ORIGINAL RESEARCH PAPER

Volume - 11 | Issue - 06 | June - 2022 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

DISCRETE WAVELET TRANSFORM BASED ECG SIGNAL ANALYSIS FOR BASELINE WANDER ELIMINATION AND R PEAK RECOGNITION

Engineering

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ABSTRACT

This study was inspired by the desire to create a simple, accurate, and fast approach for analyzing ECG signals. A new study showed that in the employed age class of roughly 24-65 years, the demise rate is only due to numerous cardiac associated disorders. Thus, ECG is the most critical signal to examine and monitor. An ECG is a biomedical signal that may be monitored by electrodes placed on the human body. In my research, I use two phases to analyze ECG signals. The first stage is to improve the ECG signal by removing noise. It is done by rejecting background disturbances, notably Baseline Wander clamor, which is a small frequency clamor, often under 0.5 Hz. This is completed utilizing both the standard MA filter and wavelet theory. A correlation between the two methodologies is found in this work. Subordinate phase is to discover the R peak by DWT and reconstruct the signal. This research also includes a projected technique and comparison for better detection in the usual ECG data. The simulation is done in MATLAB. The findings are provided to evaluate several threshold strategies for proper recognition of R peaks for rapid and precise calculation.

KEYWORDS

DWT (Discrete Wavelet Transform); ECG (Electrocardiogram); MA (Moving Average) filter; Baseline Wander.

INTRODUCTION:

Biomedical signals such as the ECG are critical for detecting heart disease. We can import heart-related data with the use of an ECG [1]. Visual analysis of ECG signals is difficult since they are non-stationary and do not follow a predictable pattern. As a result, we may easily analyze ECG signals using computational algorithms [2] [3].

Manual and computer-based ECG detection methods are available. Previously, a patient's ECG signal was recorded and written on graph paper before being checked visually to make treatment decisions. If you're going to use this strategy for a lengthy period of time, you're going to have to deal with a lot of noise. ECG signals are processed by a computer system in the latter method, making it more suitable for long-tenure observing. During conduction of ECG data, there is a chance that the signal will be corrupted due to noise in the system.

Clamors accountable for ECG data exploitation contain power line [5] intrusion which lay about 50-60 Hz, Baseline drift, inappropriate electrode location planning etc. As a result, when evaluating ECG signals, we always receive incorrect results. Denoising the signal, also known as signal augmentation, is the first step in the analysis process.

Cardiovascular System Of The Human Being

The heart is the most important organ in the human cardiovascular system. The entire circulatory system is handled by this method. An illustration of what has just been said can be seen in Figure 1.

The heart is divided into two parts, the right and the left. Atrium and ventricle are two separate chambers in the heart. It is the top chamber, which receives blood, and the lower chamber, which transmits blood. The atria are electrically insulated from the ventricles by non-conductive fibrous tissue [5]. The mitral valve separates the left atria from the ventricles, allowing the tricuspid valve to isolate the left and right atriums [6].

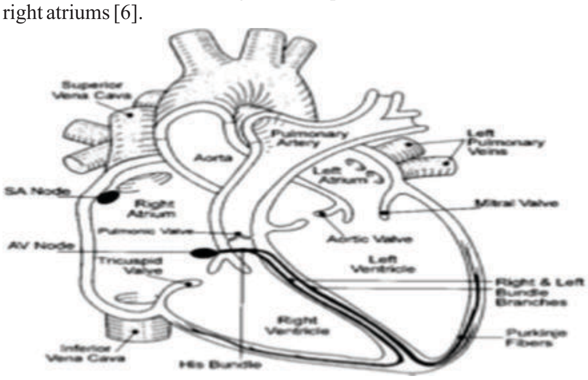

Figure 1: Cardiovascular System Of The Human Being.

Existing Work Done:

The filter proposed by Dai et al. (2009) can be used to enhance signals. The small-frequency BW clamor is picked, collected, and lastly deleted to recover the genuine ECG data from this sort of filter. A low pass filter is used to remove the noise in this instance. The fast processing speed of this approach makes it ideal for noise removal, but the filtered ECG signals may suffer data loss as a result of the filtering process.

It has been proposed by Lin et al. (2013) that there are two key research projects. Discrete Wavelet Transform (DWT) is one method for removing noise. Soft thresholding is utilized for thresholding, while Symlet wavelet (sym5) is employed for wavelet functionality. As a result, we may reduce the ECG signal's BW noise by using the appropriate technique. It is an innovative technology that allows us to remove a large number of noises with minimal complexity and loss.

Another approach has been given by Lin et al (2013). There are many techniques that can be used to better capture the peaks, for example one verge and two verges. As a result, R Peak is identified, and this value is utilized to calculate heart rate.

Proposed Algorithm:

MA Filtering:

An ECG signal of 360 Hz and 3600 samples is used in this technique. After deducting with base and distributing by gain, the raw data is turned to physical data. The technique is tested by generating more BW noise in the form of a sinusoidal wave. Then the signal is mixed with the generated noise to create a blaring data. The blaring data is now subjected to the Moving Average filter, a LPF in essence. Because BW clamor has a lower frequency, we can eliminate it with this sifter and end up with a denoised ECG data.

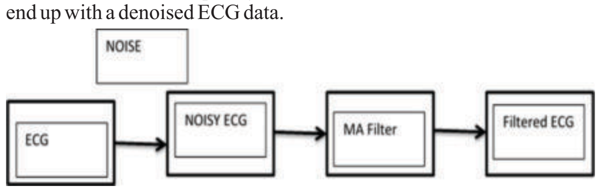

Figure 2: ECG Filtering with MA Block Daigram.

Subsequently applying Moving average filter to ECG signal results are shown in figure 3.

DWT filtering:

A BW is added to data in this technique to make it more erratic. The sub band code technique breaks the wavelets into distinct level coefficients, which is how the Discrete Wavelet Transform divides this noisy ECG data. The ECG signal is then recreated using these coefficients.

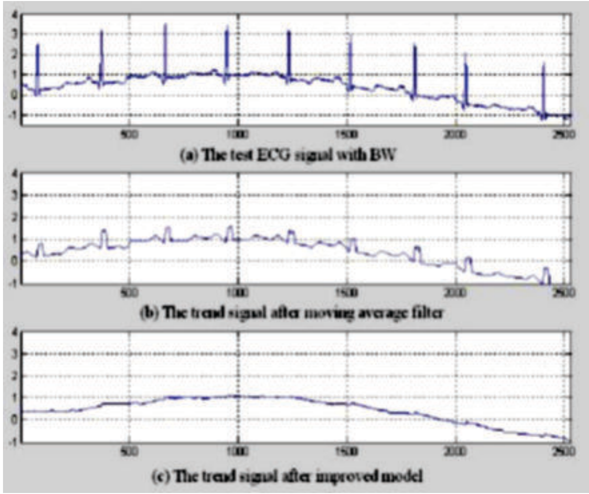

Figure 3: Application of MA filter for ECG baseline wandering removal.

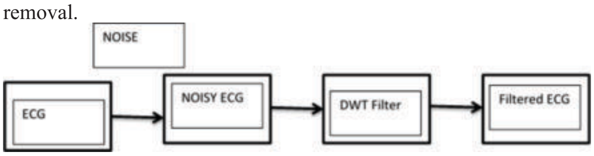

Figure 4: Figure 2: ECG Filtering with DWT Block Daigram.

In order to save calculation time, DWT employs two filters for signal analysis and signal processing. These two types of filters are High Pass and Low Pass and have frequencies that are equal to one-half the bandwidth of the main signal's frequencies. Down filtering and down sampling by factor 2 are used in this analysis. Up sampling by a factor of two is used for reconstruction, and then zeros are injected for the combinations process.

Discrete Wavelet Transform denoising requires the use of thresholding methods to either delete or decrease the wavelet coefficients above and under the verge value given by the noise variance. These approaches are called Hard and Soft thresholding.

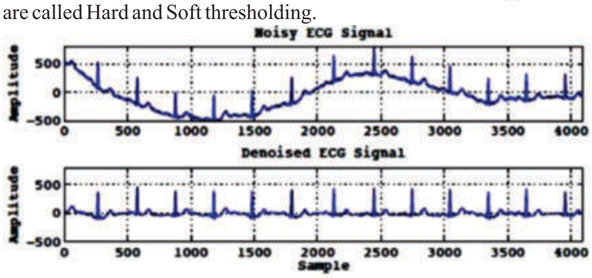

Figure 5: DWT filtered ECG signal.

R- peak Detection:
The DWT algorithm is used in this proposed method. The R peak identification method begins when the ECG data is decomposed into multiple ranks. The most important part of this is the reestablishment of wavelets at the 3rd, 4th, and 5th levels. The high frequency components in the first and second decomposed wavelets are the basis for ignoring them.

The frequencies of the sixth, seventh, and eighth components are so low that they can be eliminated. The localized coefficients are derived from the reconstructed signal's absolute value after the reconstruction procedure. After that, an adaptive window is used, which takes 0.5 s windows and moves them every 0.1 s. The threshold approach is used in this window. Two different threshold approaches are used here to generate a clean signal where we can spot R peaks.

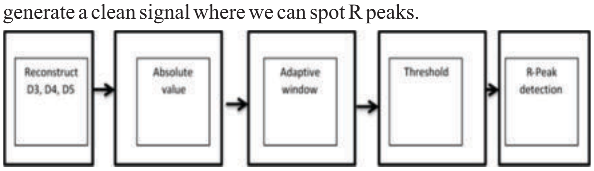

Figure 6: ECG R- Peak detection block diagram.

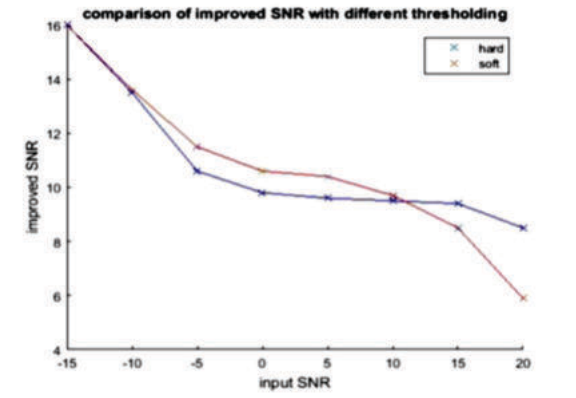

Figure 7: Comparison Of Improved SNR With Different Thresholds.

Table 2: Assessment Of Enhanced SNR With The Thresholding Approaches.

Input SNR	-15 dB	-10 dB	-5 dB	0 dB	5 dB	10 dB	15 dB	20 dB
Hard thresholding (Improved SNR)	15.5	14.2	10.8	9.5	9.6	9.7	9.6	8.9
Soft thresholding (Improved SNR)	15.5	14.5	11.5	10.9	10.5	9.5	8.9	6.2

After applying to DWT filter and comparing the performance of MA and DWT filter, it is concluded that DWT filter are better in performance for removing base line wandering from ECG signal while preserving the basic information of signal.

We use two different threshold methods in this study to find the R peak. The R peaks are obtained with less detail using the one threshold method, so the results are better fixed using the two threshold method.
1. To begin, we must go through the steps of signal decomposition and signal reconstruction.
2. For a localized signal, we must now take the absolute value.
3. Thresholds are applied to the reconstructed signal in this step.

The MA filter algorithm produced a signal with a cross-correlation of 0.9253, which was improved. As opposed to 0.9051 for the DWT algorithm Thus, we discovered that the DWT is superior to the MA filter because the latter's disadvantage is the cost of data, which is critical for extracting ECG constituents.

The R peaks of numerous ECG signal were discovered alongside the enhancement, and the final sensitivity was calculated to be 99.64 percent.

CONCLUSION:

The Electrocardiogram (ECG) signal is the most important component in this study. The primary goal of this study is to analyze the signal in order to enhance it and identify the most critical element of an ECG. Finally, we wanted to make the ECG signal more similar to the final reconstructed signal while also enhancing it.

Analysis of ECG signals using the proposed MA filtering algorithm to remove baseline wander noise was successfully implemented. A cross-correlation of 0.9253 was discovered despite the fact that data loss was necessary for the ECG component extraction. DWT analysis used a combined BW noise for the enhancement of the resultant signal. The cross-correlation factor was found to be 0.9051, which reduced computation time. As a result of comparing the two methods, we came to the conclusion that the DWT decomposition method is superior to the traditional Moving Average filter for improving the ECG.

We used two threshold methods for R peak detection. There are two ways to find peaks: one uses an adaptive window and the other uses an average of R-R peaks and the first threshold output.

In order to extract the true peak, as well as false positive and false negative results, we looked at the database's ECG data and discovered that the sensitivity was 99.64 percent.

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