ELECTROCARDIOGRAM SIGNAL DATA PROCESSING

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ABSTRACT

An electrocardiogram shows electrical activity of the heart. Doctors are used it to find out any abnormalities in the working of the heart. Manual inspection of ECG is very difficult as the signals of ECG are transient in nature. It is difficult to observe them within short span of time. Now a days most of the manual activities are computerized. So now a days computerized methods are used. These methods are able to tell the type of abnormality. These methods use the data produces by ECG. So the results of computerized inspection are totally dependent on the data produced by ECG. If the produced data is accurate then the result will be accurate. The data produced by ECG suffers from two drawbacks – first is baseline wander and second is noise. Both should be removed for perfect analysis of ECG. In this paper, a framework is produced for getting perfect ECG data. Baseline wander is removed by applying savitzky golay filter and noise is removed by using db6 wavelet upto level 5 decomposition. Then only approximation co-efficients are used for classification of ECG signals. It is found that the accuracy of classification of ECG signals reached to 100%.

Keywords - Electrocardiogram, discrete wavelet transform, baseline wander, filter.

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I. INTRODUCTION

Biomedical signals which can be used to find out any abnormality in the working of a particular part of body e.g. heart, brain. Special devices are used to capture these signals. An ECG signal is a biomedical signal generated due to electrical activity of the heart. A special arrangement is made for it. Special electrodes are attached to human body for producing ECG. Useful information can be extracted from ECG. ECG (electrocardiograph) is a device which is used to record heart's electrical activity by placing electrodes on surface of the body. It is a diagnostic machine to detect any defect in working of heart. The recording given by this device is called electrocardiogram. An ECG signal is divided into three waves-P wave, QRS complex and T wave. P wave is caused by contraction/ activation of atria, QRS complex is created due to contraction/activation/depolarization of ventricles and T wave is caused due to ventricular muscels relaxation or repolarization of ventricles. U-wave is not always seen. If it is present, it shows that something is wrong in working of heart. The electrical activity of the heart originates in the sino-atrial node. It spreads through right atrium to atrio-ventricular node. It also spreads through atrial muscle directly from right atrium to left atrium. P-wave shows right and left atrial depolarization.

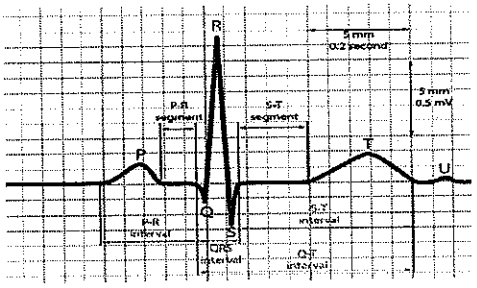

Figure 1 : Different waves and intervals in ECG signal

II. Related Work

Signal data processing deals with filtering of signal to get accurate information from the signals. In the literature several methods are tried to make ECG signal as pure. A detailed review is given below:-

i) Heart rate, Frequency detection

The author J. Parak, et al. in [1] addressed the challenge of noise in digitalized signals. According to them there is an interference with other noisy signals like power supply, breathing muscle artifacts. The removal of noise should be performed before extracting some information like heart rate frequency from the signal. The algorithms written for heart rate frequency detection are complicated in terms of implementation. Artificial neural network, genetic algorithm, wavelet transforms are used till date for detecting QRS complex. They does not consider physical stress test. The proposed algorithm used statistical signal processing methods –autocorrelation. Then heart rate is detected by using difference between R-waves. They have less computing time and effective for processing the ECG signal.

ii) Emprical Decomposition base ECG Denoising

The author Binwei Weng et al. in [2] proposed a noise removal method for ECG. According to them ECG recordings are corrupted by power line interference, mechanical force of electrodes. It needs to be removed for better evaluation. They suggested Empirical Mode Decomposition method for noise removal. It is able to remove high frequency noise with minimum signal distortion. Wavelet based methods are used till now for noise removal. But it is suitable for Gaussian type noise removal. EMD algorithm is proposed by Huang. EMD decompose a signal into finite number of intrinsic mode functions (IMF). An IMF is defined as a function with equal no. of extrema and zero crossing with its envelopes. These are small components. It represent simple oscillatory mode. EMD identify all local maxima and minima for a signal x(t). Local maxima are connected by cubic spline curve as the upper envelop $e_u(t)$. Local minima are also connected by cubic spline curve and they form lower envelop $e_l(t)$. The mean of two envelopes is subtracted from the signal and first prototype IMF is obtained. This process continues until sum of difference is less than some threshold. New maxima and minima are obtained along with new envelops for maxima and minima. Again mean is find out and subtracted from the signal. The process continues and is known as sifting process. Selection of sifting stopping criteria is important and can affect the result. The QRS complex is preserved using window function. The authors are sure that this method is effective for ECG diagnose during stress testing and holter monitoring.

iii) Study of Noise Removal

The author Bhumika Chandrakar, et al. in [3] has addressed the issue of change in original ECG signal due to various artifacts. A study of different types of FIR(Finite Impulse Response) and IIR(Infinite Impulse Response) filters for removal of noise is presented. It is concluded that Kaiser window based FIR filter gives better response as the modification in the original wave is very less.

iv) Baseline Wander Removal

The author Rahul Dev, et al. in [4] has addressed the challenge of masking of ECG important features due to baseline wandering. It should be removed for proper analysis. A review of different techniques is presented in the paper. According to the review the efficient methods for baseline wander removal are median filter, wavelet adaptive filtering.

v) Statistical Feature Extraction of ECG Signal

The author Ashutosh Kar, et al. in [5] has addressed the challenge of accuracy given by various techniques and algorithm used for feature extraction of ECG. He presented a review of some ECG feature extraction methods. These methods are R wave detection using wavelets daubechies and symmetric, an algorithm based on wavelet transform, multi-resolution wavelet transform. Mostly wavelet transform method is used for feature extraction.

vi) Feature Extraction of ECG Signal

The author S.Karpagachelvi, et al. in [6] has also addressed the challenge of accuracy given by feature extraction methods. He presented a comparative review of the various techniques used for feature extraction.

vii) Removal of Baseline Wander

The author Manpreet Kaur, et al. in [7] has addressed the challenge of baseline wander in ECG due to which original values of an ECG signal may lost. She presented a comparative review of various filters like high pass filter, IIR filter, FIR filter, zero phase filtering, moving average approach, savitzky-golay filter for baseline wander removal. It is concluded that IIR zero phase filtering is an efficient method.

III. Proposed Method for removing baseline wander and noise :-

The proposed method consists of two steps. The first step removes baseline wander and second step noise removal from the signal. Baseline wander and noise is caused by no. of artifacts – powerline interference, electrode contact noise, baseline drift, respiration and body movement. After removal of these artifacts the statistical features mean, median, mode and standard deviation of approximation signals are extracted to perform classification.

3.1 Baseline Wander Removal-

ECG signals have baseline wander defect caused by respiration and motion with frequency between 0.15 Hz and 0.3 Hz. In this work, savitzky golay smoothing filter is applied to remove this drift. It performs much better than standard averaging filters. It is also capable of preserving high frequency components, where original signal is not distorted. It preserves the peaks and valleys of the ECG signal[8]. It is very much useful for noisy signals. The reason behind choosing this method is that the smoothing effect of savitzky golay filter is not harsh

as it is with other filters like moving average. So the original information is not lost. In other types of filters like moving average, there is loss of original information. After removal of baseline wander, the signal becomes stationary. But still some other types of noises are present in the signal so denoising should be performed to get accurate information from the signal.

3.2 Denoising-

Denoising is performed using discrete wavelet transform. It is simple technique and provides more valuable information. It decomposes the signal into detail signal and approximation signal. There are many types of discrete wavelet transform e.g. db1, db2, ..., db10. But here db6 (Daubechies wavelet 6) is used and decomposition is performed till level 5. The signal is divided into approximation and detail coefficients from level 1 to level 5. Five levels are considered because frequency content of QRS complex is mainly concentrated in these levels[9].

The Signals are collected from MIT-BIH online physionet database[10]. Detail is provided in Table-1.

Table 1-Details of beats collected

Beat Type	MIT-BIH data file	No. of Beats	Duration of beat
PVC	208	21600	1 hr.
NPC	234	21600	1 hr.
FPN	217	21600	1 hr.
NB	100	21600	1 hr.
RBBB	118	21600	1 hr.

The above data is preprocessed using above discussed method. First of all Savitzky Golay Filter is applied to remove baseline wander. The obtained result is used for applying db6 wavelet and decomposed upto level 5. Then the statistical features of approximation signals are used as input to classifier multilayer perceptron to do the classification of the signal. The obtained accuracy of classification was 100% for the mentioned five types of beats.

IV. Conclusion and Future Work

The combination of savitzky golay filter and db6 wavelet decomposition upto level five helps to improve the classification accuracy of the ECG signals upto 100%. The same combination can be applied to other types of beats to make a universal system of classification.

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Author's Biography

Sonia Bagga, is a lecturer of Computer Science at Calorx Teachers' University and providing training to graduate students. She has worked with NIIT Ltd. as NIIT Certified training specialist and guided students for their projects. She has over ten years of experience and written articles and research papers. Her areas of interests are Data Mining, Database Management System, Programming, Web Designing, Animation, Multimedia, Graphics, and Networking.