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Wavelet Transform for ECG Signal Analysis

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Abstract- **The ECG is used for diagnosis of heart diseases. Generally, the recorded ECG signal is often contaminated by noise. In order to extract useful information from the noisy ECG signals, the raw ECG signal has to be processed. The baseline wandering is significant and can strongly affect ECG signal analysis. The detection of QRS complexes in an ECG signal provides information about the heart rate, the conduction velocity, the condition of tissues within the heart as well as various abnormalities. Supplies evidence for the diagnosis of cardiac diseases. An algorithm based on wavelet transforms (WT's) has been developed for detecting ECG characteristic points. Discrete Wavelet Transform (DWT) has been used to extract relevant information from the ECG signal in order to perform classification. The QRS complex can be distinguished from high P or T waves, noise, baseline drift, and artifacts. By using this method, the detection of QRS complexes and the P and T waves can also be detected, even with serious base line drift and noise.**

Index Terms- **Electrocardiogram (ECG), Wavelet Transform, QRS Complex.**

INTRODUCTION

The ECG signal is a recording of the heart's electrical activity and provides valuable clinical information about the heart's performance. It is a graphical representation of the direction and magnitude of the electrical activity that is generated by depolarization and repolarization of the atria and ventricles. It provides information about the heart rate, rhythm, and morphology. ECG varies from person to person due to the difference in Position, size, anatomy of the heart, age, relatively body weight, chest configuration and various other factors. There is strong evidence that heart's electrical activity embeds highly distinctive characteristics, suitable for various applications and diagnosis. The electrical activity during the cardiac cycle is characterized by five separate waves of deflections designated as P, Q, R, S and T. The QRS complex is generally chosen for the detection of Cardiac arrhythmias, such as an irregular heart rate. The detection of QRS complex, specifically, the detection of the peak of the QRS complex, or R wave, in an ECG signal is a difficult problem since it has a time-varying morphology and is subject to physiological variations due to the patient and to corruption due to noise.

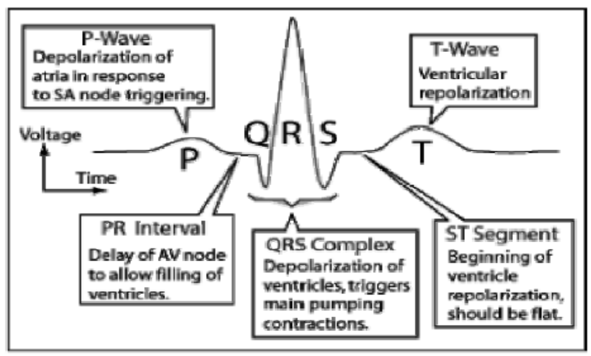


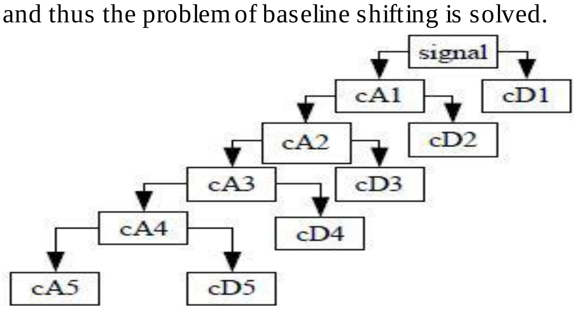
Fig. 1 The Normal ECG Waveform

Computer based ECG analysis system have proved to be more efficient, having made possible rapid retrieval of data for storage and techniques of data Presentation whose clinical utility is evident. In the last decade many approaches to QRS detection have been proposed, involving artificial neural networks, real time approaches, genetic algorithms, and heuristic methods based on nonlinear transforms and filter banks. As noted in, most of the current QRS detectors can be divided into two stages: a preprocessor stage to emphasize the QRS complex and a decision stage to threshold the QRS enhanced signal. Typically, the preprocessor stage consists of both linear and nonlinear filtering of the ECG. Recognition of ECG wave starts with the R identification; with the help of Wavelet transform. The wavelet transform, which has been used in biomedical signal processing also, has its role in ECG characterization and QRS detection. To overcome the limitations imposed by fixed duration windowing techniques in detecting time-varying transients, a general, adaptive technique that captures the spectral/temporal variations in QRS morphology is needed. QRS detection is one of the fundamental issue in the analysis of Electrocardiographic signal. The QRS complex consists of three characteristic points within one cardiac cycle denoted as Q, R and S. The QRS complex is considered as the most striking waveform of the electrocardiogram and hence used as a starting point for further analysis or compression schemes. The detection of a QRS complex seems not to be a very difficult problem. However, in case of noisy or pathological signals or in case of strong amplitude level variations, the detection quality and accuracy may decrease significantly

Once the position of the QRS complex is obtained, the location of other components of ECG like P, T waves and ST segment etc. are found relative to the position of QRS, in order to analyze the complete cardiac period. Recently Wavelet Transform has been proven to be useful tool for non-stationary signal analysis. Among the existing wavelet approaches, (continuous, dyadic, orthogonal, biorthogonal), we use real dyadic wavelet transform because of its good temporal localization properties and its fast calculations.

Discrete Wavelet Transform can be used as a good tool for non-stationary ECG signal detection Wavelet Transform the Wavelet Transform is a time-scale representation that has been used successfully in a broad range of applications, in particular signal compression. Recently, Wavelets have been applied to several problems in Electro cardiology, including data compression, analysis of ventricular late potentials, and the detection of ECG characteristic points. The Wavelet transformation is a linear operation that decomposes the signal into a number of scales related to frequency components and analyses each scale with a certain resolution. The WT uses a short time interval for evaluating higher frequencies and a long time interval for lower frequencies. Due to this property, high frequency components of short duration can be observed successfully by Wavelet Transform. One of the advantages of the Wavelet Transform is that it is able to decompose signals at various resolutions, which allows accurate feature extraction from non-stationary signals like ECG. A family of analyzing wavelets in the time frequency domain is obtained by applying a scaling factor and a translation factor to the basic mother wavelet.

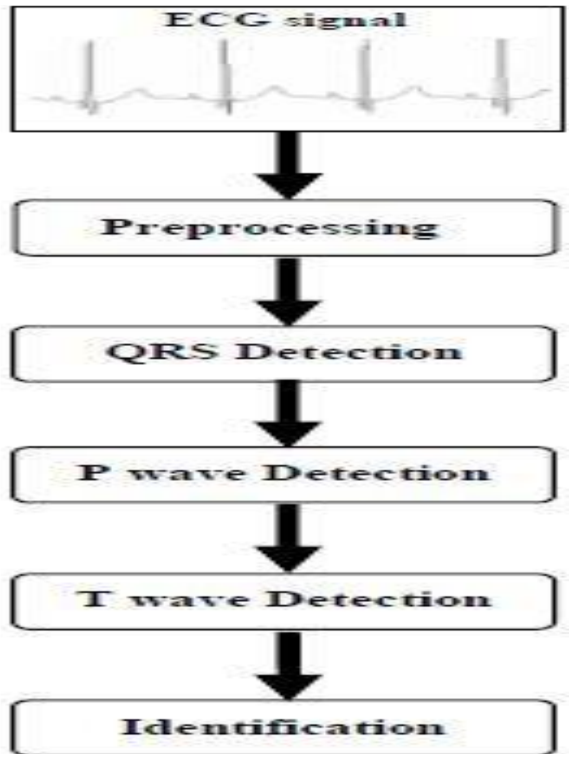
In the DWT analyses, the signal at different frequency bands and at different resolutions is decomposed into a 'coarse approximation' and 'detailed information'. Two sets of functions are employed by the DWT, the scaling functions (associated with the low pass filter) and the wavelet functions (associated with the high pass filter). The signal is filtered by passing it through successive high pass and low pass filters to obtain versions of the signal in different frequency bands. The fundamental idea behind wavelets is to analyze according to scale. Wavelets are functions that satisfy certain mathematical requirements and are used in representing data or other functions. Wavelet algorithms process data at different scales or resolutions. If we look at a signal with a large window, we would notice gross features. Similarly, if we look at a signal with a small window, we would notice small features. The result in wavelet analysis is to see both the forest and the trees, We decompose the ECG signal into 5 levels by using DWT and reconstruct the approximation (A5) and detail (D5) signals at level 5 as shown below. Then the summation of A5 and D5 will be the low frequency signal in ECG that causes the baseline shifting. This low frequency signal is deducted from the original ECG signal to get the one without baseline shifting and thus the problem of baseline shifting is solved.



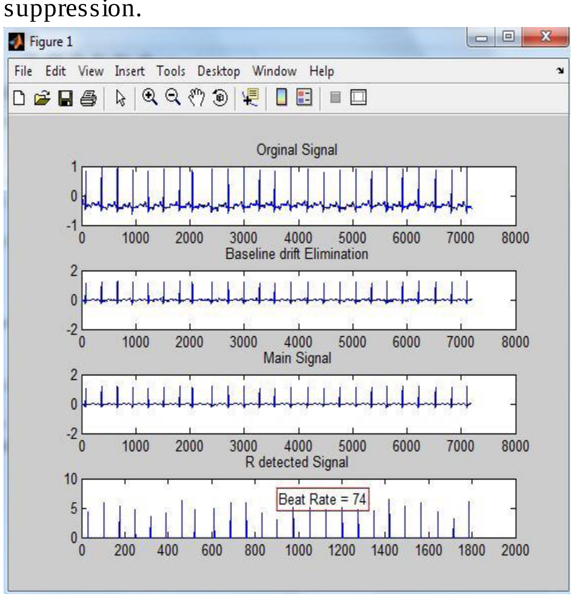
Five Level Wavelet Decomposition Tree

METHODOLOGY

In order to extract useful information from the ECG signal, the raw ECG signal should be processed. ECG signal processing can be roughly divided into two stages by functionality: Preprocessing and Feature Extraction as shown



ECG signal mainly contains noises of different types, namely frequency interference, baseline drift, electrode contact noise, polarization noise, muscle noise, the internal amplifier noise and motor artifacts. Artifacts are the noise induced to ECG signals that result from movements of electrodes. One of the common problems in ECG signal processing is baseline wander removal and noise suppression.



a)Original Signal b).Baseline Drift limination c).Main Signal d). R Detected Signal

CONCLUSION

An algorithm for R Peak and QRS complex detection using Wavelet Transform technique has been developed. The information about the R Peak and QRS complex obtained is very useful for ECG Classification, Analysis, Diagnosis, Authentication and Identification performance. The QRS complex is also used for beat detection and the determination of heart rate through R-R interval estimation. This information can also serve as an input to a system that allows automatic cardiac diagnosis. The overall sensitivity of the detector improves. The main advantage of this kind of detection is less time consuming for long time ECG signal

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