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A Novel Approach to QRS Detection: Integrating Time, Amplitude Thresholds, and Statistical False Peak Elimination

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ABSTRACT

Each heartbeat provides a QRS complex in the electrocardiogram (ECG) which is centered at the R-peak. The analysis of ECG is hindered by low-frequency noise, high frequency noise, interference from P and T waves, and changes in QRS morphology. Detection of the QRS complex is the most important step in analyzing ECG signals for heart monitoring and diagnosis. ECG analysis mainly includes signal denoising, wave detection, and heartbeat classification. These three issues are relevant that the signal denoising can help attenuate the noises. This proposed system presents a new peak detection algorithm that can suppress the noise and adapt to changes in ECG signal morphology for better detection performance. The proposed algorithm is based on wavelet algorithm and it is compared with existing algorithm statistical false peak elimination (SFPE) with median and moving average filters. Wavelet is efficient for analyzing non stationary signals like ECG signals for signal denoising, wave detection and heart beat classification.

Keywords: Electro cardiogram, peak detection, premature ventricular contraction, segmentation, statistical false peak elimination

1. INTRODUCTION:

Heart is the one organ that is responsible for almost all of the processes in the Human Body. Major work of a Human Heart is pumping of Blood, Blood is the one thing that is responsible for every process in the entire Human Body. Blood contains Hemoglobin which is oxygen carrying protein, oxygen is the single most important thing that is required by the Human Body. So, the oxygen is supplied to various parts of the body through Blood. Without the Blood many organs that may be from the Brain to Hair everything will not work. We can't put it in words, of "How much our Body depended on the Heart", so, a healthy and hygienic lifestyle to be followed for a better working of the Heart. Health and many diseases are depended on functioning of the Heart, so, it became very essential task to record the functioning of Heart, for that, scientists came up with the idea of Electro-Cardiogram (ECG) Signals which records the activity of the Human Heart. Electro-Cardiogram or ECG records the electrical activity of the Human Heart using the electrical signals produced by the Heart. Even though the ECG produces the electrical activity of the Heart, the resultant signal extraction become a hard and complex task where we are losing the vital information related to the Heart. So, there exists a number of techniques and methods for extracting the important information from the ECG signal. A typical ECG signal contains PQRST waves of which QRS are the most significant waves, so, extracting at least these three peaks are is an important task. Even though there exists many techniques and methods to extract the QRS peaks from an ECG signal, the signal extraction is not an easy task, because it is susceptible to various noises. There exists a number of noises that degrade these QRS peaks. They are, Baseline Wander (BW) noise, power line interference, muscle artifact.

The transmission of ECG often introduces noise due to poor channel conditions. Moreover, there are other types of noise inherent in the data collection process. These artifacts are particularly significant during a stress test. The main sources of such artifacts are:

1. The Baseline Wander (BW) mainly caused by respiration.
2. High-frequency noise such as the electromyography (EMG) noise.

It is caused by the muscle activity. Moreover, the motion of the patient or the leads affects both types of artifacts. In ECG enhancement, the goal is to separate the valid ECG from the undesired artifacts so as to present a signal that allows easy visual interpretation. Many approaches have been reported in the literature to address ECG enhancement. Some recent relevant contributions have proposed solutions using a wide range of different techniques, such as perfect reconstruction maximally decimated filter banks and nonlinear filter banks, advanced averaging, the wavelet transform, adaptive filtering, singular value decomposition, and independent component analysis.

2. LITERATURE SURVEY

Mohammed Basheer Mohiuddin; Isam Janajreh. "Analysis and Synthesis of Electrocardiogram (ECG) using Fourier and Wavelet Transform," J. Eng., Vol. 17, pp. 85-97, 2020. Here, from this project ECG signals are analyzed with Fourier and Wavelet transforms and to highlight and demonstrate the advantages of the Wavelet transform. Firstly, it

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involves simulating the temporal digital ECG signal and explaining the signal constituents, i.e., P, Q, R, S, T waves while staying in the time domain. Secondly, the ECG signal will be transferred into the frequency domain for quick, fast, and compressed analysis and carry out signal processing using Fourier analysis and highlight the pros and cons of this technique. We perform Fast Fourier Transform (FFT) on the ECG signal. This gives us information about the High Frequency (HF) and Low Frequency (LF) components of the ECG. The LF gives information about the physiological activities of the heart whereas HF indicates respiratory activity.

Xuanyu Lu; Maolin Pan; Yang Yu. "QRS Detection Based on Improved Adaptive Threshold," J. Healthcare Eng., pp.1-8, 2018. Here, In this paper an improved adaptive threshold algorithm for QRS detection. The overall process is divided into 4 stages known as preprocessing, peak finding, adaptive threshold QRS detecting and displaying of abnormal area and drawing of RR- peak plot. In the ECG signals it consists of different noises such as frequency interference, baseline drift, bodily noises etc., by using pre-processing stage for data the noise can be removed and signal can be amplified easily by using different techniques. To analyze the signal using Fourier Transform, we perform FFT on the ECG signal. This gives us the frequency domain response of the signal. However, the T wave also has a slope. To divide T and QRS waves, the feature is amplified by squaring and then this information is collected by window integration. After that, preprocessing step is completed. The signals are integrated after the preprocessing step so that the detection is simplified and here comes the crucial step, finding peaks. In this algorithm, peaks are regarded as the candidates of the QRS complex. When peaks are found, the nearby samples are checked to select the largest signal. This step helps to find QRS waves more precisely and contributes a lot to QRS detection and the threshold method is thus improved.

3. EXISTING SYSTEM

The QRS complex is the electrocardiogram's (ECG) most noticeable feature, its identification is necessary for distinguishing the ECG's other waves and segments and for extrapolating clinically relevant data. Variable QRS morphologies, noise, artifacts, and interference from tall and pointed P- and T-waves all contribute to the difficulty of QRS detection. In this study, we suggest a novel method for QRS detection that involves weighted total variation (WTV)

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denoising before preprocessing the ECG.. Similar to most other QRS detection techniques, the proposed method consists of two stages: a preprocessing stage and a peak detection stage, as shown in the block diagram in Fig. 3.1.

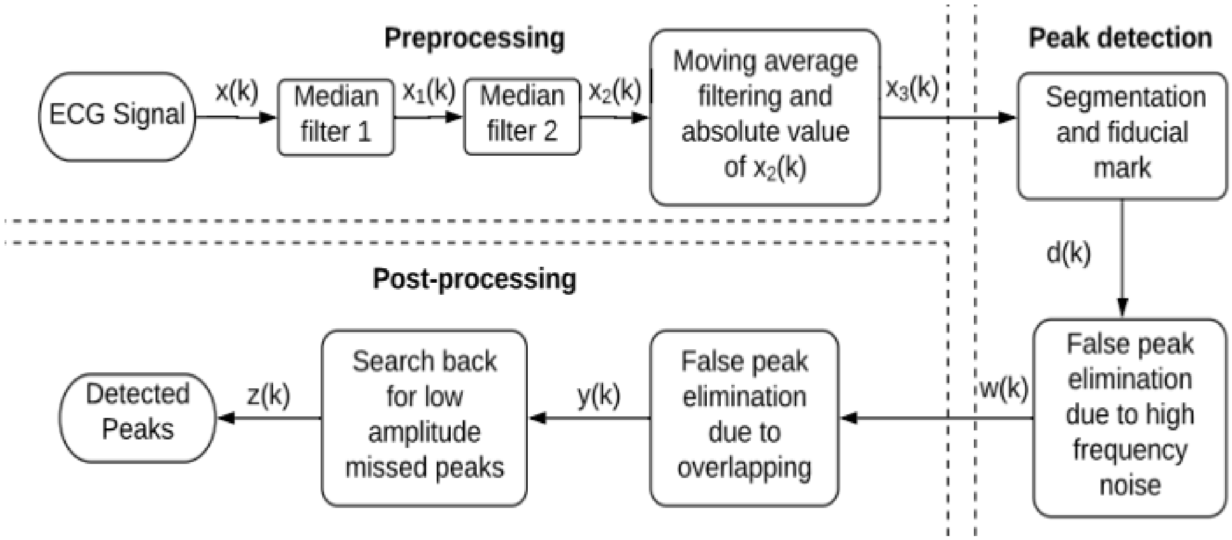

Fig 3.1: Block Diagram of existing Method

The noise filtered ECG signal will be sent to the Peak detection stage where the peaks are detected using Amplitude and Time Thresholds. The thresholds for estimating the QRS peaks. The thresholds are done based on the statistical analysis of the ECG signal. The thresholds are the values that result in the typical QRS peaks or waves. The particular Q peak or R peak or S peak will have a regular time instants or lengths or heights. These can be used to threshold to extract the near exact Q or R or S peaks. The peak detection will be better whenever there is better thresholds. For that we have to remove the noise at a greater value. The R peaks are the most and easily detectable among all of the ECG peaks. The typical tallest peak or that which peak that has highest amplitude in an ECG signal is always an R peak. So, the R peaks are easily be extracted and can be used for reference in estimating the other peaks. Like the difference between the two R peaks and the threshold difference between the QR peaks as well as RS peaks. So, the threshold will result in better way, if the R peaks are detected perfectly.

ISSUES IN EXISTING SYSTEM

- There may have a chance of data loss.
- False peaks are more.

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4. PROPOSED METHOD

The electrocardiogram (ECG) is a non-invasive test for the heart which is conducted by placing electrodes on the chest to record the electrical activity of the heart. It contains P waves, QRS complex and T waves. R peaks are prominent features in the ECG signal. The signal obtained has large amounts of noise components which makes the R-peak detection very challenging. Due to noise, they are quite often suppressed and cannot be detected properly without removing the noise contaminating the sample. The Haar wavelet transform is a popular signal processing algorithm that is frequently used in electrocardiogram (ECG) analysis. It is a type of discrete wavelet transform that can be used to decompose a signal into a set of wavelet coefficients at different scales and locations. In ECG analysis, the Haar wavelet transform can be used to identify important features of the ECG signal, such as the QRS complex, the P wave, and the T wave. These features can be used to diagnose various cardiac conditions, such as arrhythmias, ischemia, and infarction

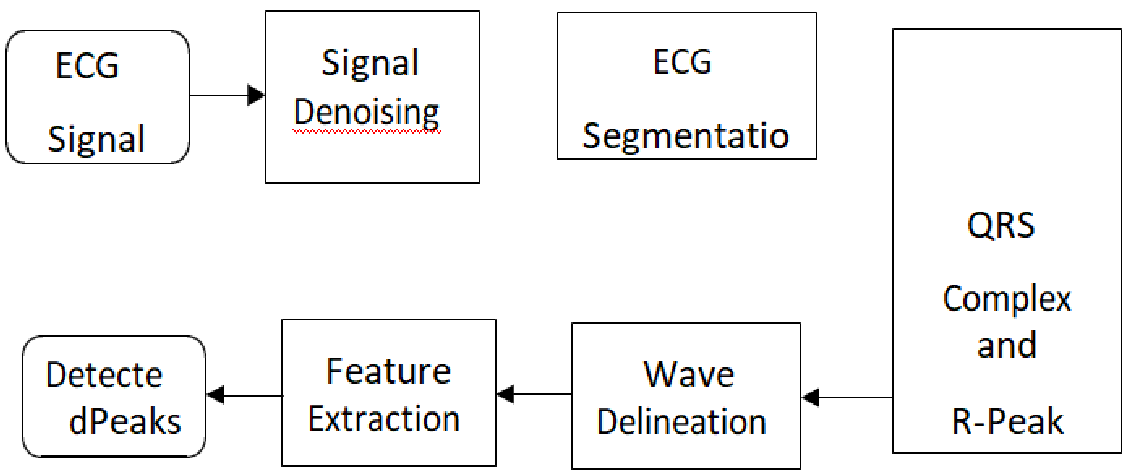

Fig 4.1: Block Diagram of Proposed System

ECG segmentation is the process of dividing an ECG signal into smaller, non- overlapping segments, each of which corresponds to a specific interval or waveform of the cardiac cycle.

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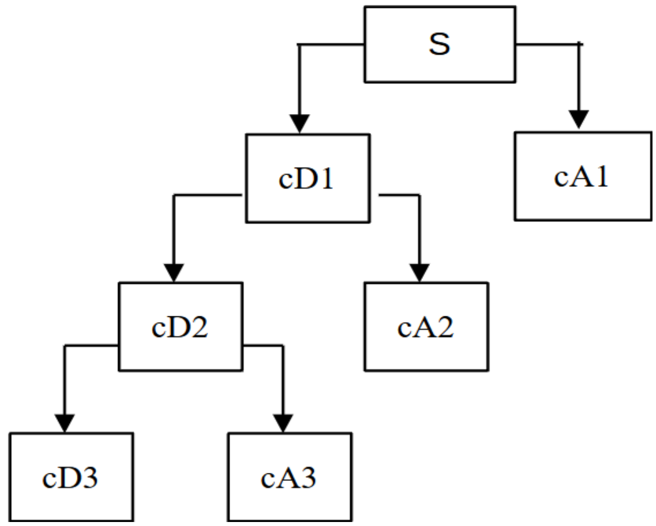

Fig 4.2: ECG Segmentation

The process of down-sampling is that what produces the DWT coefficients which are the approximation coefficients obtained from the low pass filter and the detail coefficients obtained from the high pass filter. A multi level wavelet decomposition tree is obtained by further decomposition process for the approximation coefficients, so that one signal is broken down into many lower resolution components.

This constitutes one level of decomposition and can mathematically be expressed as follows:

$$y_{high}[k] = \sum_{n} x[n] \cdot g[2k - n]$$

$$y_{low}[k] = \sum_{n} x[n] \cdot h[2k - n]$$

Where y high[k] and y low[k] are the outputs of the high-pass and low-pass filters, respectively, after sub-sampling by 2. signal. For filtering the signal, there are different types of filters are used. In DWT, the original signal passes through two filters. Low-pass filter producing the approximation coefficients h[n] which is the most important part. High-pass filter which produces the detail coefficients g[n]. Here, these two functions are called scaling functions and wavelet functions.

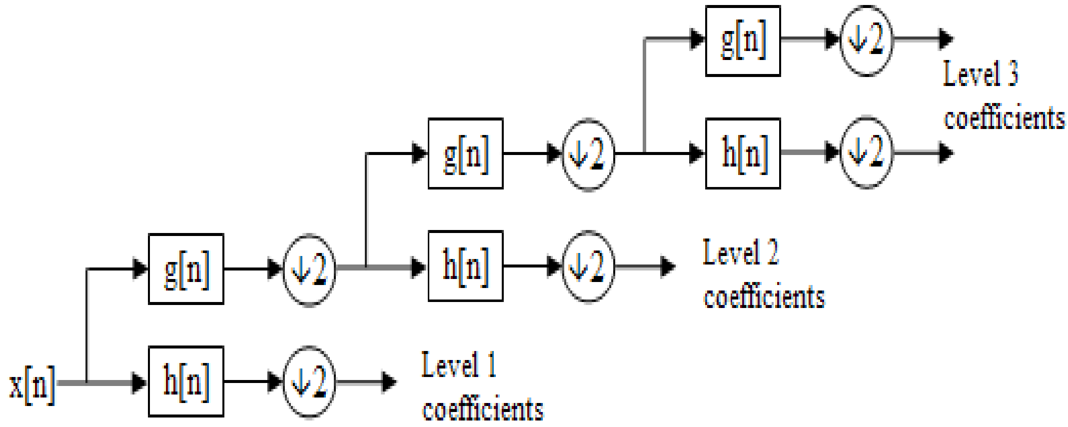

Fig 4.3: Process of Discrete Wavelet Transform

Mainly the basic filters are used to eliminate the baseline wander and low frequency, high frequency noises. There are different types of basic filters. Low-pass filter, High-pass filter, Band-pass filter and band-stop filter. In the wavelet transform it has two types of in-built filters. They are low-pass filter and high-pass filter. The ECG signal passes through these filters for the purpose of denoising the signal.

5. RESULTS

We have applied this algorithm on MIT-BIH Long-Term ECG first databaserecord of 14 hours which is sampled with sampling rate of 114 Hz.

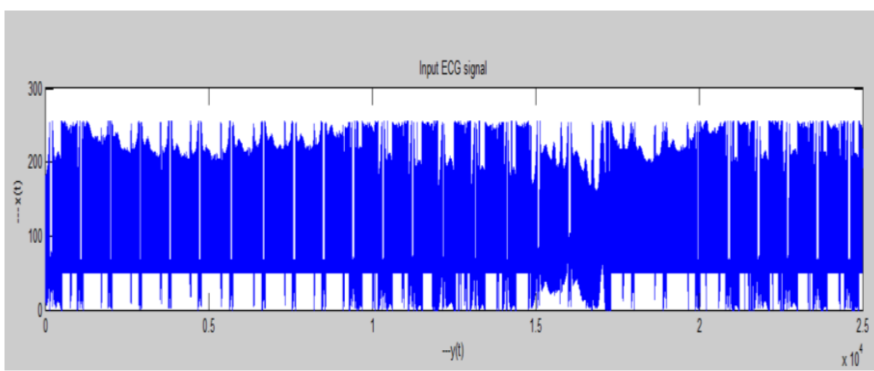

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Fig 5.1: Input ECG Signal

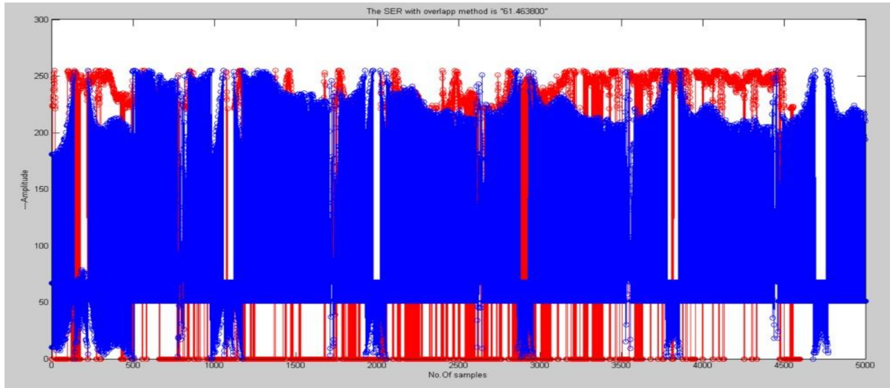

Fig: 5.2: SER Value by SFPE for EC

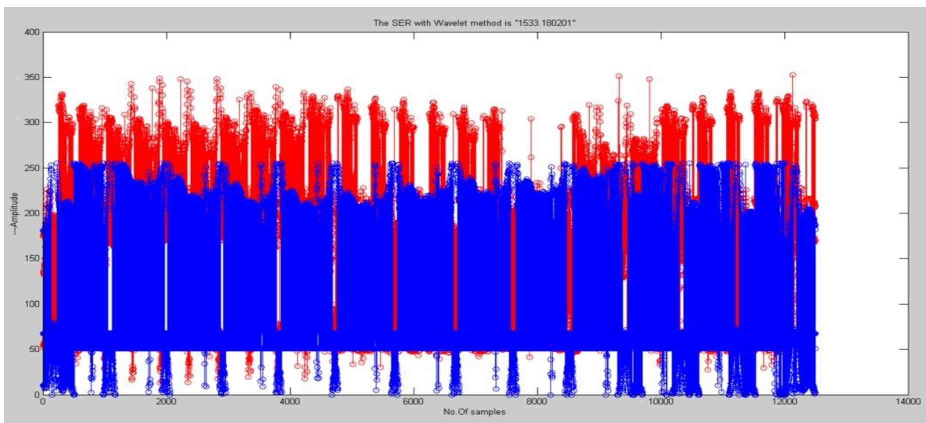

Fig **5**.3: SER value by Wavelet method ECG

5. CONCLUSION

In this paper, QRS detection using a simple statistical analysis of the ECG signal has been presented. Discrete Wavelet Transform algorithm and Haar Wavelet algorithm have been considered in this paper for effective detection of QRS complexes. Dividing the record into multiple segments resulted in low processing time and better accuracy. Furthermore, eliminating false peaks, identified very few false positives and therefore have shown better positive predictivity than other methods mentioned in the paper. We have analysed the output with the previous models. Simulation results have shown better performance in most of the records than other methods. Thus, the proposed algorithm performs better in terms of automatic detection with a higher percentage of overall detection rate.

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