL) neural network Fourier Transform Neural Network (FTNN) and Discrete Wavelet Transform (DFT1). Further their

comparison have been made.Accuracy level has been found to be greatest for the DWT approach.[3]

4. Rajini *et al*2010 This paper give various technique which is used1to1detect1the abnormalities in ECG signal. There are different method for ECG signal analysis.Earlier ECG signal analysis1was done in time domain1method1but it is not1sufficient for a analysis of different type of characteristics of ECG signal. To overcome with this problem we another method: a) Fast Fourier transform-converting time domain into a frequency domain to obtain all coefficients of frequency. Compressing of ECG signal with of FFT is 1**)** obtaining the ECG input signal.**2)** Compressing of input by removing low pass filter**. 3)** BY taking inverse fft we recover original signal. Limitation:it neglected to give the data with respect to the exact area of parts in time. b) Short Time fourier transform (STFT) 1) it helps in providing both time and frequency information. But its time frequency precision is not optimal. **3)** Discrete wavelet transform: It is best method for ECG signal analysis because it has multiresolution property which give both time and frequency information through variable window size. But STFT have always a fixed size and it does not have mutiresolution property.[4]
5. Rani *et al*2011: This paper shows the examinations of Digital FIR &IIR filter many-sided quality and their exhibitions to expel Baseline commotions from the ECG flag consequently it is attractive to evacuate these clamors for appropriate investigation and show of the ECG flag. IIR filter have a stage twisting that is caused by nonlinear stage reaction of IIR filter. On the off chance that we increment the request of channel then vast motions can get delivered. However, to evacuate Baseline commotion we require just channel of request 2 at which there are just little motions at the beginning of waveform which is called Ringing impact. This issue can be settled by applying the IIR filter to the ECG motion in the two headings.[5]
6. Islam *et al*2012: This paper manages the examination and investigation of ECG signal process by implies that of matlab device viably. Investigation of graphical record signal incorporates age and reproduction of graphical record signal, obtaining of ongoing graphical record data, ECG flag separating and process. Both MATLAB and LabVIEW have huge impact on ECG flag preparing. They are so valuable and helpful that even one can screen his/her heart condition basically using the energy of MATLAB as well as

LabVIEW without having an ECG machine and furthermore self conclusion is conceivable. Every one of these illustrations and methods that are talked about here can be truly helpful for test/lab reason even we don't have any ECG information regardless we can mimic and examine it.[6]

7. Dubey*et al*2013:The elucidation of ECG signal is a utilization of example acknowledgment. Signal pre-preparing, QRS identification, highlight extraction and neural system for flag order are those procedures which utilized as a part of this example acknowledgment contain. Among various structures, it was discovered that a three layer organize structure with 25 inputs, 5 neurons in the yield layer and 5 neurons in its shrouded layers had the best execution with most elevated acknowledgment rate .Several retraining trials showed that accomplishing ideal execution, amid information handling, requires the non-linear neural system model to comprise of 2 concealed layers of 20 neurons each. A more mind boggling model leads to an emotional increment of reaction time.[7]
8. Sao *et al*2013: The concept of pattern recognition refers to characterization of information designs and recognizing them into predefined set of classes. The investigation ECG is a use of example acknowledgment. The ECG signal produced waveform gives all data about movement of the heart. The ECG signal highlight extraction parameters, for example, ghostly entropy, Poincare plot and lyapunov type are utilized for examine in this paper. The ECG is for the most part utilized for conclusion of heart disease. Various managed and unsupervised Artificial Neural Network demonstrate have been proposed in the writing for ECG signals include extraction and arrangement. The ANN classifier was nourished by three parameters to be specific otherworldly entropy, Poincare plot geometry and biggest Lyapunovexponent (LLE) got from the heart rate signals are talked about.[8]
9. Sharma *et al*2014: The paper presents expulsion of commotion from the ECG motion by utilizing Digital channels planned with FIR and IIR procedure .By looking at the power otherworldly thickness and normal power, prior and then afterward filtration utilizing diverse window methods. It reasons that the decision of the cut-off frequency is vital, a lower than required cut-off frequency does not channel the real ECG signal segment, however a portion of the noise effectively, yet the ECG signal is twisted all the while.

Slice off frequency differs comparing to heart rate and standard noise spectra. In this manner, consistent cut-off frequency isn't generally fitting for baseline noise concealment; it ought to be chosen after a watchful examination of the signal range.[9]

10. Kumar *et al*2014 The task propounded in this article is removal of low frequency interference i.e. baseline wandering and high frequency noise i.e. diagnostic procedure in ECG signal and digital filters are enforced to delete it. The digital filters accomplished are FIR with various windowing methods as of Rectangular, Hann, Blackman, Hamming, and Kaiser. The results for various filters are considered and evaluated by waveforms, power spectrums density (PSD), signal to noise ratio (SNR), Mean square error (MSE) where Kaiser Window show the best outcome. The order 300 filters designed showing the best results comparison to order 450 and 600.Hence it can be finalized that Kaiser Windowing shows best outcomes at order 300.
11. Gachake*et al* 2014 One of the fundamental issues in biomedical signs like electrocardiogram is the partition of the coveted signal from noises caused by control line impedance, muscle antiquities, benchmark meandering and terminal ancient rarities. Distinctive sorts of digital filters are utilized to isolate signal segments from undesirable frequency ranges. Along these lines noise evacuation utilizing FIR advanced filter is better choice in examination with IIR digital filter. Thus it is cleared from the results that FIR Equiripple Notch Filter is the best option as compared to Kaiser Window and IIR filter to remove the power line interference from the ECG signal due to sufficient noise reduction with minimum order.[10]
12. Jadhav*et al* 2017 In this paper we have contemplated Finite Impulse Response (FIR) filter in view of different windows and Infinite Impulse Response (IIR) filters for commotion expulsion of ECG signal. This paper indicates FPGA usage for noise concealment of electrocardiograph signals (ECG). Consequently this paper demonstrates the strategy used to evacuate ECG commotion is more proficient than the conventional middle filter technique. Likewise, the implantation of this work on FPGA is less demanding. The in view of FPGA`s are more adaptable than ASIC due their reinvent capacity.
13. Gupta *et al* 2014This paper gives electronic execution of electrocardiograph (ECG) circuit by utilizing instrumentation amplifier (IA) as bio-potential amplifier in such a

way which lessens commotion, basic voltage, DC balance esteem and RF obstruction from the current circuit. Commotion and normal voltage can be expelled from ECG utilizing driven right leg circuit or by utilizing isolator circuit. This paper proposes the electronic execution of ECG circuit by utilizing instrumentation speaker as bio-potential enhancer. This paper likewise discloses the few methods to lessen noise and to build CMRR by utilizing driven right leg circuit. With the assistance of high pass channel with pick up G, we can decrease DC offset.RF impedance can be diminished by separating.[11]

14. Dhiman *et al* 2014 The aim of this paper is hardware optimization of the electronic circuit of electrocardiogram (ECG) by using a bio-potential amplifier in such a manner that it reduces noise, RF interference, DC offset value, and common voltage from the existing circuit. This work indicates the performance of ECG circuit in terms of electronics using an instrumentation amplifier. It further explains several procedures carried out to reduce the circuitry to increase CMRR and noise with the help of right leg drive circuit. We can diminish DC offset with the help of high pass filter and by filtering we can reduce RF interference.[12]

The project mainly focused on the analysis of ECG signal. Which include different filtering techniques. This analysis mainly contains 3 process denoising, feature extraction and classifier block.

After reading all these papers we have performed our project including the introduction of ECG signal and its wave form explanation. Chapter 3 is the preprocessing which being done prior starting the research work. Chapter 4 is feature extraction of ECG signal using different wavelet transform and various features. Chapter 5 is classification of ECG signal.

CHAPTER 3
PREPROCESSING

Electrocardiography (ECGs) are necessary medic al specialty signals that are reflective of an electrical activity of the heart. Within the recent years there has been an intensive analysis with the intent of developing economical and effective ways of process & analysis of graphical record ECG signals. This paper presents the review of various papers based on the analysis of ECG. Later this paper illustrates various noise removal techniques. In this paper, different low pass IIR filter, high pass FIR filter, notch filter and adaptive filter has been designed by using various approximation methods, windowing techniques and algorithms. Comparisons of two physical parameters i.e. signal to noise ratio (SNR) and power spectral density (PSD) has been done on the basis of before and after filtering. These filters have been designed using MATLAB R2016a. Results with the best filters were cascaded to attain denoised ECG signal better performance. The cascaded filter design gives the high SNR of 2.1081dB and low PSD i.e. -71.7429.

Electrocardiography (ECG or EKG) is a method of recording an electrical activity of the center over an amount of the time victimization electrodes placed on the skin [1, 2]. These electrodes observe the little electrical changes on the skin that arise from the center muscle's electrophysiological pattern of depolarizing and repolarizing throughout every heartbeat. In the normal heart, the electrical activity associated with each cardiac cycle originated in a specialized group of cells in the high right atrium known as the Sino atrial Node (SA Node). SA Nodal cells spontaneously depolarize at a rate that is dependent on the relative balance of sympathetic and parasympathetic tone. At rest, vagal (parasympathetic) tone predominates and the SA node spontaneously depolarizes, on average, 60-100 times per minute. From SA node the wave of depolarization propagates in an orderly timed fashion to the remaining atrial tissue, to the Atrioventricular Node (AV Node), the His- Purkinje system and then to the left and right ventricular myocardium (Figure 1) [3]. The AV node conducts relatively slowly, thereby allowing the atrium to fully contract before the start of ventricular contraction. The His-Purkinje system (also named a specialized physical phenomenon system) consists of the left and right bundle branches and the diffuse fine network of bodily cavity Purkinje fibers.

Relatively rapid conduction in the His-Purkinje system allows for synchronized contraction of the ventricles.

ECG signal consists of different waves, segments. Its signal consists of noise. This paper works on denoising of signal. Various noises were removed by different digital filter techniques. Section 2 explains the literature review, Section III gives the methodology and section IV explains the results and discussions for the various noises which is followed by the conclusion and future work.

3.1 MATERIAL AND METHODS:

For the analysis of ECG signal a flow graph was made which consists of mainly three blocks which are shown in Figure

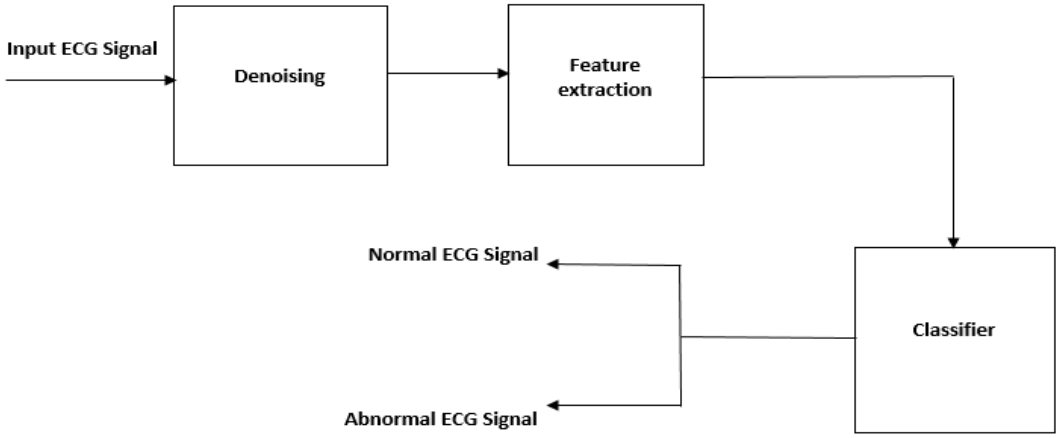

Fig 3: Analysis of ECG signal block diagram [8]

3.1.1 DENOISING BLOCK:

In an ECG signal there are various types of noises like low frequency noise, power line interference noise, burst noise, and electromyography noise.

i) Low frequency noise (baseline wander noise): These are those noise which is caused due to the patient movement and movement of cable, leads wire and loose electrodes. The range of frequency in which baseline wander is dominant is typically less than 1.0 Hz.

ii) High frequency noise (power line interference and muscle contraction): These noise are being removed using FIR high pass filter. Amplitude of EMG is random in nature and is modeled by Gaussian distribution function. Mean of noise assume to be zero, while variance may vary.

iii) Medium frequency range (Power line interference noise): This noise is due to electromagnetic interference of frequency (50 Hz or 60 Hz). Capacitive and inductive coupling are the mechanisms that contribute to Power line interference.

iv) Burst noise: classified as a white Gaussian noise (WGN), some of examples are - electrode popup noise, electrode motion artifact, electro surgical noise, instrumentation noise etc. The frequency ranges for these noises are not well defined. There are mainly different types of filters: Digital filters (FIR and IIR), notch filter and adaptive filter. Graphical record signal generally varies from five cycle -120 cycles. Among these, the foremost action is the calculation of cut off frequency (fc) of the filter and its characteristics function. The fc needs to be selected in such a way that the clinical data within the graphical record signals remains ingenuous whereas removing the baseline wander the maximum amount as attainable. Hence, it's essential to seek out all-time low frequency element of the graphical record spectrum.

3.2 RESULTS

An ECG signal consists of five waves namely P, Q, R, S, T. ECG signals are sensitive signals. These signals get contaminated due to noise resulted it unsuitable for various Biomedical Applications. These noises were removed by filtering of signal from ECG recordings. There are different types of filters which are useful to remove different noises. There are various types of filters those are : Mean filter, Median filter, Center weighted median, Adaptive median filter, Savitzky–Golay filter, Moving average filter, Weiner filter, Lee filter, Anisotropic diffusion filter and Homomorphic filter. Except these filters we have digital filters, adaptive filters and notch filter which are mainly used to remove the different noises occurred in an ECG signals.

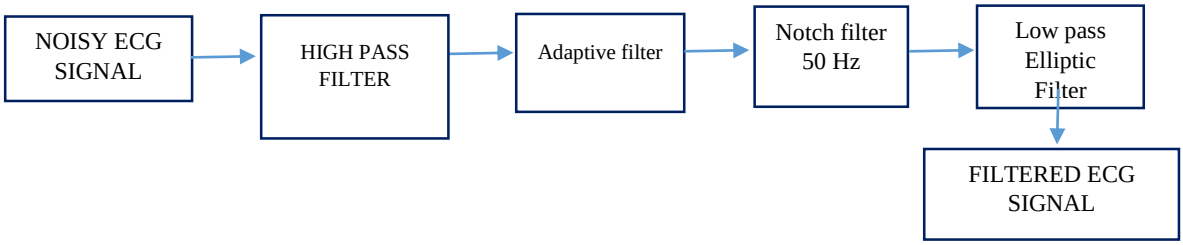

Fig 4: Flow graph of filtered ECG signal by Cascading [4]

Fig 4 shows the flow graph of filtered ECG signals by cascading. Input is noisy ECG signal. Later it is passed to high pass filter which is used to remove baseline wander noise which can be done by using FIR filters. There are different FIR filters which include Rectangular, Hann, Blackman, Hamming, and Kaiser. FIR filters with varied windows evaluated the PSD, SNR and MSE of ECG signal.Using these windows, we have a tendency to design the high pass filter of cut-off frequency 0.5 cycles per second for removing baseline wandering. We have a tendency to optimize the filter in many ways. The fundamental plan is to style the filter coefficients till a specific error is reduced. The goal of the improvement method is to search out the best filter coefficients that closely approximate the required frequency response. Once we do the frequency sampling technique there's no constraint on the response between the sample points, and poor results is also obtained.

To remove the electromyography noise, low pass filter was designed using IIR filters (butetrworth, elliptic, chebyshev) were designed to remove these noises. Table 1 show the SNR and MSE values of different filters. ECG input signal MIT-BIH Arrhythmia v5 is taken from Physio Bank ATM database of 100 records. This input ECG signal has length of 1454 samples. ECG signal has frequency range between 0.5 Hz -100 Hz and sampling frequency taken for data signal is 360 Hz. SNR should be high while MSE should be minimum so based on this Elliptic filter comes out the best

Table 1: SNR and MSE values of different IIR filters

Filter Name	Filter Order	SNR	MSE
Chebyshev I	3	-6.625	0.0078
Chebyshev II	5	-6.018	0.0501
Butterworth	5	-8.122	0.0163
Elliptic	3	-7.655	0.0093

Later Notch filter was designed with f_c= 49.5Hz- 50.5 Hz. In the end an Adaptive filter was designed to remove the burst noise. The frequency of burst noise is not defined. We have cascaded all the best filters whose flow graph is shown in Fig 4.

Table 2: SNR and PSD using Cascading Filter

SNR Before Filtering	SNR after filtering	PSD Before filtering	PSD after filtering
-5.5313	2.1081	-54.883	-71.7429

Performance metrics has been obtained in terms of SNR and PSD by filtering the noisy ECG signal by different digital filters. These parameters i.e. SNR and PSD before filtering and after filtering has been observed and shown in tabular form (Table 2). Time domain output waveform of ECG signal filtered by Cascading Filter is shown in Figure 4) and corresponding Frequency spectrum of an ECG filtered signal is shown in Figure 5

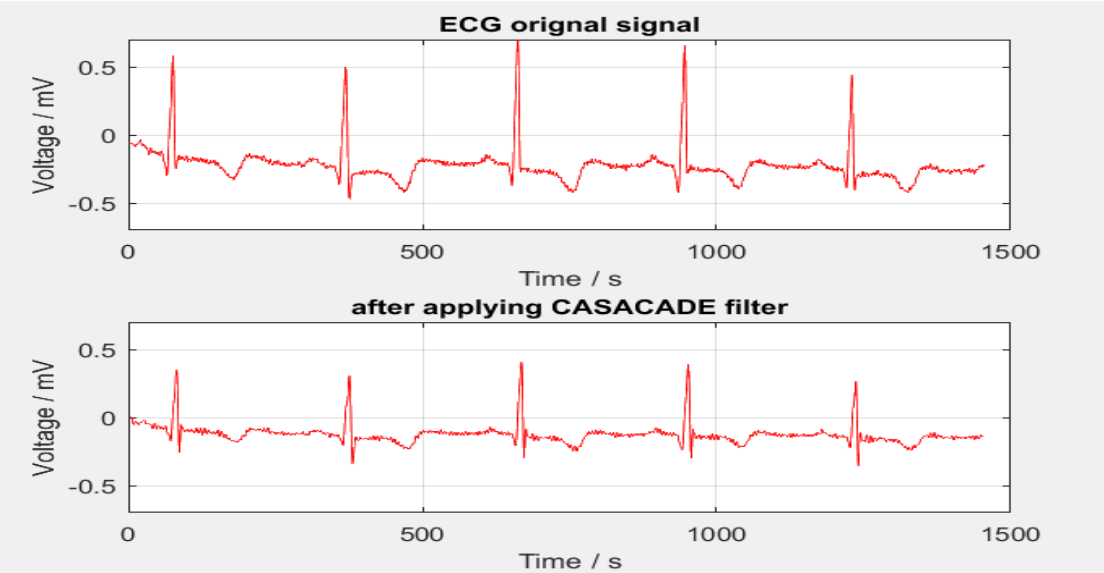

Fig 5: Time domain analysis of ECG signal by Cascading

CHAPTER 4

FEATURE EXTRACTION

This block is used to remove the High frequency noise (power line interference and muscle contraction).It uses discrete wavelet transform method where we discarded the first detail component. The output from denoising block is passed through low pass and high pass filters. The output of low pass filter is further passed till enough decomposition is reached. The output of each filter is down sampled by factor 2.The extraction centered through R-peaks of ECG signal. When we record ECG signal then it contain a lot of noise and artifacts are present in it so its quality get degrade and making exact interpretation of a signal is more difficult. There are different methods of feature extraction which is shown in fig:5.

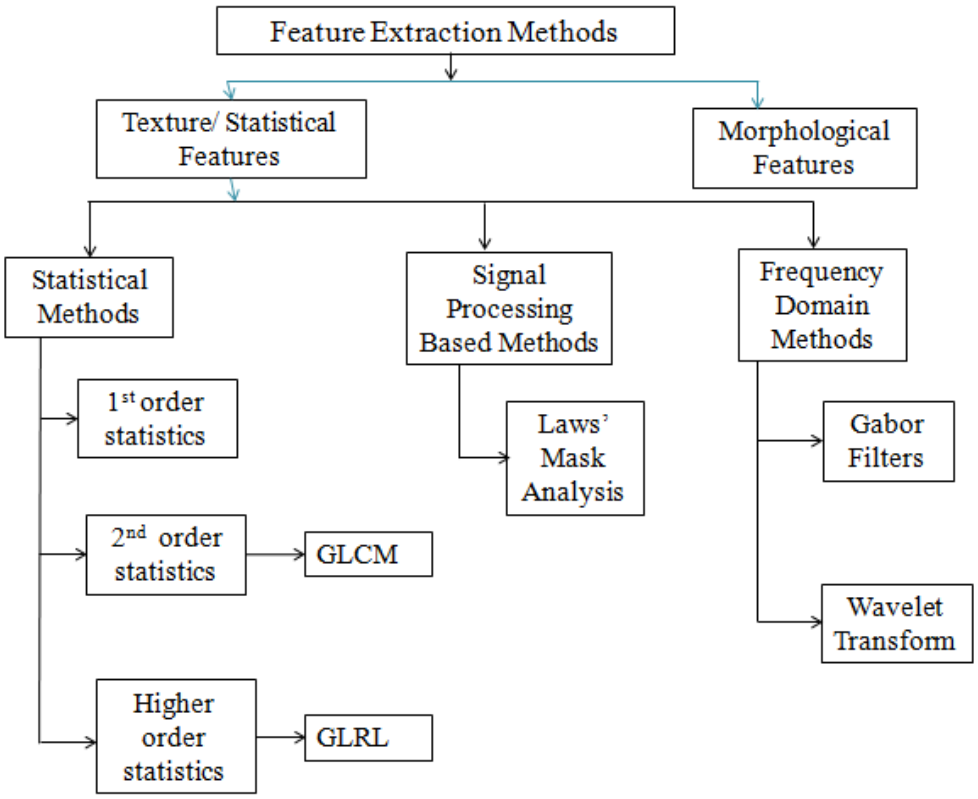

Fig 6: Block diagram representation of different feature extraction methods[12]

4.1 MORPHOLOGICAL FEATURE: Morphological image processing could be a assortment of non-linear operations associated with the form or morphology of options in a picture. Morphological operations trust solely on the relative ordering of pixel values, not on their numerical values, and thus are particularly suited to the process of binary pictures. Morphological operations can even be applied to greyscale pictures such their light-weight transfer functions are unknown and thus their absolute element values are of no or minor interest.

Morphological techniques probe a picture with a little shape or guide known as a structuring component. The structuring component is positioned the least bit attainable locations within the image and it's compared with the corresponding neighbourhood of pixels. Some operations check whether or not the component "fits" among the neighbourhood, whereas others check whether or not it "hits" or intersects the neighbourhood.

4.2 SIGNAL PROCESSING METHODS: Signal process issues the analysis, synthesis, and modification of signals, that are generally outlined as functions conveyance, "information regarding the behavior or attributes of some phenomenon",such as sound, images, and biological measurements. as an example, signal process techniques are used to improve signal transmission fidelity, storage potency, and subjective quality, and to emphasise or observe parts of interest in a very measured signal.

Various signal processing methods are:

4.2.1 FAST FOURIER TRANSFORM:

A fast Fourier Transform (FFT) rule computes the separate Fourier transform of a sequence, or its inverse (IFFT). Analysis converts a proof from its original domain (time) to an illustration within the frequency domain and contrariwise. Earlier technique} used for analysis of EKG is in time domain however this methodology is not comfy for study all characteristics of ECG signal. so a replacement technique FFT was developed. Fourier transform might be a regular technique that transforms time domain signal to frequency domain to induce the frequency coefficients. FFT is degree elementary retread in digital

signal method and has varied applications in frequency analysis, signal method etc. It a fast and extra capable rule to work out the separate DFT and obtains constant impact EKG signals is compressed by victimization kind of techniques. the whole method consists of the subsequent steps:

- To get an ECG sample as input signal.
- Compress the ECG I/P signal by removing the low frequency components.
- Obtain the original signal by using inv. FFT.

But the disadvantage of FFT is that it is failed to provide the information regarding the accurate location of frequency components in time.

4.2.2 SHORT TIME FOURIER TRANSFORM:

It is related to a Fourier transform which is used to determine the sinusoidal frequency and phasal content of local section of a signal as it varies with a time. To overcome the problem of a FFT We introduced the windowed-Fourier transform, i.e. Short- Time Fourier transform far-famed later as Gabor transform. STFT has each time and frequency info .It is accustomed verify the curving frequency and section content of the signal because it varies with time. The STFT primarily based spectrograph may be a straightforward and quick technique compared to alternative time– frequency analysis. It's a simple approach of slicing the wave shape of interest into variety of short-segments. Then it analyzes every section mistreatment commonplace Fourier transform. A window operate is applied to a section of knowledge, with efficiency uninflected that section from the wave shape and Fourier transform is applied there to section. this can be referred to as the spectrograph or Short-Time Fourier transform. For a sign x (t), the definition of STFT is given by equation.

$$STFT\{x(t)\}(a,w)=X(a,w)=\int x(t)w(t-a)\,dt \quad (1)$$

Where w (t) is a window, having duration T, centred at time location t, the Fourier transform of the windowed signal x (t) w (t - a) is the STFT.

But the limitation of STFT is that its time frequency precision is not optimal. Hence a more suitable technique is opted to overcome this drawback.

4.2.3 WAVELET TRANFORM:

Wavelet transform decomposes the signal into reciprocally orthogonal set of wavelets that is that the main distinction from the continuous wavelet transform (CWT), or its implementation for the separate statistic generally referred to as discrete-time continuous wavelet transform (DT-CWT). thence to beat the matter of short time Fourier transform that have mounted window size therefore it doesn't provides a multi resolution info of signal. However wavelet transform contains a multi resolution that offer each info time and frequency info of signal by variable window size. A rippling could be a little wave that has energy focused in time and provides a tool for the analysis of transient, non- stationary or time-varying signals. There square measure numerous Wavelets on the market to be utilized in giant type of applications. Types of wavelets Biorthogonal, Haar, Coiflet, Symlet, Daubechies Wavelets, etc. features which make them useful are:

- Wavelets are in both time and frequency.
- For analyzing non-stationary signals such as ECG which have frequent level variations and uneven features.
- Wavelet separates a signal into multiresolution components.

Advantage of wavelet transform

- The wavelet transform may be a time-scale illustration that has been used effectively in an exceedingly type of applications, especially signal compression.
- It may be a linear method that decomposes the signal into variety of scales related to Frequency elements and analyzes every scale with an explicit resolution.

Another advantage of Wavelet technique is various Wavelet functions available, that allows to select the best operate for analyzing the signal whereas just in case of analysis it's restricted to feature morphology that's the sinusoid.

4.2.3.1 Types of wavelet transform

i. **Biorthogonal wavelet**: biorthogonal could be a riffle wherever the associated wavelet transform is invertible however not essentially orthogonal. Planning biorthogonal wavelets permits a lot of degrees of freedom than orthogonal wavelets. One extra degree of freedom is that the risk to construct radial riffle functions. within the biorthogonal case, there are 2 scaling functions $\varphi,\bar{\varphi}$ which can generate completely different multiresolution analyses, and consequently 2 completely different riffle functions $\varphi, \bar{\varphi}$ therefore the numbers M and N of coefficients within the scaling sequences $a,\bar{a}$ might dissent. The scaling sequences should satisfy the subsequent biorthogonality condition.

$$\sum_{n\in z} a_n \bar{a}_n + 2m = 2\delta_{m,0} \qquad (2)$$

Then the wavelet sequence can be determined as

$$b_n = (-1)^n \bar{a}_{M-1-n} \qquad (n = 0, \dots\dots, N-1) \qquad (3)$$

$$\bar{b}_n = (-1)^n a_{M-1-n} \qquad (n = 0, \dots\dots, N-1) \qquad (4)$$

ii. **Haar wavelet:** The Haar wavelet could be a sequence of rescaled "square-shaped" functions that along kind a wavelet family or basis. wavelet analysis is comparable to Fourier analysis in this it permits a target perform over an interval to be delineate in terms of an orthonormal basis.

The Haar wavelet is additionally the best attainable wavelet. The technical disadvantage of the Haar wavelet is that it's not continuous, and thus not differentiable. This property will, however, be a plus for the analysis of signals with fast transitions, like observation of tool failure in machines.

iii. **Daubechies wavelets:** The Daubechies wavelets, based on the work of Ingrid Daubechies, are a family of orthogonal wavelets defining a discrete wavelet transform and characterized by a maximal number of vanishing moments for some

given support. With each wavelet type of this class, there is a scaling function (called the *father wavelet*) which generates an orthogonal multiresolution analysis.

iv. **Coiflets wavelet:** Coiflets are discrete wavelets introduced by Ingrid Daubechies, at the request of Ronald Coifman, to possess scaling functions with vanishing moments. The wavelet is close to bilaterally symmetrical, their wavelet functions have N/3 vanishing moments and scaling functions N/3 -1, and has been utilized in several applications using Calderón-Zygmund Operators.

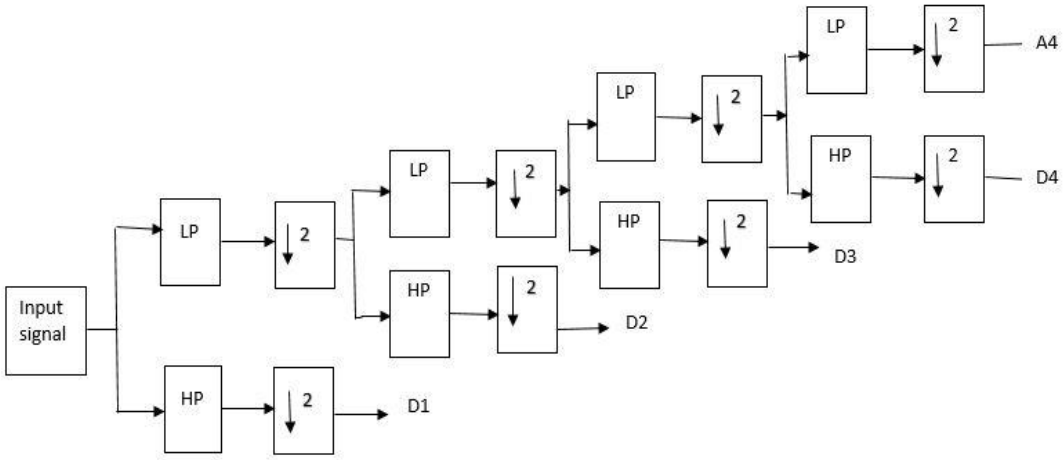

Fig 7: Decomposition of wavelets[12]

The other various filters can be used to analyise the signal processing which are as follows:

Table 3: Different filters

Fliters	**Mathematical expression /example**
Mean filter: The mean filter may be an easy sliding-window abstraction filter that replaces the middle price within the window with the common (mean) of all the values within the window. The window, or kernel, is sometimes sq. however will be any form.	The arithmetic mean=1/n (x_1+x_2……..x_N). 5 3 6 2 1 9 8 4 7 5+3+6+2+1+9+8+4+7=45/9=5=mean. Filtered * * * * 5 * * * *
Median filter: The median filter is additionally a sliding-window spatial filter, however it replaces the middle worth within the window with the median of all the component values within the window. As forpthe mean filter, the kernel is sometimes sq. however will be any form.	The median of values given in box is 4 (6,2,3, 3, 4,10,19,97) 6 2 0 3 97 4 19 3 10 Filtered: * * * * 4 * * * *
Center weighted median: In center weighted median filter they applied a weight adjustment to the center or origin pixel within the sliding window.	
Adaptive median filter: The adaptive Median Filter classifies components as noise by comparison every pixel within the image to its close neighbor pixels. The dimensions of the neighborhood is adjustable, also because the threshold for the comparison.	

Savitzky–Golay filter: A Savitzky– Golay channel could be an advanced channel that might be connected to a gathering of computerized data focuses for the point of smoothing the information, that is, to broaden the SNR while not extraordinarily misshaping the flag. This can be accomplished, amid a technique called convolution, by fitting successive sub-sets of neighboring data focuses with a low-degree polynomial by the procedure of linear statistical strategy.	The is finished by a **least squaresi(LS)** appraise between the X matrix and the y vector: $y = Xb.$ The standardpsolution is given by: $b = (X^T X)^{-1} X^T y.$ The assessed esteems that are utilized for the smoothing are: $\hat{Y} = Xb = X(X^T X)^{-1} X^T y = Hy.$
Moving average filter: The moving average filter may be an easy LowpPass FIR (Finite Impulse Response) filter normally used forpsmoothing associate degree array of sampled data/signal. It takes M samples of input at a time and take the common of these M-samples and produces one output purpose.	$P=\frac{1}{n}\sum_{i=0}^{n-1} pm - i$ Where, n are samples of data. pm is weighted average.
Weiner filter: The Wiener filter may be a filter wont to turn out Associate in Nursing estimate of a desired or target random method by linear time-invariant (LTI) filtering of Associate in Nursing determined rip-roaring method, presumptuous notable stationary signal and noise spectra, and additive noise.	In order tooderive the coefficients of the Wiener filter, consider the signal $w[n]$pbeing fed to a Wiener filter of order N and with coefficients. The output of the filter is denoted $x[n]$ which is given by the expression $X[n]=\sum_{i=0}^{n} a_i w[n-i]$. Error is defined as: $ai=argminE\{e^2[n]\}.$

Lee filter: The Leepfilter is ready tolswish away noise in flat regions, however leave fine details (such as lines and text) unchanged. It uses little windows (3x3, 5x5 or 7x7). at intervals every window, the native mean and variance area unit calculable..	***Y_{ij}=k+4W(c-k)***. where, Y_{ij}isdespeckled image. K is mean of kernel /window. W is weighing function. C is center element of window.
Anisotropic diffusion filter: The may be a technique aiming at reducing image noise while not removing important elements of the image content, usually edges, lines or alternative details that area unit vital for the interpretation of the image. eolotropic diffusion resembles the method that makes a scale house, wherever a picture generates a parameterized family of in turn additional and additional blurred pictures supported a diffusion method.	
Homomorphic filter: Homomorphic filtering may be a generalized technique for signal and image process, involving a nonlinear mapping to a distinct domain within which linear filter techniques square measure applied, followed by mapping back to the initial domain.	

4.3 DIFFERENT FEATURES

i. **Mean:** Simple or arithmetic average of a spread of values or quantities, computed by dividing the entire of all values by the quantity of values.

$$\text{Mean}=\overline{X} = \frac{\sum_{i=1}^{n} x_i}{n} = \frac{x_1+x_2+\cdots x_n}{n} \tag{5}$$

ii. **Median:** Denoting or concerning a worth or amount lying at the center of a distribution of ascertained values or quantities, such there's associate degree equal likelihood of falling on top of or below it.

$$\text{Median} = l + \frac{h}{f}\left(\frac{N}{2} - c\right) \tag{6}$$

Where,

l is lower class boundary.

h is size of median class interval.

f is frequency corresponding to median class.

N is total no. of observation.

C is cumulative frequency preceding median class.

iii. **Standard deviation:** An amount expressing by what quantity the members of cluster differ from the average for the group**.**

$$SD = \sqrt{\frac{\sum |X-\bar{X}|^2}{n}} \tag{7}$$

iv. **Variance**: Variance is a measure of the unfold between numbers during a knowledge set. The variance measures however so much every variety within the set is from the mean.

$$\sigma^2 = \frac{\sum_{i=1}^{N}(x_i-\bar{x})^2}{N} \tag{8}$$

v. **Kurtosis:** Kurtosis is outlined because the measure of thickness or heaviness of the given distribution for the stochastic variable on its tail. In different words, it is outlined because the measure of "tailedness" of the distribution.

$$k = \frac{1}{N}\left(\frac{x_i - \bar{x}}{SD}\right)^4 \tag{9}$$

vi. **Skewness:** Skewness is asymmetry in a measurable conveyance, during which the bend appears misshaped or inclined either to 1 aspect or to 1 aspect. skewness may be measured to characterize the degree to that a dissemination varies from a normal circulation.

$$s = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{\sigma^3} \tag{10}$$

vii. **RMSE: root-mean-square error** (**RMSE**) is a much of the time utilized measure of the contrasts between values (test and populace esteems) anticipated by a model or an estimator and the qualities really watched.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(X_{obs,i} - X_{model,i})^2}{n}} \tag{11}$$

Where, Xobs is observed values and

X_{model} is modelled values at time/place i.

4.4 RESULTS

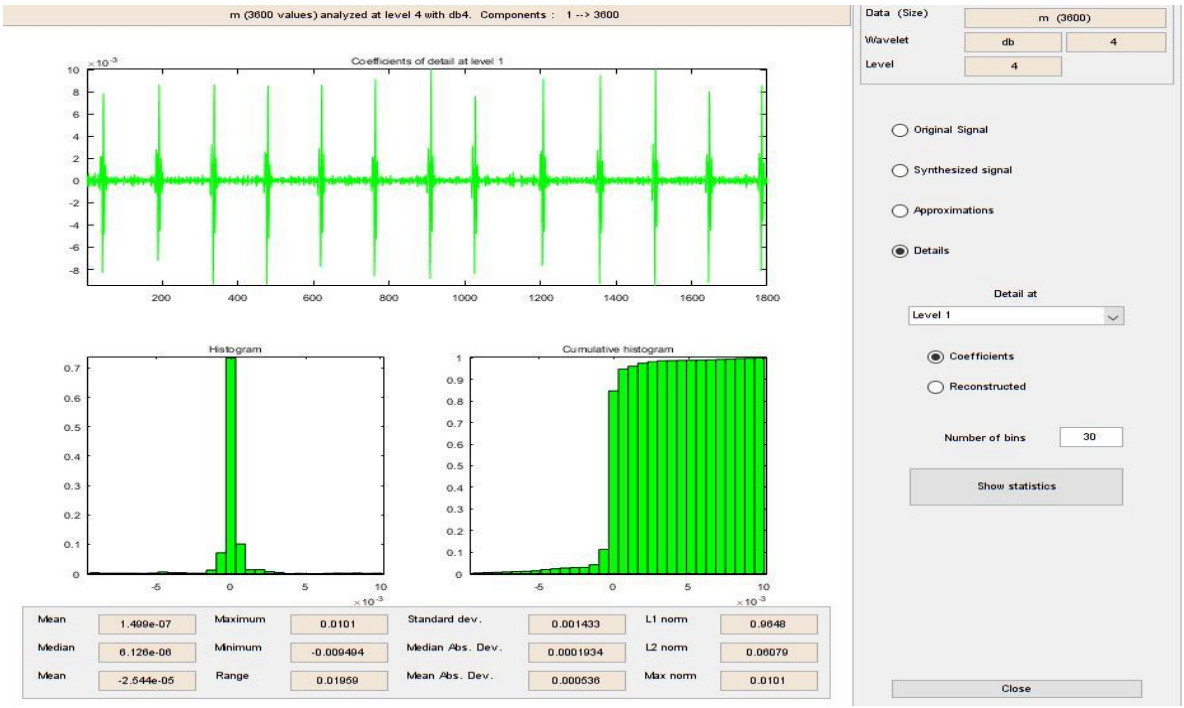

Fig 8 : Detail Coefficient of signal at level 1.

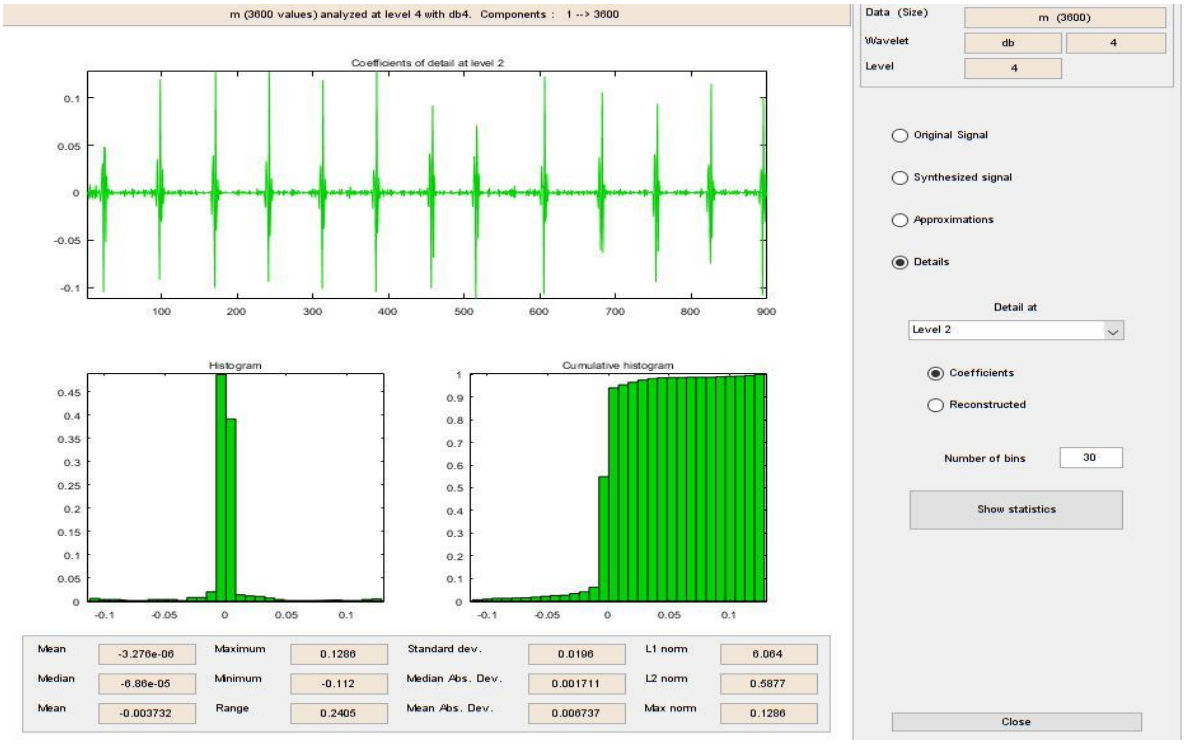

Fig 9 : Detail Coefficient of signal at level 2.

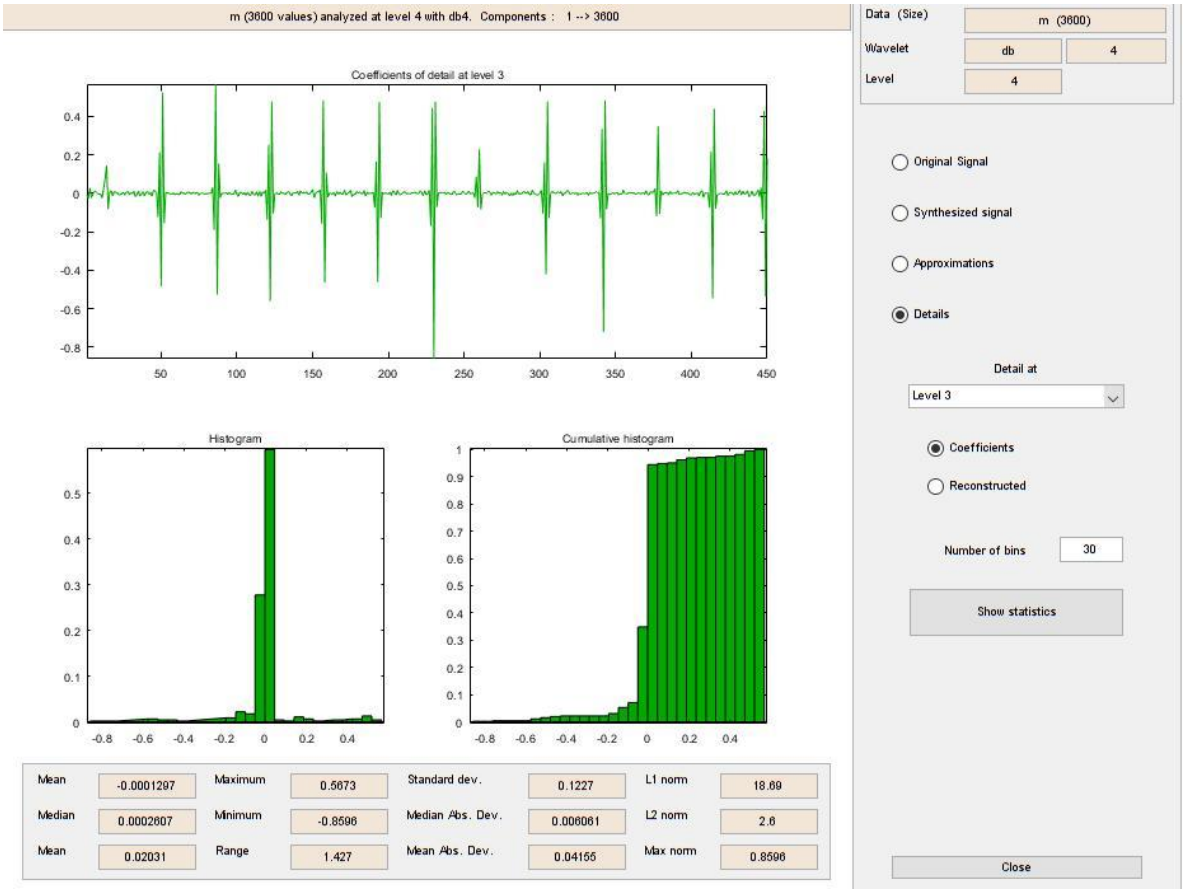

Fig 10 : Detail Coefficient of signal at level 3.

Here we can see that noise is still at level 3 as ecg signal is not clear enough.

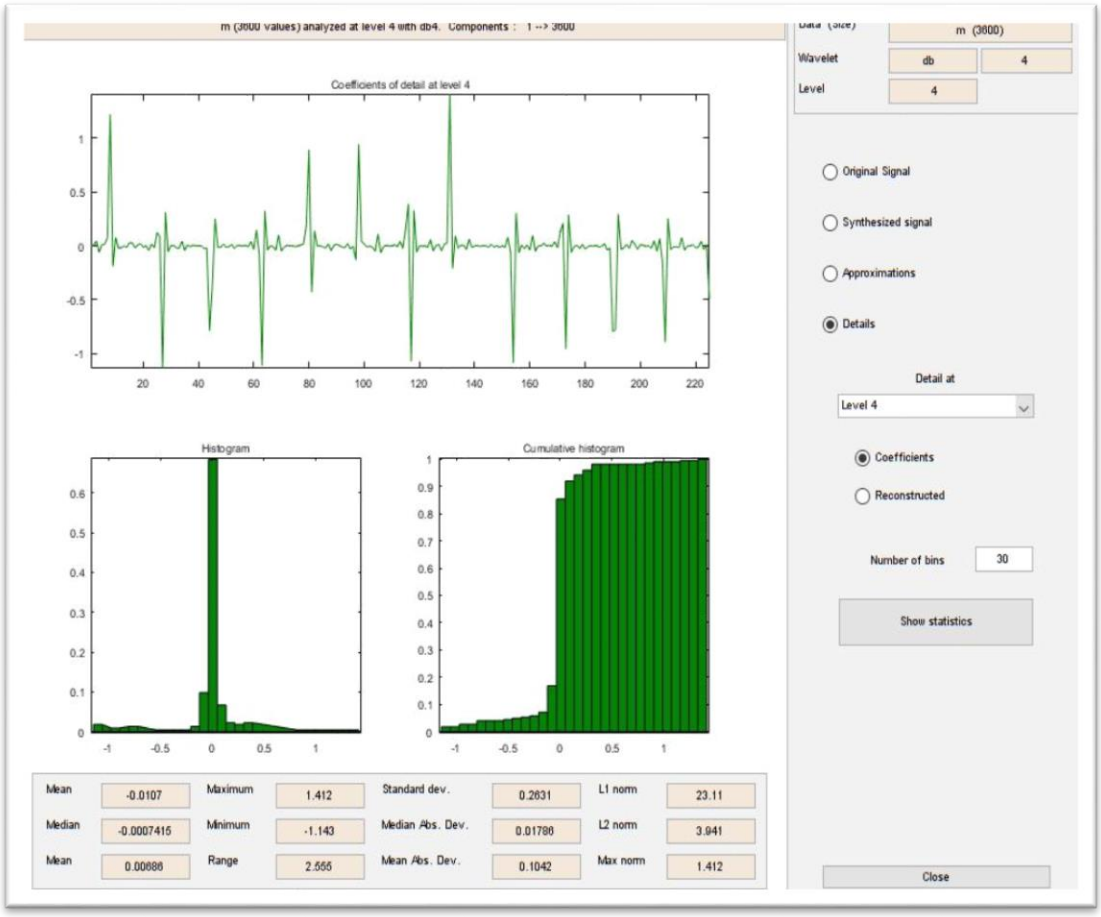

Fig 11 : Detail Coefficient of signal at level 4.

Noise has been removed at level 4 , now ECG signal can be analyzed and different features of the signal can be obtained.

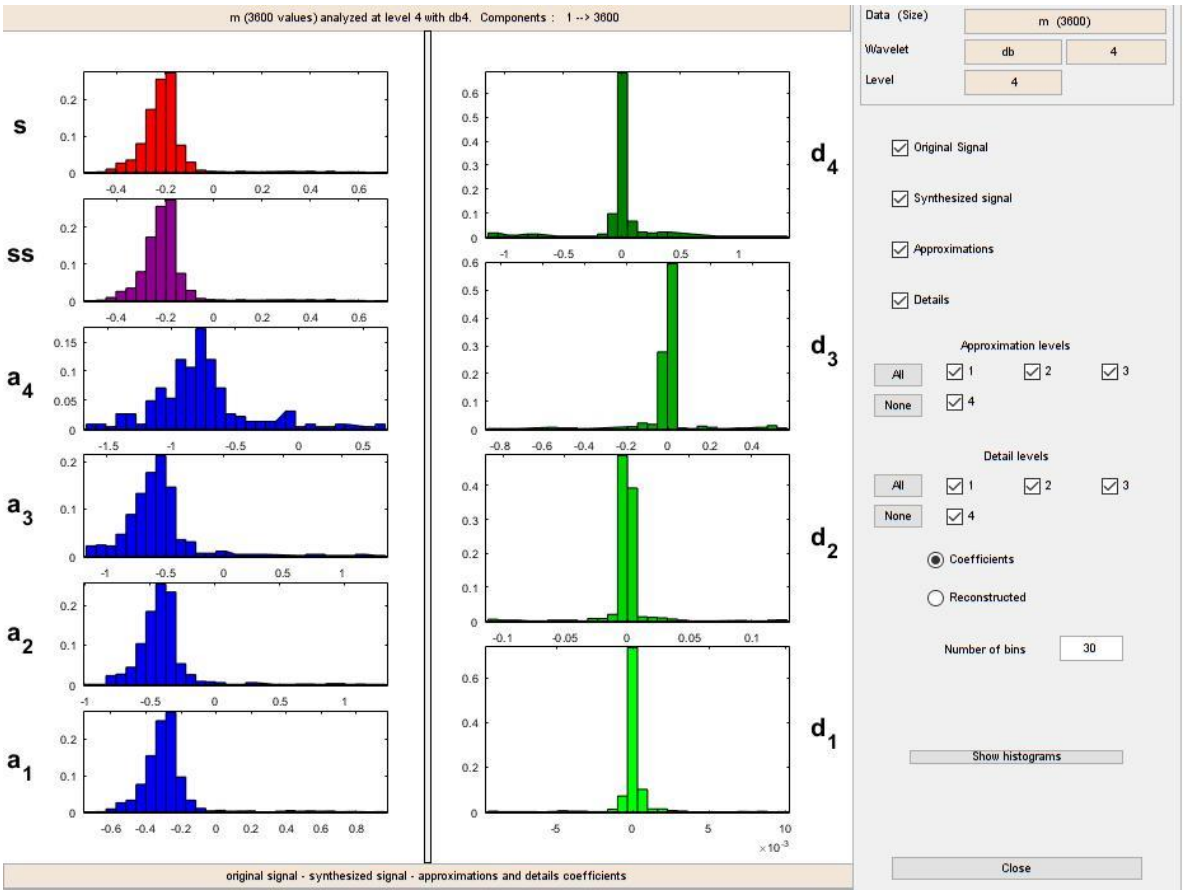

Fig 12 :Histogram at different levels.

Fig12: Histogram of signal at level 4.

From histogram we can infer that as noise is removed from level to level histograms of approximation coefficients starts expanding. While the detail coefficient's histogram starts shrinking.

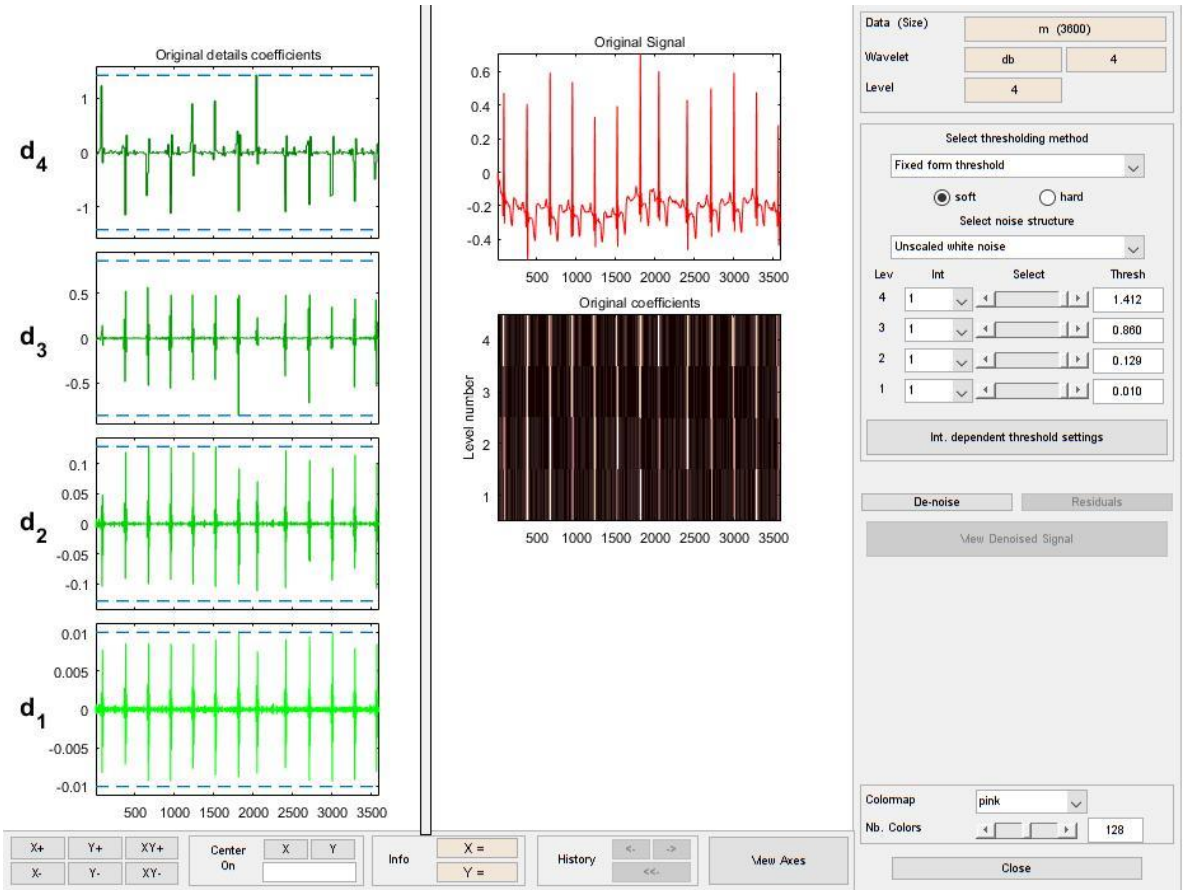

Fig13 : Noise coefficients of signal .

Here detail coefficients have been compared and we can see that how noise is removed from level to level, also at level 4 signal information can be interpreted easily.

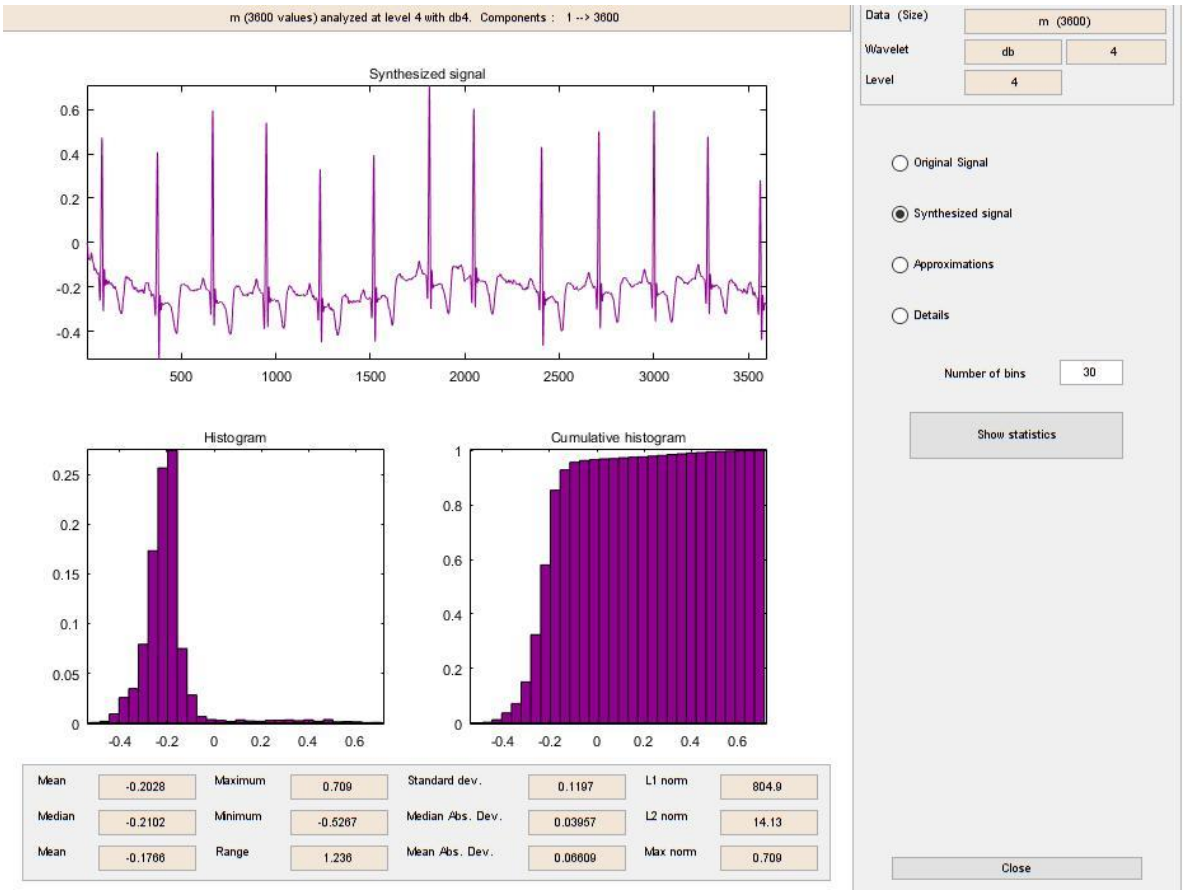

Fig 14: Synthesized signal

Synthesized signal has been obtained by processing ECG signal through various decomposition levels. Various features have been extracted from the synthesized signal.

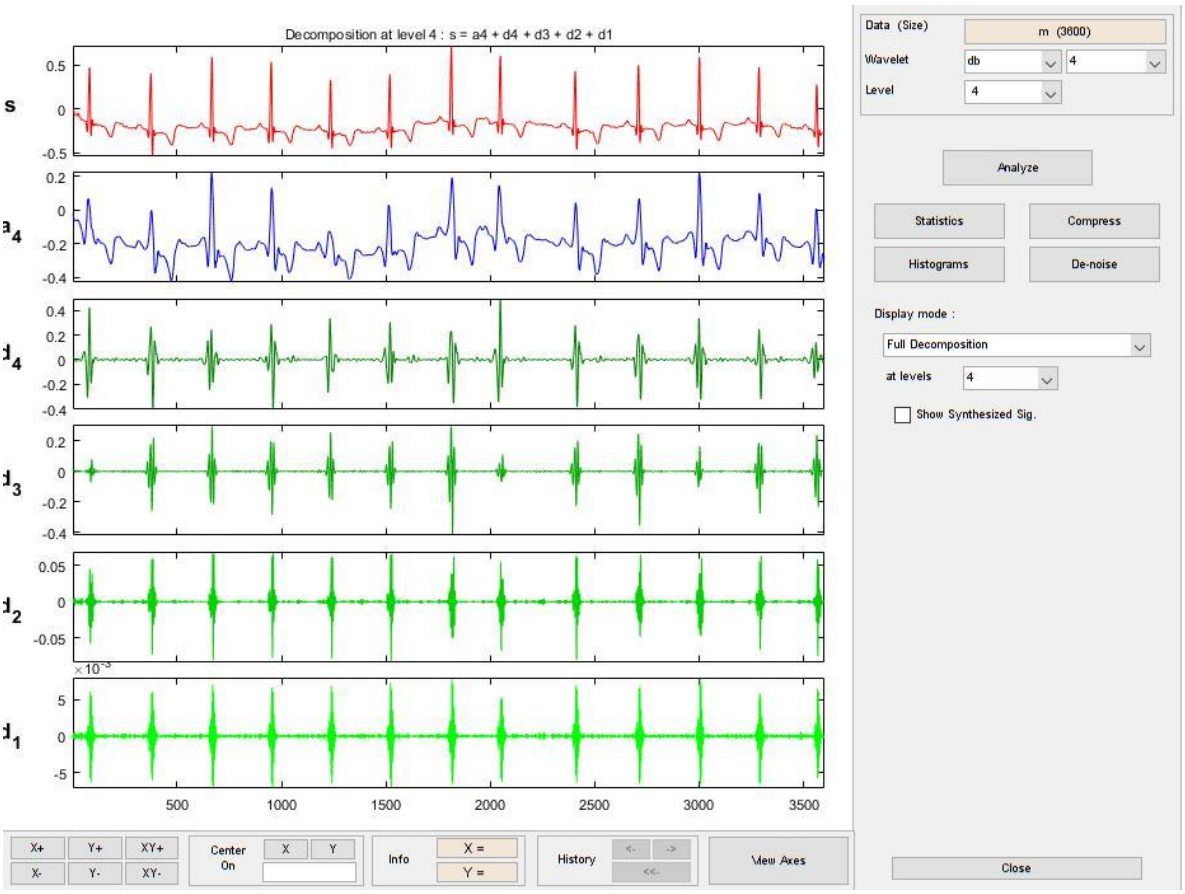

Fig 15: decomposition of signal at different levels.

For Feature Extraction we have chosen db4 wavelet at level 4.While selecting a wavelet for feature extraction we should keep in mind that wavelet should match with our signal. The closer the wavelet matches with signal the better and accurate will be the results.

Here db4 wavelet best match with the ECG signal and we have performed db4 at level 4 as at level below 4 we are not able to get the complete details of the signal whereas above level 4 signal starts deteriorating, so level 4 is the best where we can get all the details of the signal.d4 refers to the details coefficient at level 4 and a4 refers to the approximation coefficient at level 4.

Also through db4 wavelet we are able to remove the noise coefficient from the signal .As we can see at level 1 detail coefficient contain some noises which are removed further at level 4.

CHAPTER 5

CLASSIFICATION BLOCK

Classification is that the method of grouping the testing samples into the corresponding categories. Classification is characterised into 2 varieties viz. supervised classification and therefore the unsupervised classification. Classification is supervised if the categories square measure already outlined for the coaching sets otherwise its unsupervised classification. In the classification module, performance of four different classifiers namely k-NN, probabilistic neural network (PNN), SVM and smooth support vector machine (SSVM) was evaluated to obtain the class of the unknown testing instances. MIN-MAX normalization procedure is used to normalize the extracted features in the range [0, 1] in order to avoid any bias by unbalanced features. There are various classification techniques which classify the data into two classes or three classes according to its use.

5.1 K-NEAREST-NEIGHBOR ALGORITHM (KNN):

The K-nearest-neighbor (KNN) rule measures the gap between a question situation and a group of eventualities within the information set.

Distances

This is how we compute the distance between two situation using some distance function d(x,y),

Where x,y are situation composed of N features, such that $x=(x1,\ldots x_n)$,$y=(y1,\ldots y_n)$.

Two distance functions are discussed below:

Absolute distance measuring:

$$d_a(x,y)= \sum_{i=1}^{N} |x_i - y_i| \quad (12)$$

Euclidean distance measuring:

$$d_e(x,y)=\sum_{i=1}^{N}\sqrt{x_i^2-y_i^2} \quad (13)$$

5.2 ARTIFICIAL NEURAL NETWORK (ANN):

An artificial neural network is an interconnected cluster of nodes, resembling the huge network of neurons in an exceedingly brain. Here, every circular node represents a man-made somatic cell and an arrow represents a association from the output of 1 somatic cell to the input of another.

An important application of neural networks is pattern recognition. ... once the network is employed, it identifies the input pattern and tries to output the associated output pattern. the ability of neural networks involves life once a pattern that has no output related to it, is given as an input.

To evaluate the ANN's performance in recognition of chronic internal organ diseases, the CSE info has been used. Here, the EKG signal is characterised by thirty seven average primary measurements and the age and gender of the patient. The system performance is sometimes quantified by means that of 2 parameters: sensitivity and specificity or sensitivity and positive prognosticative accuracy (PPA), once the definition of false negatives could also be questionable. Sensivity(i) indicates the speed of true positive events for class(i) ,specivity(i) measures the speed of true negative events for class(i) ,PPA(i) and is that the rate of truth positive events among all the classified events in class(i).

Artificial neural networks area unit machine models that work the same as the functioning of a person's system. There area unit many forms of artificial neural networks. These form of networks area unit enforced supported the mathematical operations and a group of parameters needed to see the output. Lets look at some of the neural networks:

5.2.1 Feedforward Neural Network – Artificial Neuron:

In this type of neural network the information propagates only in one direction. The info is passed from the input nodes to the output nodes. This type of neural network might or might not have the hidden layers of neurons. In straightforward words, it's a front propagated wave and no back propagation by employing a classifying activation operate sometimes.

A single layer feed-forward neural network is shown below. Here, the total of the product of inputs and weights are computed and fed to the output. The output is taken into account if it's on top of an exact value i.e threshold (generally 0) and also the nerve cell fires with associate degree activated output (generally 1) and if it doesn't fire, the inactive value is discharged (generally -1).

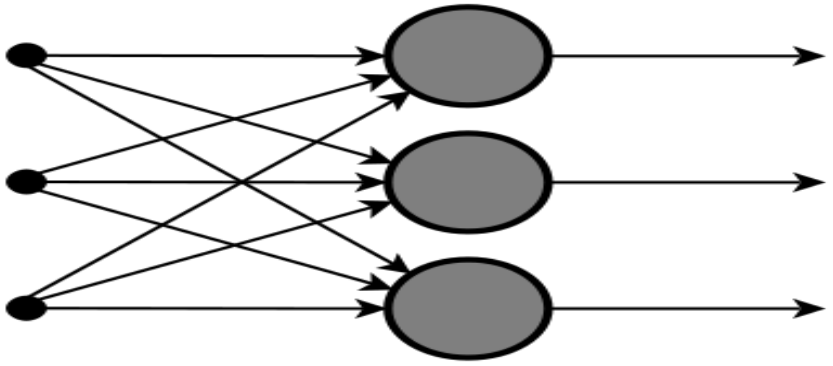

Fig 16: Single Layered Feed Forward Network [4]

5.2.2 Radial Basis function Neural Network

Radial basic functions contemplate the gap of some extent with relation to the middle. RBF functions have 2 layers, initial wherever the features are combined with the Radial Basis operate within the inner layer and so the output of those features are taken into thought whereas computing an equivalent output within the next time-step that is largely a memory.

Below may be a diagram that represents the space shrewd from the middle to some extent within the plane the same as a radius of the circle. Here, the gap measure utilized in euclidian, alternative distance measures can even be used. The model depends on the most reach or the radius of the circle in classifying the points into completely different classes. If the purpose is in or round the radius, the chance of the new purpose begin categoryified into that class is

high. There may be a transition whereas ever-changing from one region to a different and this may be controlled by the beta operate.

Fig 17: The Distance Calculating From the Center to a point in the plane[5]

5.2.3 Kohonen Self Organizing Neural Network

The objective of a Kohonen map is to input vectors of discretionary dimension to distinct map comprised of neurons. The map has to Maine trained to form its own organization of the training information. It contains of either one or 2 dimensions. once training the map the situation of the nerve cell remains constant however the weights disagree reckoning on the worth. This self organization method has totally different elements, within the 1st section each nerve cell price is initialized with a tiny low weight and also the input vector. within the second section, the nerve cell nearest to the purpose is that the 'winning vegetative cell' and also the neurons connected to the winning neuron will move towards the purpose like within the graphic below. the space between the purpose and also the neurons is calculated by the geometer distance, the nerve cell with the smallest amount distance wins. Through the 1iterations, all the points are clustered every nerve cell represents each quite cluster. this is often the gist behind the organization of Kohonen Neural Network.

5.2.4 Recurrent Neural Network (RNN) – Long Short Term Memory

The recurrent Neural Network works on the principle of saving the output of a layer and feeding this back to the input to assist in predicting the end result of the layer.

Here, the primary layer is made like the feed forward neural network with the merchandise of the total of the weights and also the options. The recurrent neural network method starts once this is often computed, this implies that from just the once step to future every nerve

cell can bear in mind some data it had within the previous time-step. This makes every nerve cell act sort of a memory cell in playing computations. during this method, we want to let the neural network to figure on the front propagation and bear in mind what data it desires for later use. Here, if the prediction is wrong we have a tendency to use the educational rate or error correction to create tiny changes so it'll step by step work towards creating the proper prediction throughout the back propagation.

5.2.5 Convolutional Neural Network

Convolutional neural networks are the same as feedforward neural networks, wherever the neurons have learn-able weights and biases. Its application are in signal and image process that takes over OpenCV in field of pc vision.

Below may be a illustration of a Convents, during this neural network, the input options are taken in batch wise sort of a filter. this may facilitate the network1to recollect the pictures in components and might work out the operations. These computations involve conversion of the image from RGB or HSI scale to Gray-scale. Once we've this, the changes within the component worth can facilitate police work the sides and pictures may be classified into completely different classes.

ConvNet is applied in techniques like signal process and image classification techniques. pc vision techniques are dominated by convolutional neural networks attributable to their accuracy in image classification. The technique of image analysis and recognition, wherever the agriculture and weather options square measure extracted from the open supply satellites like LSAT to predict the longer term growth and yield of a specific land are being enforced.

5.2.6 Modular Neural Network

Modular Neural Networks are assortment of various networks operating severally and contributory towards the output. every neural network encompasses a set of inputs that are distinctive compared to alternative networks constructing and acting sub-tasks. These networks don't act or signal one another in accomplishing the tasks. The advantage of a modular neural network is that it breakdowns an outsized computational method into smaller parts decreasing the complexness. This breakdown can facilitate in decreasing the quantity

of connections and negates the interaction of those network with one another that successively can increase the computation speed. However, the interval can rely on the quantity of neurons and their involvement in computing the results.

Below is a visual representation,

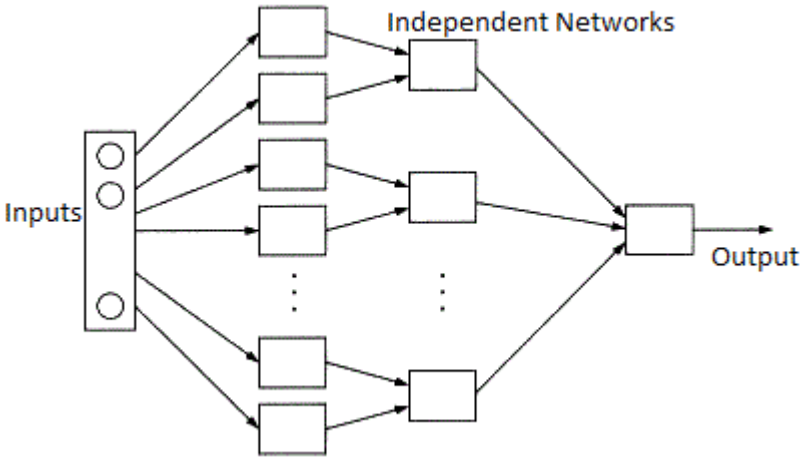

Fig18: Modular Neural Network[9]

Modular Neural Networks (MNNs) may be a quickly growing field in artificial Neural Networks analysis. This paper surveys the various motivations for making MNNs: biological, psychological, hardware, and process. Then, the final stages of MNN style are made public and surveyed additionally, viz., task decomposition techniques, learning schemes and multi-module decision-making methods.

5.3 FUZZY HYBRID NEURAL NETWORK

A fuzzy neural network or neuro-fuzzy system is a learning machine that finds the parameters of a fuzzysystem (i.e., fuzzy sets, fuzzy rules) by exploiting approximation techniques from neural networks.

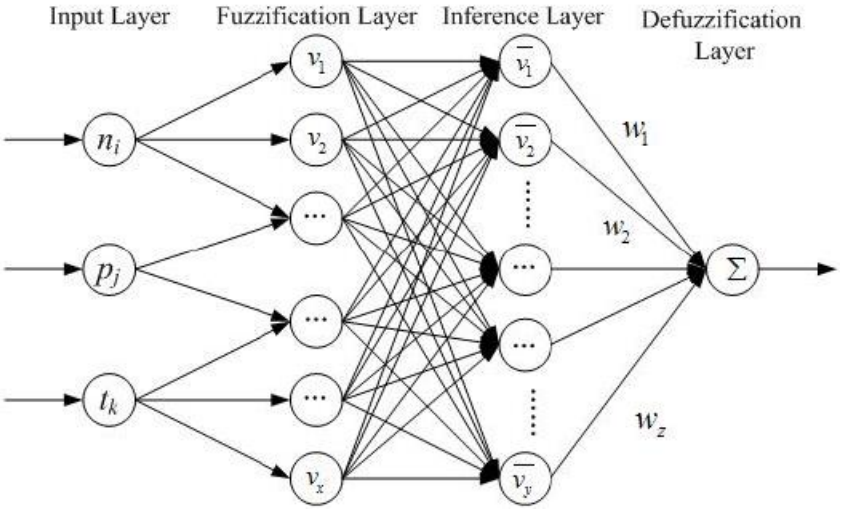

Fig 19 : Fuzzy System[10]

The rule base of a fuzzy system is taken as a neural network. Fuzzy sets is considered weights whereas the input and output variables and therefore the rules are sculptural as neurons. Neurons is enclosed or deleted within the learning step. Finally, the neurons of the network represent the fuzzy mental object.

5.4 SUPPORT VECTOR MACHINES (SVM)

Support vector machines (SVMs, additionally support vector networks) are supervised learning models with associated learning algorithms that analyze knowledge used for classification and multivariate analysis. Given a group of coaching examples, every marked as happiness to at least one or the opposite of 2 classes, associate SVM training algorithm builds a model that assigns new examples to at least one class or the opposite, creating it a non-probabilistic binary linear classifier (although strategies like Platt scaling exist to use SVM in an exceedingly probabilistic classification setting). associate SVM model may be a illustration of the examples as points in house, mapped so the samples of the separate classes square measure divided by a transparent gap that's as wide as attainable. New examples are then mapped into that very same house and foreseen to belong to a class supported that facet of the gap they fall.

In addition to activity linear classification, SVMs will expeditiously perform a non-linear classification victimization what's known as the kernel trick, implicitly mapping their inputs into high-dimensional feature areas

When information don't seem to be tagged, supervised learning isn't potential, and an unattended learning approach is needed, that makes an attempt to seek out natural agglomeration of the info to teams, so map new information to those shaped teams. The agglomeration rule that provides Associate in Nursing improvement to the support vector machines is termed support vector agglomeration and is usually employed in industrial applications either once information don't seem to be tagged or tagged as a preprocessing for a classification pass.

5.5 BACK PROPAGATION

Backpropagation Neural network has two phases. In first phase training is provided to network's input layer. The network propagates the input from layer to layer until the output pattern is generated by output layer. In the second phase, if this pattern is different from desired output, an error is calculated and then propagated backward from output layer to input layer. Then weights are modified as the error is propagated.

Backpropagation may be a special case of an older and additional general technique known as automatic differentiation.Within the context of learning, backpropagation is usually utilized by the gradient descent optimisation rule to regulate the load of neurons by shrewd the gradient of the loss operate. This method is additionally generally known as backward propagation of errors, as a result of the error is calculated at the output and distributed back through the network layers.

The backpropagation rule has been repeatedly rediscovered and is like automatic differentiation in reverse accumulation mode. Backpropagation needs a notable, desired output for every input value—it is so thought of to be a supervised learning methodology (although it's utilized in some unsupervised networks like auto encoders). Backpropagation is additionally a generalization of the delta rule to multi-layered feedforward networks, created doable by exploitation the chain rule to iteratively reckon gradients for every layer.

it's closely associated with the Gauss–Newton rule, and is an element of continuous analysis in neural backpropagation. Backpropagation will be used with any gradient-based optimizer, like L-BFGS or truncated Newton

5.6 RESULTS

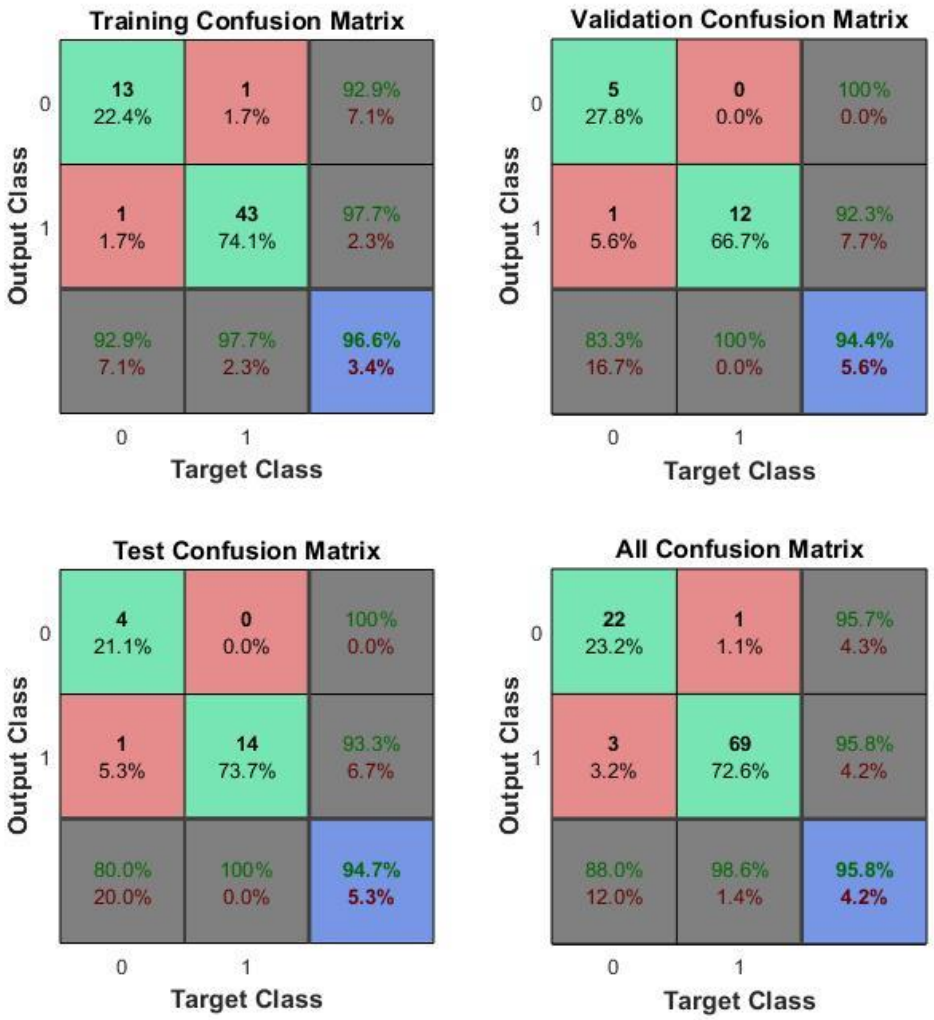

Fig 20: Confusion Matrix

Confusion Matrix: It is used to outline the performance of a classification model on a particular set of data provided to the classification model.

The confusion matrix which we have obtained from classifier block predicted two possible classes 0 & 1. 0 means that there is no presence of arrhythmia while 1 means there is arrhythmia present.

For training data set classifier block made a total of 58 predictions. Out of 58 these predictions classifier block is able to predict that 44 samples have arrhythmia present whereas 14 samples do not have arrhythmia present.

True Positives (TP) : These are the cases in which we forecasted 1(they have arrhythmia)and they do have the arrhythmia.

True Negatives (TN): These are the cases in which we forecasted 0 (they do not have arrhythmia) and they do not have the arrhythmia.

False Positives (FP): We forecasted 1 and actually they do not have arrhythmia.

False Negatives (FN): We forecasted 0 and actually they do have arrhythmia.

Results we obtained after Training Validating and Testing shows that out of 95 Samples we were able to predict correctly 22 samples which do not have arrhythmia & 69 samples which have arrhythmia .Also in 4 samples our predictions turn out to be wrong.

Overall we achieved a 95.8% accuracy in predicting arrhythmia with a 4.2% error rate.

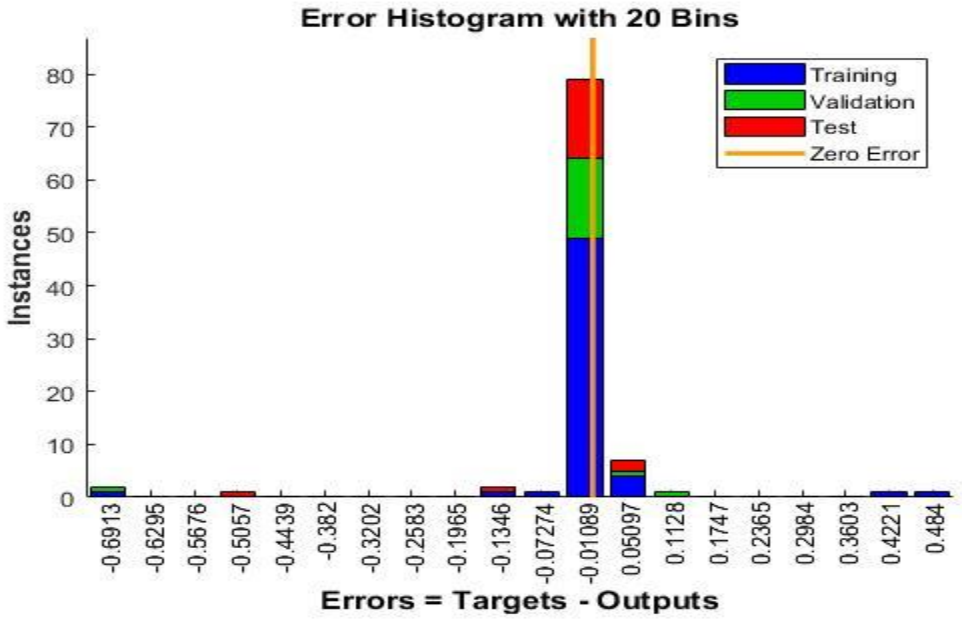

Fig21:Error Histogram

From histogram we can interpret that at a certain point neural network is unable to predict right response and if we remove this point from the data set neural network can learn more efficiently.

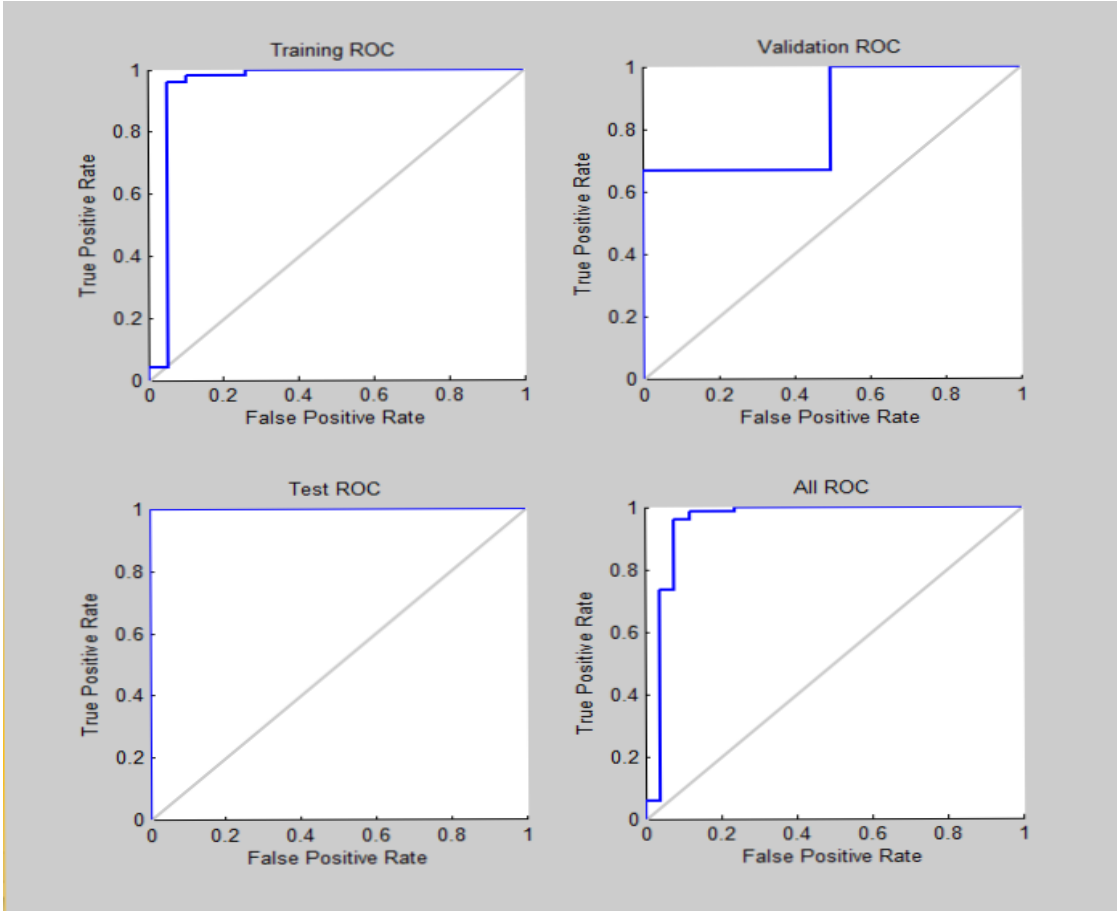

Fig 22: ROC Curve

In ROC curve true positive rate of confusion matrix is plotted against the function false positive rate. ROC curves reflects the efficiency of a neural network. As we can see in ALL ROC curve which includes a combined result of Training, Validation and Testing .The graph lies towards True Positive rate more as we have achieved a overall success rate of 95.8% .

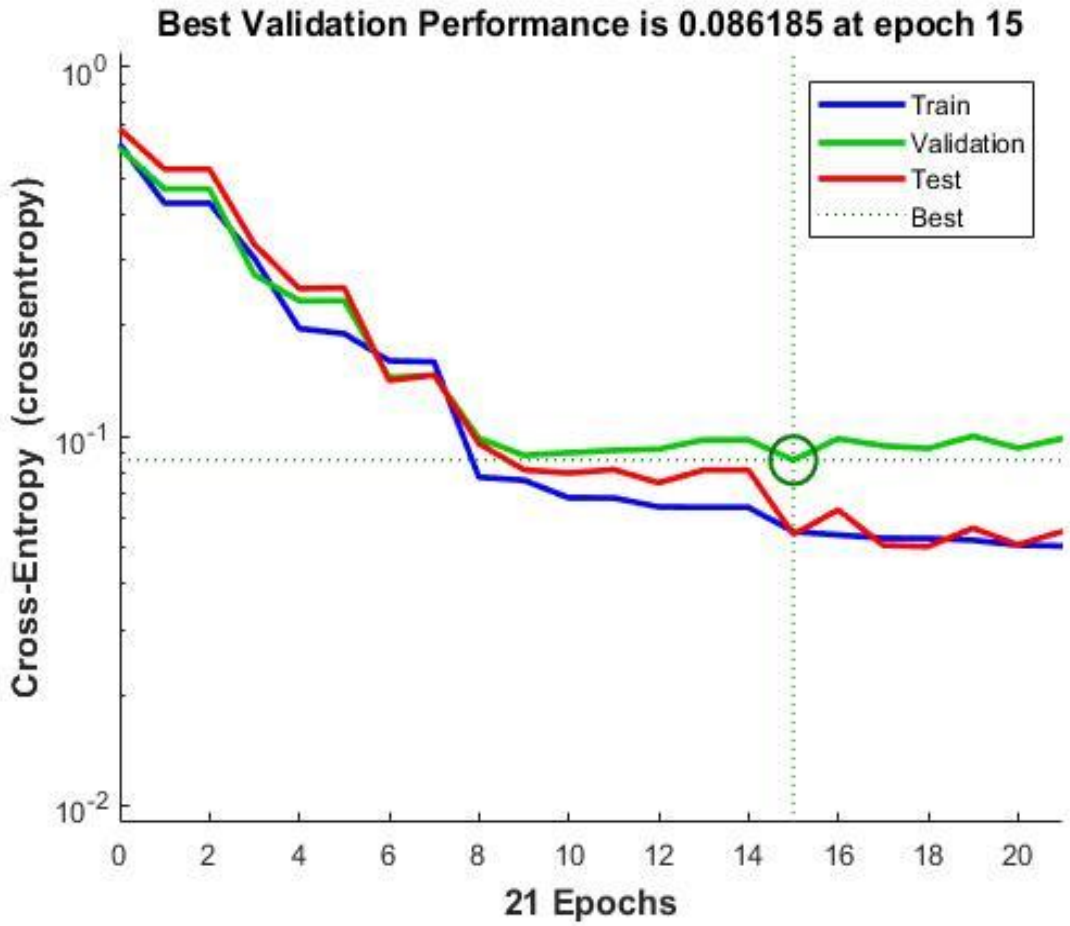

Fig 23: Performance Analysis Graph

An *epoch* describes the number of times the algorithm sees the *entire* data set. So, each time the algorithm has seen all samples in the dataset, an epoch has completed. As we can see that at 15 epoch the performance is best.

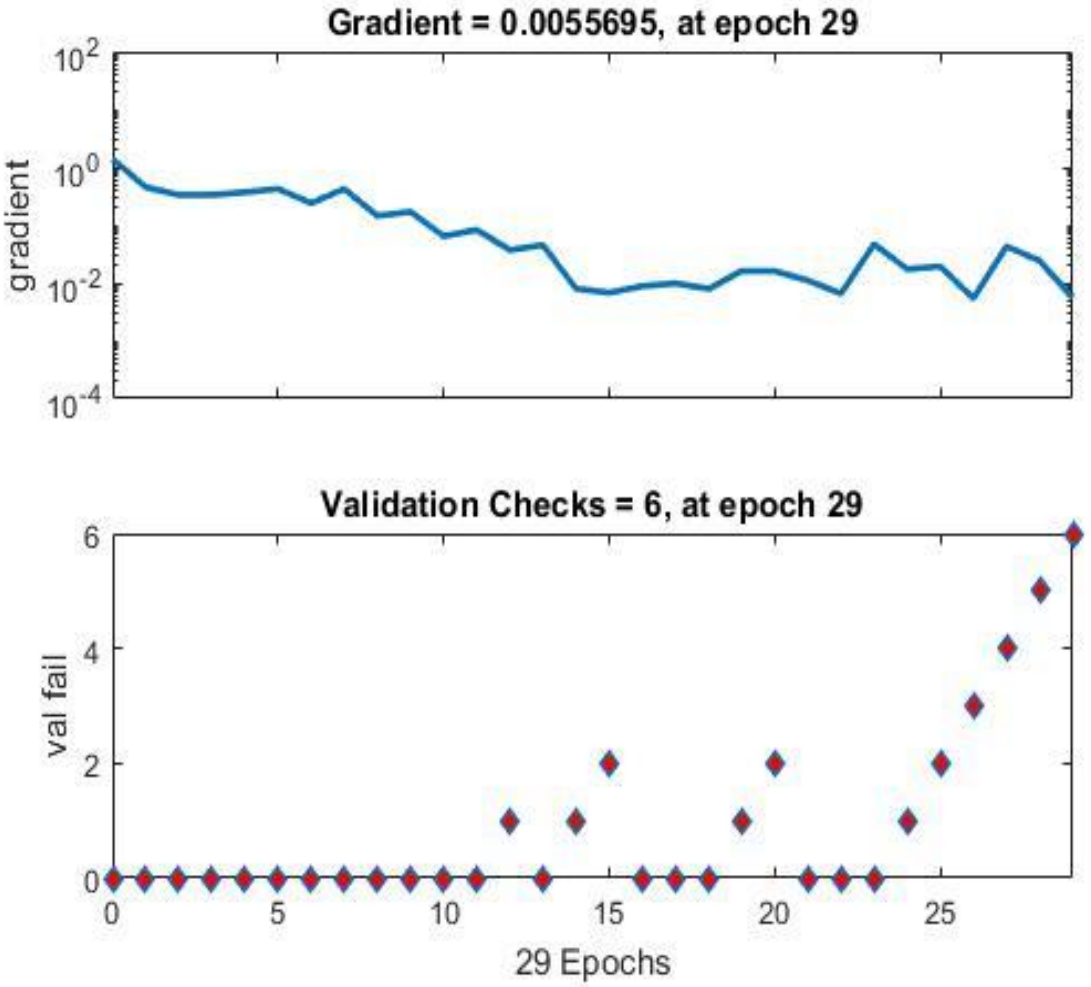

Fig 24: Training State Graph

Low value of gradient plot indicates that the network is learning up to a large extent which means finer adjustments in the weights and bias. This makes neural network more accurate and reliable, avoiding chances of false predictions. Validation plot shows the point where the network learned sufficiently and passed validation without. The point where the failures cross the defined limit is the stoppage point of training and indicates the starting of the over fitting of the data.

CONCLUSION

ECG signal has been through the preprocessing block where different type of noises i.e. baseline wandering noise, power line interference, burst noise are removed. Then preprocessed signal is passed through the feature extraction block from where different features of signal i.e. mean, median, kurtosis, skewness, variance, standard-deviation, rmse are extracted.. In classification block data set is provided for ECG signal classification. Their using Backpropagation neural network algorithm training, validation and testing is performed. From the classifier block we have a achieved a 95.8% accuracy in predicting the arrhythmia along with a 4.2% error rate which is shown in the confusion matrix Fig [19].

REFERENCES

[1] S.Osowski, T.H.Linh," ECG Beat Recognition Using Fuzzy Hybrid Neural Network", IEEE TRANSACTIONS, Volume 48 NO. 11, 2001.

[2] G. Lera, M. Pinzolas," Neighborhood Based Levenberg–Marquardt Algorithm for Neural Network Training", IEEE TRANSACTIONS, Volume 13 NO.5, 2002.

[3] M.M.Sadaphule, S.B. Mule, S.O.Rajankar,'' ECG Analysis Using Wavelet Transform and Neural Network'', International Journal of Engineering Inventions, Volume 1 Issue 12 PP: 01-07, 2007.

[4] Rajini,'' Electrocardiography signal analysis'', 2010

[5] S.Rani, A.Kaur, J.S.Ubhi,'' Comparative study of FIR and IIR filters for the removal of Baseline noises from ECG signal'', International Journal of Computer Science and Information Technologies, Volume 2(3) , 1105-1108,2011.

[6] Mk. Islam, A.Haque,'' Study and analysis of ECG signal using MATLAB & LABVIEW as effective tool'', International Journal of Computer and Electrical Engineering Volume 4 No. 3, 2012.

[7] V.Dubey, V.Richariya,'' A Neural Network Approach for ECG Classification'', International Journal of Emerging Technology and Advanced Engineering, Volume 3 Issue 10, 2013.

[8] P.Sao, R.Hegadi, S.Karmakar,'' ECG Signal Analysis Using Artificial Neural Network'', International Journal of Science and Research, ISSN: 2319-7064, 2013.

[9] M.Sharma, H.Dalal,'' Noise Removal from ECG Signal and Performance Analysis Using Different Filter'', International Journal of Innovative Research in Electronics and Communication, Volume 1Issue 2, PP.32-39, 2014.

[10] MayuriGachakeȦ, G.S. Gawande,'' Performance Comparison of Various Digital Filters for Elimination of Power Line Interference from ECG Signal'', International Journal of Engineering Research, Volume 3 Issue No.12, pp: 753-756, 2014.

[11] R.Gupta, Singh, K.Garg, S.Jain, "Indigenous Design of Electronic Circuit for Electrocardiograph", International Journal of Innovative Research in Science, Engineering and Technology, 3(5), 12138-12145, May 2014.

[12] A.Dhiman, A.Singh, S.Dubey, S.Jain, *"*Design of Lead II ECG Waveform and Classification Performance for Morphological features using Different Classifiers on Lead II *",* Research Journal of Pharmaceutical, Biological and Chemical Sciences (RJPBCS),7(4), 1226- 1231: July-Aug 2016..

[13] https://www.eleceng.adelaide.edu.au/students/wiki/projects/index.php/Projects:2016s1-131_ECG_Enhancement_with_Advanced_Signal_Processing#Objectives

[14] Book "Introduction to Biomedical Equipment Technology" by Joseph J.Carr

[15] http://physionet.org/cgi-bin/atm/ATM

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