CERTAIN EXPLORATIONS OF ECG PRE-PROCESSING AND R-PEAK DETECTION TECHNIQUE USING WAVELET ANALYSIS

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Abstract

Cardio Vascular Disease (CVD) is one of the leading causes of death among Human beings. Automatic assessment of such Cardiac Vascular Diseases for patients has been a long time research. The main causes of Cardiac Vascular Diseases are due to the variations in heart rate or abnormal heart beats which are characterized by the Electrocardiogram (ECG) beats or patterns. Accurate detection of ECG beats are the key requirement for detecting CVD. Generally ECG recordings are often corrupted by artifacts. Removal of high frequency noises like electromyogram, power line interferences, or electrodes with mechanical forces and Baseline Wander (BW) that may be due to respiration or the movement of the electrodes can be done using linear and non-linear filters. In the proposed work initial task done by using Translation Invariant(TI)filter to remove the Wavelet noise and the second task is the R-peak detection using Discrete Wavelet Transform. The results obtained that enhances ECG signals by the removal of such noise and detect R-peak of ECG signals which reduces time and increases the accuracy level of ECG.

Keywords*:Electrocardiogram(ECG),DiscreteWavelet Transform(DCT),ECGDenoising,TranslationInvariant (TI),Cardio Vascular Diseases(CVD).*

1. Introduction

Electrocardiogram (ECG) is the simplest non-invasive diagnostic tool for determining various heart diseases. The analysis of Electrocardiogram (ECG) is not moderate work when noises interfere the ECG and encapsulates important information.ECG mainly focused on P, QRS and T-waves. These waves reflect the rhythmical electric repolarization and depolarization of the myocardium accompanied with the contractions of the ventricles and auricles. The interest of the work is to remove Baseline wander and power line interference which are known as common types of noises found in the ECG signals. Normally ECG signals are associated with artifacts. Artifact is a type of noise that arises mainly due to movement and electrical Interferences.Artifacts are of two types which are as follows:

- Physiologic
- Extraphysiologic

Physiologic artifacts that arises from other parts of body except brain, whereas Extraphysiologic that arises from Equipments and Environment. When the blood flows to a part of the heart , which is blocked by a blood clot is called as an Heart attack. Heart beat rate is a key factor for the risk of heart attack shown by CVD. The Electrocardiogram (ECG) is a vital sign signal for heart functional investigation. This electric signal is generated from human heart to create the cardiac cycle, which generates the blood circulation. It is composed with three basic components named P wave, QRS complex and T wave [4]. The patients whose heart rate above 70 beats per minute have significantly higher rate of heart attacks. Accurate extraction of clinical parameters from noisy biomedical signals is a critical and on-going challenge [7].

Symptoms of heart attack includes:

- shortness of breath
- lightheadedness
- pressure in the upper back
- extreme fatigue

A typical ECG signal is as follows:

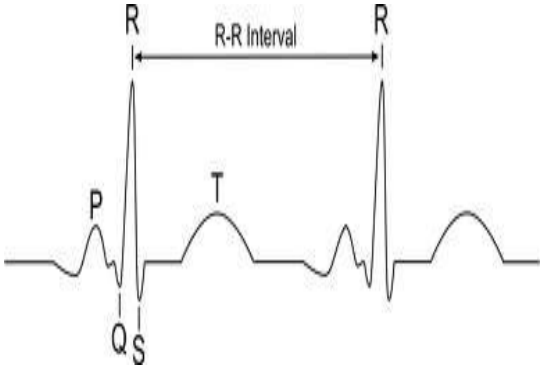

Figure 1. Typical ECG Signal

1.1 Concept Behind ECG

The main function of heart is to Contract Rhythmically and pumps blood to the lungs for oxygenation and pump this oxygenated blood into general circulation.

This rhythm is continuously maintained and signaled by spread of electrical signals generated by "Pacemaker"(or)"Sinoatrial node" . Under Pathological conditions several changes may occur in the ECG. They are as follows:

- Altered paths of excitation in the heart.
- Changed origin of waves
- Altered relationships (sequences) of features.

1.2 Types of noises associated with ECG

- ❖ Baseline Wander
- ❖ Powerline Interference
- ❖ Electrode pop
- ❖ Myocardial Noise
- ❖ Motion Artifacts

Normally unwanted random disturbances are said to be noise. Such noises associated with ECG degrades the performance of ECG signals to be obtained. The Baseline Wander noise is the repeatation of improper pattern on the screen due to electrode malfunction. Powerline interference caused by the main powerlines. Motion Artifacts are mainly due to the motion of electrodes.

1.3 Generation of ECG Waves

- **P-wave:**

P-wave generated during atrium depolarization.

- **QRS complex:**

QRS generated during Ventricular depolarization.

- **T-wave:**

T-wave generated when the ventricle recovery occurs.

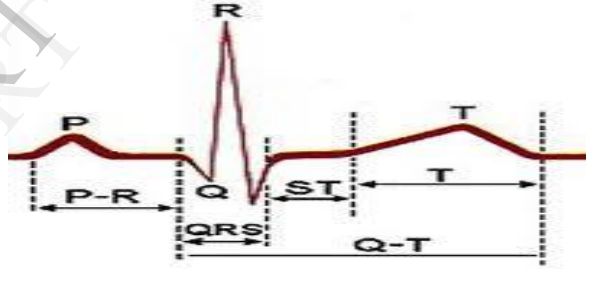

Fig 2. Specifications of ECG Components

Table 1. Amplitude and Duration of ECG Waves

S:No	Waves	Amplitude (mV)	Intervals	Duration (Sec)
1.	P-wave	0.25 mv	P-R	0.12 to 0.20 sec
2.	R-wave	1.60 mv	Q-T	0.35 to 0.44 sec
3.	Q-wave	25% of R-wave	S-T	0.05 to 0.15 sec
4.	T-wave	0.1 to 0.5 mv	QRS	0.09 sec

1.4 ECG Used For

- Screening test for cardiomyopathies, left ventricular hypertrophy and coronary artery disease.
- Preoperatively to rule out coronary artery disease.
- Can provide information about the presence of metabolic alterations .
- Discovery of heart disease, coronal insufficiency ,infarction as well as cognitial heart disease.
- Evaluation of ryhthmical malfunctions.
- Basic cardiological test and it is widely applied in patients with known heart disease.

2. Materials and Methods

A) Previous work

Noise Reduction in ECG signals normally carried out by using linear and non-linear filters. However these filter approaches are not suitable for the applications that requires Diagnostic ECG analysis. Nonlinear filtering is a common approach to detect QRS complexes in considerably less time and can be easily implemented. Generally, QRS complexes are detected using various algorithms like Derivative approach, Filter-bank approach ,Wavelet and Mathematical morphology and correlation.

B) Existing Approaches

In Derivative approach ECG signal Signal is first smoothed with an appropriate moving average filter for suppressing any high frequency noise outside the range of 5.25 Hz band.The smoothed signal is differentiated to forced upon the high slopes that occurs in ECG and to suppress and smooth ECG waves and Baseline Wanders. Next in Filter Bank approach of QRS detection, subbands at different scales are combined to confirm the positions of local maxima.It mainly depends upon integers,having sampling rate.

In wavelet Approach, it uses mainly the principle of Singularity detection in the wavelet coefficients. Wavelet coefficients of ECG Signals are used for, to find the local maxima and positions of matching in two consecutive scales to locate QRS positions. This is based upon the hypothesis that the energy of QRS complex is uninterrupted in time spread over the spectral bands.The noisy signal may not have this property and hence false rates can be less using Multiscale approach.

Finally, Morphological operations mainly uses Peak Valley Extraction.This is especially used for mapping the smooth parts of signals to corresponding zero amplitude flat segments to extract peaks and valleys in the signals. Curve Length Transform is used for the detection of QRS Complex.

3. Proposed Methodology

From the analysis of review pre-processing (i.e) removal of noises can be performed using various techniques in ECG. In the proposed work de-noising can be done by using **Translation Invariant** (TI) filter. The main advantage of using this filter is that it remains the geometrical characteristics of ECG signals and also suppresses the averaging noises in ECG. The number of wavelet coefficients are selected according to the estimated noise level in ECG in order to avoid data spending for noise. In addition this TI wavelet keeps the amplitudes of ECG waveforms efficiently. Using such wavelet analysis will provide the absolute value of signals.

3.1 TI Noise Suppression

TI denoising suppresses noise by average calculation over thresholded signals of all circular shifts that can be performed. We carry out TI multiwavelet denoising algorithm in the following steps:

1) Tainted ECG signal can be shifted within range of cycle spinning to get a new shifted ECG signal.

2) Convert the new shifted ECG signal by DWT and apply necessary thresholding and for reconstruction perform Inverse DWT.

3) For associated denoised ECG signal Inverse shifting can be done and whose phase is the same as that of noisy ECG signal.

4) Continue the procedure from 1 to 3 for the next shifts constantly to obtain the series.

5) Estimate the average for all the obtained denoised ECG signals to get the denoised ECG signal finally.

The flow diagram shows the de-noising of ECG signal using Translation Invariant is as follows.

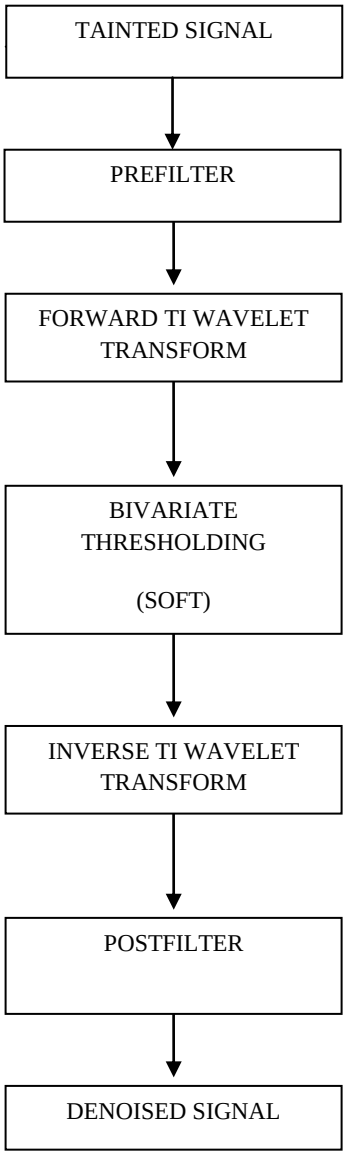

Fig 3. Denoising using TI filter

4. R-Peak Detection

ECG signal can be expressed as repetitions of P-QRS-T waves. Fundamental principle of analysis of ECG signal is the identification of QRS complex.To detect R-waves, the specific detail components of decomposed signals are kept and the other components of low frequency and high frequency are removed. Discrete Wavelet Transform can be effectively used for detecting R-peak after perprocessing has been completed.

4.1 Discrete Wavelet Transform

Wavelet techniques are used for feature minings where the features are mined by decomposition of signals and hence the multiresolution method of analysis of signals gives their respective details. Normally there are two kinds of Wavelet transform (i) Discrete wavelet transform and (ii) Continuous wavelet transform.

Discrete Wavelet Transform (DWT), which is based on sub-band coding which will provide the faster computation of Wavelet Transform. It is easy to implement and reduces the computational time and resources required. Different narrow-band filters are used normal filtering techniques so the frequency content can be extracted from the signal. The signal is then analyzed at different frequencies with different types of resolutions as a feature of using this Wavelet Transform.Such analysing of different frequency in different environment called as multiresolution analysis.Using Multiresolution wavelet analysis, the localization of time of spectral components can be attained and this method provides time-frequency representation of the signals.

Compared to Fourier Transform the DWT is localized in both time and frequency domain and perhaps it is the most efficient transform due to its many favourable properties, and its having the ability to solve various problems including biomedical signal analysis,data compression,noise removal and feature extraction etc…

5. Simulated Results

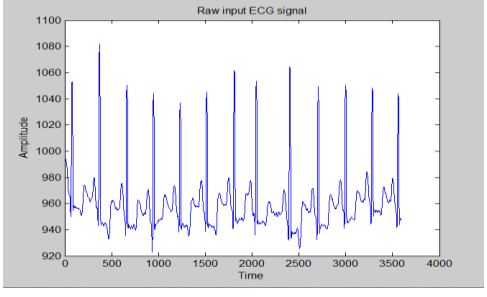

Fig 5.1 Raw Input ECG Signal

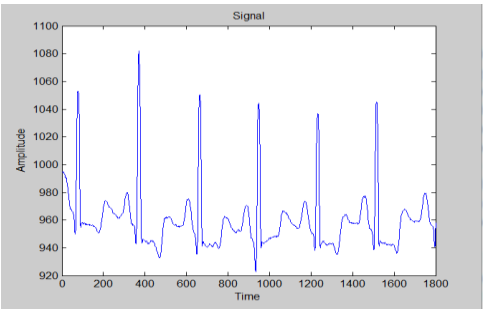

Fig 5.2 Denoised ECG Signal

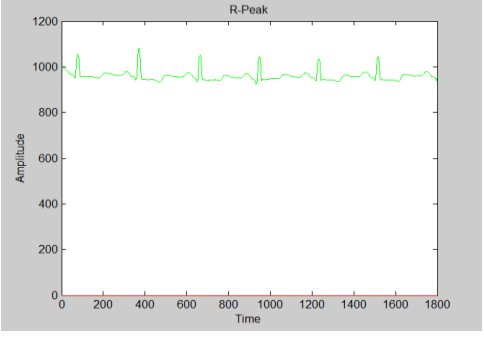

Fig 5.3 R-peak Detection

The simulated results shown the removal of noise from ECG by filtering. Such results obtained that enhances the quality of ECG signal in an efficient manner. The noisy signal enters into prefilter and forward TI wavelet transform, then soft threshold can be applied and then Inverse wavelet transform can be applied and finally post filtering takes place to obtain the denoised ECG signal. After denoising, the original signal can be obtained as noiseless and from that signal particularly R-Peak can be detect using DCT which reduces time and increases the accuracy level of ECG signal which are helpful in diagnosis of cardiac applications.

6. Conclusion and Future Scope

We have proposed the task of pre-processing using TI filter for the removal of Wavelet noise efficiently and enhances the quality of ECG signals. TI filter is a non-linear filter that reduces the complexities and redundancies in the raw input ECG signal (i.e) the tainted ECG signal gets filtered and the De-noised signal can be obtained which are useful for health care centers to identify ECG applications.Then detection of R-peak can be done effectively using Discrete Wavelet Transform from Denoised Signal with less computational time. Hence our future work mainly focuses on finding various abnormalities and classification of abnormalities using effective classifiers of ECG with less rate of Probability of Fault tolerance.

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