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DENOISING OF ECG USING UWT AND DIAGNOSIS OF DISEASES

Eldho George[1]*, M. Rajmohan[2]
*[1]PG Scholar, VLSI Design, Hindustan university, Chennai, eldhogeorgekarakkattu@gmail.com
[2]M. Tech, Assistant Professor, Hindustan University, Chennai, mrajmohan@hindustanuniv.ac.in

Corresponding Author: -
Email: eldhogeorgekarakkattu@gmail.com

Abstract: -
This paper presents a new approach to eliminate the noise found in ECG signals due to artifacts and cardiac rhythm. This work is carried out using the Undecimated Wavelet Transform (UWT). The signals were acquired using an MATLAB SIMULATION of bioelectrical The ECG signals are obtained through the implant of electrodes connected to a channel of the front- end board. The cardiac rhythm is then obtained using an optic dactilar sensor connected to an independent channel of the ECG signal. In order to get a better identification of the acquired signal the Wavelet filter D6 (Daubechies) was chosen, primarily because its scaling function is closely related to the shape of the ECG, fitting very well with the applications constraints The processed signals were further analyzed using SIMULATION using MATLAB. The application to denoise the ECG signals was developed by MATLAB 2008Rb and is capable of graphically representing the data before and after it's processed.

Keywords: *noise cancelation, wavelet transform, Wavelet filter D6, ECG,Diagnosis..*

I. INTRODUCTION

Filtering ECG signals helps us eliminate those signals that contaminate our reading. These contaminating agents can be classified in the following categories: • Line interference • Noise by contact in the electrode • Electrical coupling of the electrodes and the board The noise, whatever the source is, significantly contaminates the ECG signal and therefore makes its analysis difficult. Obtaining an ECG signal could be an easy task, but obtaining a **reliable** ECG signal to provide a clinic analysis by a specialist is a more complicated task, This is why manipulating and filtering a signal is a complex task.

The advantage of effectively filtering the ECG signals is to determine in a clear and simple way the PQRST complex, that helps the specialist identify different types of arrhythmias, like the pvc, tachycardia or the bradycardia and variations in the heart rate; as well as determine other types of abnormalities in the myocardium [3]The Wavelet Transform is a mathematical tool also known as a mathematical microscope. It has the Short Window Fourier Transform (STFT) as its antecedent. Its main characteristic is the Multi Resolution Analysis (MRA), different scales and resolutions, constituting an adapted way for the analysis of non-stationary signals, as the bioelectrical signals are . Given a signal f(x), we wish to produce an estimation judged as a quite faithful representation of f '(x). The problem of de noising, is that the coefficients must be noise free. This noise could be due to any number of sources the environment. The purpose for applying a filter is to reduce the noise level in the signal and simultaneously preventing a loss in the signal's wave fidelity which could deform it. To remove the noise level in the signal using Wavelets, it must be selected among those similar to ECG waveforms, like the ones developed by Daubechies, Coiflets, or Biortogonals. In this research, all the above waveforms were tried out but only the Daubechies was selected. Subsequent to the selection of the Wavelet, the de noise process involves a smoothed stage by a threshold, using the minimax principle.

II. PROBLEM DEFINITION

A. The Discrete Wavelet Transform.

The most popular wavelet transform algorithm is the discrete wavelet transform (DWT), which uses the set of *dyadic* scales (i.e. those based on powers of two) and translates from the mother wavelet to form an orthonormal basis for signal analysis To implement the discrete wavelet transform, we need to use a discrete filter bank and make use of the equation scale to two.

$$\varphi(2^j t) = \sum_k h_{j+1}(k)\varphi(2^{j+1}t - k)$$

Eqation 1

Where $\varphi(2^j t)$ is the scaling function, the two-scale relation states that the scaling function $\varphi(2^j t)$, at a certain scale can be expressed in terms of translated scaling functions at the next smaller scale. Where J indicate the resolution level associated to the frequency, k indicates the localization and t is the translation variable. The first scaling function replaced a set of wavelets and therefore we can also express the wavelets in this set in terms of translated scaling functions at the next scale. More specifically we can write for the wavelet transform at level *j*:

$$\psi(2^j t) = \sum_k g_{j+1}(k)\varphi(2^{j+1}t - k)$$

Equation 2

This is the two-scale relation between the scaling function and the wavelet transform. Manipulating these two equations, and keeping in mind that the inner product can also be written as integration, we arrive at the next result:

$$\lambda_{j-1}(k) = \sum_m h(m-2k)\lambda_j(m)$$

$$\gamma_{j-1}(k) = \sum_m g(m-2k)\gamma_j(m)$$

Equation 3 and 4

These two equations state that the scaling function coefficients (h) and the Wavelet function (g) on a certain scale can be found by calculating a weighted sum of the scaling function coefficients from the previous scale. Now that we have implemented the wavelet transform, as an iterated digital filter bank it's possible now to speak of the *discrete wavelet transform* or *DWT*. Thanks to this we can do the downsampling and upsampling of the signal. As we can see in equations (3) and (4), a factor of 2 exists that allows us to do the downsampling or the upsampling, besides that the sum of the outputs is exactly the same as the input signal. *B. Signal Decomposition.*

The decomposition of the signal is an iterative process as it can be observed in the wavelet and scaling function, where the signal is divided to obtain a better resolution in the time- frequency domain. The process begins creating two symmetrical filters of a mother wavelet function (2) and a scaling function (1) that provide a orthogonal basis dividing the signal in its frequency spectrum, generating low and high frequency signals in each of these iterations, the low frequency components are the "approximation coefficients" obtained by the low pass filter, whereas the components of high frequency are the "Detail Coefficients" obtained by the high pass filter

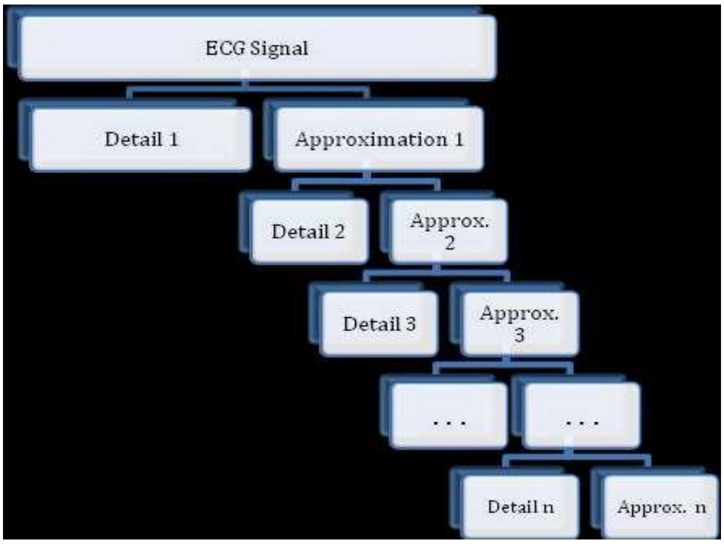

Fig 1 Decomposition signal tree with its Approximation Coefficients (low pass filter) and the Detail Coefficients (high pass filter).

C. The Stationary Wavelet Transform.

Whereas the discrete Wavelet transform has a suitable implementation in applications like data compression where compact signal description is required the obtained results were not the optimal for our signal filter noise reduction application to analyze the signal; this is mainly due to the loss of the invariant translation property of the Discrete Wavelet Transform, but the variation of this parameter is allowed, this take us to the Undecimated Wavelet Transform (UWT), for a signal. Actually, the UWT transform can be calculated in N log N using fast filter banks algorithms

The Wavelet function selection depends on the application or the application for which it's going to be used. Selecting a Wavelet function that looks like the signal that will be processed is the most convenient selection. Daubechies 6 (D6) from Daubechies family is similar in shape to the QRS complex and its energy spectrum is concentrated around low frequencies. Unlike the DWT transform, which downsamples the detail and approximation coefficients in each decomposition level, the UWT transform does not incorporate downsampling operations. The UWT transform upsamples the low and high pass filter coefficients in each level. The resolution of the UWT transform coefficients decreases with the increase in the decomposition levels.

III. METHODOLOGY

Using the tools for digital signal processing of MATLAB it was realized the processing of the ECG file obtained from the database. The tool for the analysis of the different filters was implemented under a friendly interface to handle it in a very efficient way. The MATLAB tool allows us to represent the ECG in two windows. The first window shows the signal before processing and in the second window the signal just filters. This feature allows the user to compare both signals.

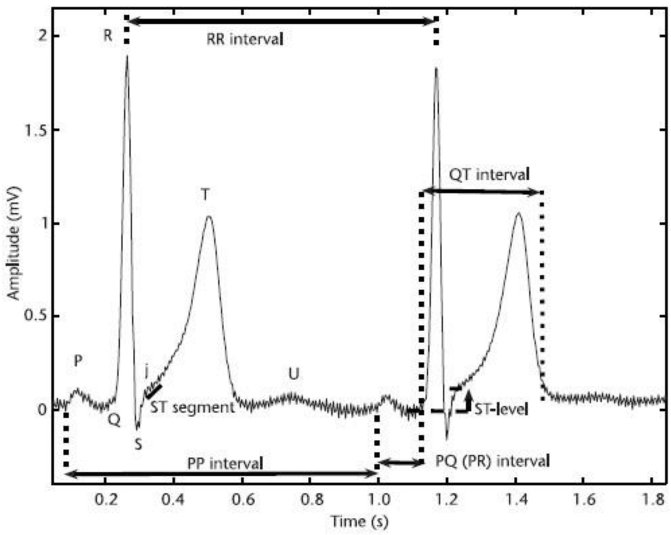

Fig 2 Standard points in the ECG (P, Q, R, S, T, and U)

Figure shows Standard fiducially points in the ECG (P, Q, R, S, T, and U) respectively typical normal values for these standard clinical ECG features in healthy adult males in sinus rhythm, together with their upper and lower limits of normality. Note that these figures are given for a particular heart rate. It should also be noted that the heart rate is calculated as the number of P-QRS-T complexes per minute, but is often calculated over shorter segments of 15 and sometimes 30 seconds.

IV. DENOISING ALGORITHM

STEP I

Apply the UWT transform to the contaminated signal to obtain the UWT coefficients of the signal. The noise in the signal usually corresponds to small value coefficients.

The first step in denoising is selection of the forward and inverse transformation. There are various types of wavelets that can be used which differ in their support, symmetry and number of vanishing moments. The various standard wavelet families are Haar, Daubechies, Coiflets, Biorthogonal, Reverse Biorthogonal families. By experimentally the Biorthogonal wavelets are suitable for medical image processing.

STEP II

Select an appropriate threshold for the UWT transform coefficients, to adjust these coefficients to values near zero. MATLAB provides methods to automatically select the threshold level. The reduction limit of the noise level with this method is of 3 dB. In order to reach better performance eliminating the noise of the signal, we can select a threshold manually. Thresholding methods can be grouped into two categories, global thresholds and level dependent thresholds.

STEP III

Rebuild the signal with UWT inverse transform. In this experiment we are performing the analysis process with the aid of filters and DWT. The result obtained by these methods we also analysed and some defects are identified in the output obtained.

Fig: shows the corresponding ECG signal obtained from the bioelectrical amplifying signal obtained from MATLAB simulation, which shows noise that need to be eliminated

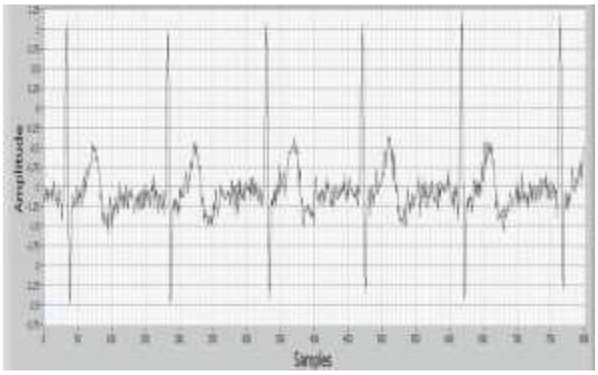

Fig 3 Original ECG signal

In figure a Biorthogonal UWT Wavelet filter has been applied where the T wave is smoother and QRS wave peak has been eliminated.

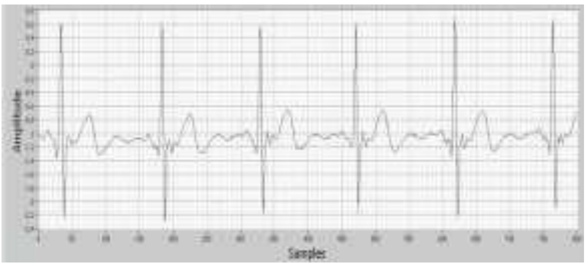

Fig 4 ECG signal applying a Biorthogonal UWT

V.   DIAGNOSIS OF DISEASES

A. PREMATURE VENTRICULAR CONTRACTION (PVC)

Premature ventricular contraction (PVC) is a form of cardiac arrhythmia in which the ventricle contracts prematurely. (PVC means wide QRS complex) .The detection of PVC beats is most important to prevent and diagnose the life threatening arrhythmias.A premature ventricular contraction (PVC), also known as a premature ventricular complex, ventricular premature contraction (or complex or complexes) (VPC), ventricular premature beat (VPB), or extrasystole, is a relatively common event where the heartbeat is initiated by Purkinje fibres in the ventricles rather than by the sinoatrial node, the normal heartbeat initiator. The electrical events of the heart detected by the electrocardiogram allow PVC to be easily distinguished from a normal heart beat.PVC may be perceived as a "skipped beat" or felt as palpitations in the chest.

We propose a method of detecting PVC using the R-R peak duration. Initially we detect R-peaks of the ECG signal & then find out the differences between these R-peaks. If the difference between the peaks exceeds a particular threshold, we mark those peaks as PVCs.

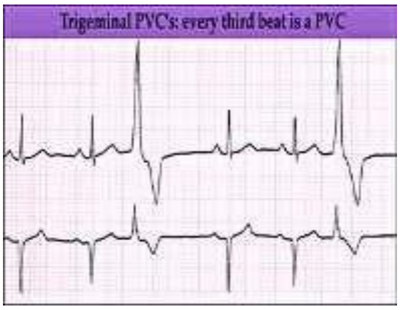

Fig 4 PVC

C.JUNCTIONAL TACHYCARDIA

Tachycardia is a heart rate that exceeds the normal range. A heart rate over 100 beats per minute is generally accepted as tachycardia. However, tachycardia can be dangerous depending on the speed and type of rhythm..The heart normally beats at a rate of about 60 to 100 beats per minute at rest. A rate faster than 100 beats a minute in an adult is called tachycardia. If tachycardia occurs at rest or without a logical cause, however, it is considered abnormal. Junctional tachycardia is an unusually fast heart rhythm originating around the atrioventricular (AV) junction. A number of issues can lead to junctional tachycardia in a patient. A doctor can identify tachycardia simply by feeling a patient's pulse or listening to the heart and noting that the heartbeat is faster than it should be. To determine the type of tachycardia involved, it is necessary to conduct an electrocardiogram, where the electrical impulses from the heart are measured. These impulses form distinctive patterns on the ECG readout and the shape of the pattern can be used to identify the source of an abnormal heart rhythm.

We propose a method of detecting the junctional tachycardia using the distance between the Q and S peaks of the ECG signal. If the distance is too small, we mark it as junctional tachycardia.

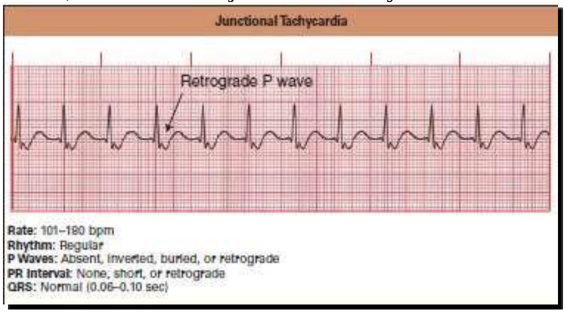

Fig 5 junctional tachy

VI. RESULTS

Result 1

The result obtained from the program for **Denoising of ECG Using UWT** is shown.

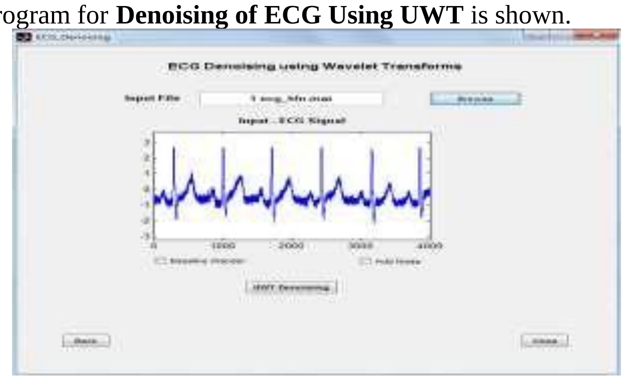

Fig 6 Input ECG signal

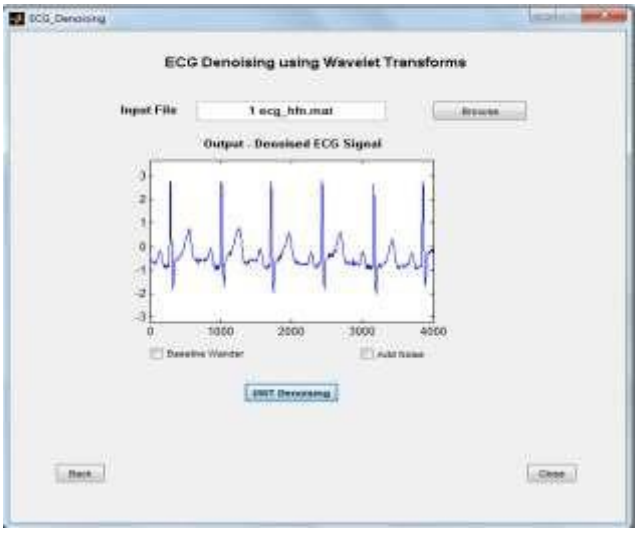

Fig 7 Denoised ECG signal

Result 2

The result obtained from the program for the **Diagnosis of Premature Ventricular Contraction** is shown below.

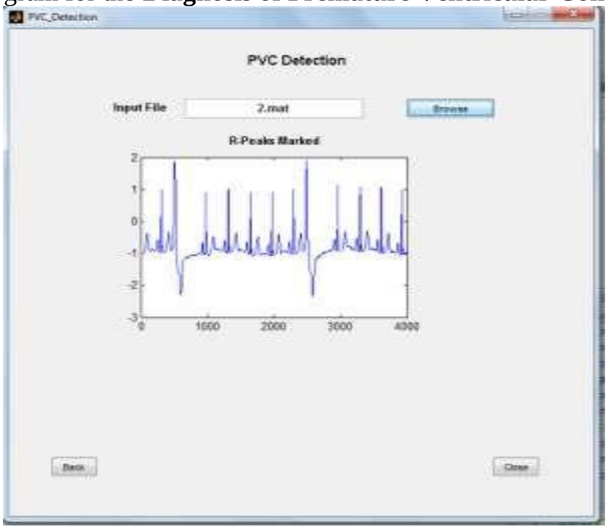

Fig 8 Input ECG signal

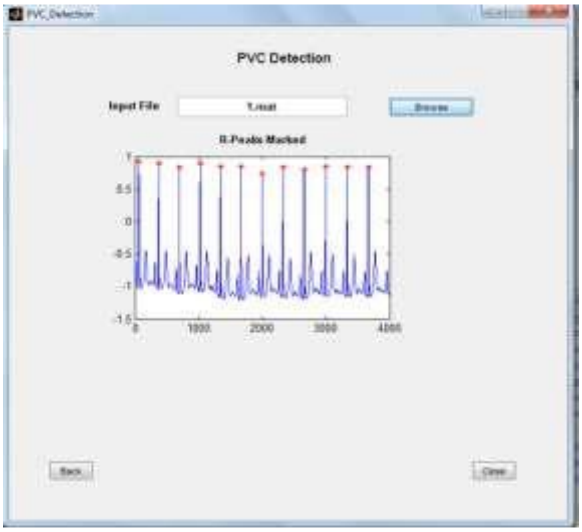

Fig 9 ECG signal without PVC

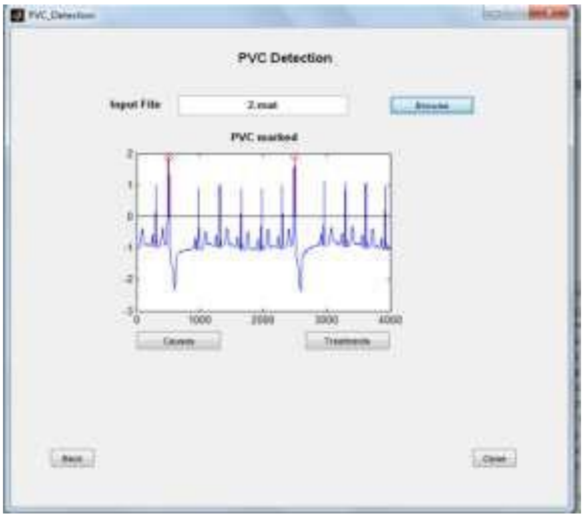

Fig 10 PVC marked ECG signal

Result 3

The result obtained from the program for the **Diagnosis of Junctional Tachycardia** is shown below.

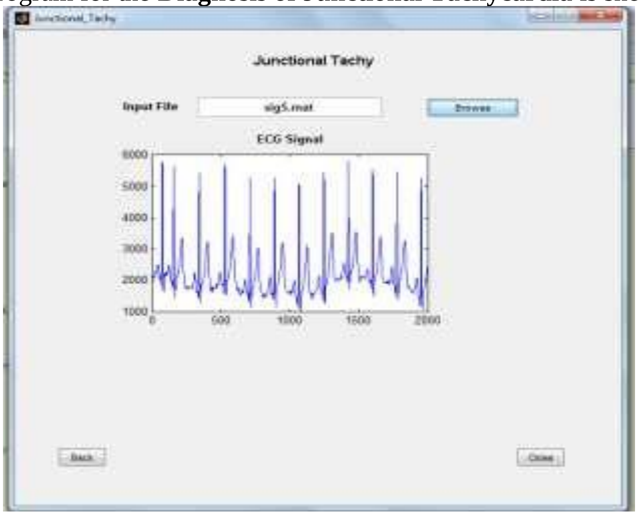

Fig 11 Input ECG signal

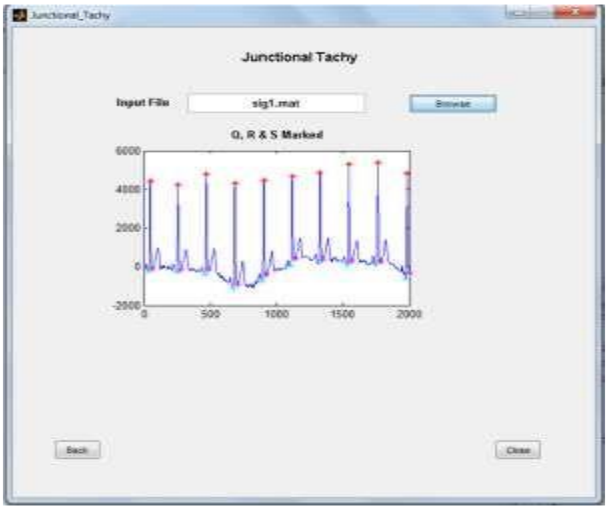

Fig 12   ECG signal without Junctional Tachycardia

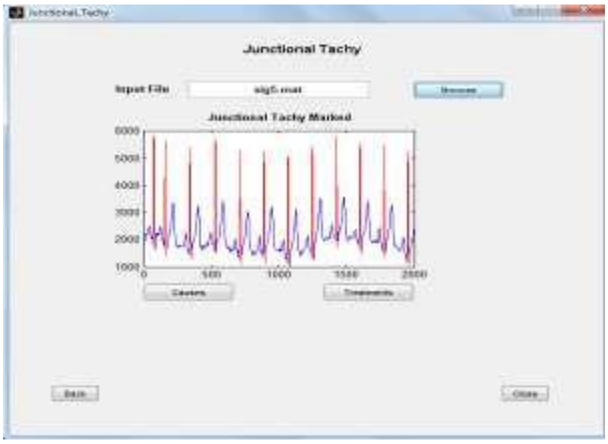

Fig 13 ECG signal with Junctional Tachycardia

VII. CONCLUSION

In this work we have tried to present an alternative to filter the ECG signal and thus obtain signals easier to interpret, that serves as a tool for biomedical signal processing and can be applied in other areas of research. Obtaining a suitable ECG signal for telemedical applications is a fundamental task in order to have accuracy of every wave that it is formed of. In fact besides processing, it is necessary to detect it with accuracy and to identify each feature of it in order to determine an accurate heart rate. Different types of diseases such as PVC, Junctional tachycardia etc can also detected by taking the variations in the ECG signal. The obtained results of the work using wavelet is demonstrated and found that it is an accurate tool for processing non-stationary signals such as the bioelectrical signals. With base on the experiments carried out to the information corresponding to the ECG signal and, the obtained results, it is possible to determine the use of Wavelets in applications like noise reduction, signal filtering and diagnosis of bioelectrical signal such as ECG.
Along with this, the advantages of UWT over DWT and other simple filter were also studied during this project work. UWT Wavelet shows better results in contrast with the DWT Wavelet transform. Different samples for their analysis were taken that were acquired by using the bioelectrical signal MATLAB SIMULATION and stored signals in a data base, to be processed latter on.

VIII. ACKNOWLEDGEMENT

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