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ANALYSIS OF ECG SIGNALS FOR THE DETECTION OF PREMATURE VENTRICULAR CONTRACTION

Shadiya.A.M[*1] & Ameetha Junaina.T.K[2]
[*1]M.tech student,Digital Signal Processing, KMCT college of Engineering, Calicut,India
[2]Asst.Professor,ECE Department, KMCT college of Engineering, Calicut,India

ABSTRACT

This paper proposes a novel method for detection of Premature Ventricular Contraction (PVC) by analyzing Electrocardiogram (ECG). The analysis is done with the help of Discrete Wavelet Transform. Three features are used for classifying the ECG signal. RR ratio, QRS area, sum of trough are the features used. An SVM (Support Vector Machine) classifier is used to classify the beats as normal and PVC. The MIT-BIH arrhythmia database is used for evaluating the proposed method.

Keywords: *Premature Ventricular Contraction,ECG,SVM,QRS area,RR ratio,sum of trough.*

I. INTRODUCTION

Electrocardiogram is a diagnostic tool that plots the electric activities of human heart. The electrical activities are recorded with the help of placing electrodes on the skin. To a trained physician the ECG gives large amount of information about the functioning of heart. For a normal heart, without any diseases the rhythm is called normal sinus rhythm. Any deviation or change from this normal sinus rhythm is termed as arrhythmia.

An ECG signal of human heart has the following entities. A P wave, QRS complex, and T wave. (Fig.1). If we can extract the information about intervals, amplitudes, and waveform morphologies of the different P-QRS-T waves, the onset of the arrhythmia can be detected.[1]

The normal heart rate of a human being varies from 60 to 100. For a person having arrhythmia this rate varies. If the heart rate is less than 60 beats per minute, such a condition is termed as bradycardia. When the heart rate is more than 100 beats per minute, the rhythm is known as tachycardia.

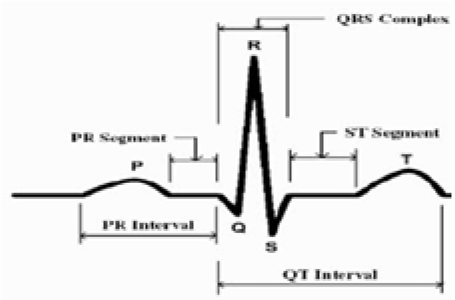

Fig.1 . ECG waveform

The different types of arrhythmia related to human heart are Atrial arrhythmia, Junctional arrhythmia, Ventricular arrhythmia, Atrioventricular block, and bundle branch block. In this paper mainly the ventricular arrhythmia is discussed. Ventricular arrhythmias normally originate from the bottom chambers of the heart called the ventricles. Ventricular arrhythmias can be divided in to Premature Ventricular Contraction (PVC), Ventricular Tachycardia, and Ventricular Fibrillation. This paper mainly concentrates on the method to detect PVC. PVC results from the early depolarization of the myocardium originating in the ventricular area and is a widespread form of arrhythmia in adults [2]. The main characteristics of PVC are: wide QRS complex, a missed P- wave and a T- wave which is longer than the normal one. An SVM classifier is employed for classifying the beats in to normal and PVC.

A lot of studies are already done on arrhythmia detection. A QRS image based geometrical features are used for detection of arrhythmia. [3] An SVM –KNN hybrid classifier is used for classification. In another work ECG beats are classified using S-transform and Genetic algorithm [4]. An MLP neural network is also used for classifying ECG beats for arrhythmia detection [5].

II. MATERIALS AND METHODS

A. ECG Data Base

The MIT-BIH arrhythmia data base is used for validation in this study. [6] The MIT-BIH Arrhythmia Database contains 48 half-hour extracts of two-channel ambulatory ECG recordings, obtained from 47 subjects studied by the BIH Arrhythmia Laboratory between 1975 and 1979. The recordings were digitized at 360 samples per second per channel with 11-bit resolution over a 10 mV range. The QRS complex of each beat is detected as a first step. After detecting the QRS complex it is easy to detect the P wave and T wave. The database contains approximately 109,000 beat labels. In MIT-BIH Database ECG signals are described by- a text header file (.hea), a binary file (.dat), a binary annotation file (.atr) and (.mat) a mat lab file. Header file describe the detailed information about the ECG like number of samples, sampling frequency, format of ECG signal, type of ECG leads and number of ECG leads, patients history and the detailed clinical information.

B. Discrete Wavelet Transform

Discrete wavelet transform is used to help in feature extraction stage. Discrete wavelet transform is a transform technique which can be used to analyse the nonstationary signals. It gives good localisation in both time and frequency. The discrete wavelet transform (DWT) is an implementation of the wavelet transform which uses a discrete set of the wavelet scales and translations which follows some defined rules. In multi resolution analysis the original signal is allowed to pass through a high pass and a low pass filter. Approximation and detail coefficients are obtained from this (Fig.2). The details are the low-scale, high-frequency components of the signal. Approximations are the high-scale, low frequency components of the signal. The different band of frequency can be analysed using DWT. The selection of mother wavelet in wavelet transforms is very important task. The selection of mother wavelet depends upon the type of signal which has to be analysed. The analysed signal which is similar to the wavelet function is usually selected. Different wavelet functions are haar, daubechies, biorthogonal, coiflets, symlets, morlet, Mexican hat etc. Real and complex wavelets such as daubechies 4 and symlets 6 can be used for de-noising because these wavelets show similarity with QRS complexes. Also their energy spectrum is concentrated around low frequencies.

C. SVM Classifier

SVM is one of the most popular classifier used for ECG-based arrhythmia detection methods [7]. Support vector machines (SVM) are supervised learning models with associated learning algorithms that analyse data used for classification and regression analysis. Given a set of training examples, each marked as belonging to one or the other of two categories, an SVM training algorithm builds a model that assigns new examples to one category or the other, making it a non-probabilistic binary linear classifier. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall. In addition to performing linear classification, SVMs can efficiently perform a non-linear classification using what is called the kernel trick, implicitly mapping their inputs into high-dimensional feature spaces.

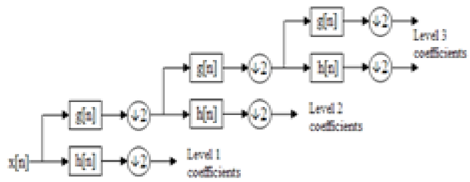

Fig.2.Wavelet Decomposition

III. PROPOSED METHOD

This method makes uses DWT as a feature extraction technique. Normally ECG signal will contain noises and artifacts. So it is necessary to preprocess the signal for removing these noises and artifacts. Preprocessing is a compulsory task in analysing any signal. The main artifacts in ECG signals are power line interference and base line wandering. The signal is detrended to remove baseline wander and the high frequency component can be removed by Savitzky-Golay least-squares polynomial filters

The wavelet decomposition process down samples the signal by transforming the samples to a much lower frequency than the original signal. By applying wavelet transform the details of the signal will be reduced and QRS complex will be preserved. With reduced number of details detection of R peaks will be easier. The mother wavelet used for decomposition is db4 wavelet. It has a shape similar to the ECG QRS complex. A threshold is set which is equal to half of the highest QRS complex in the down sampled signal. R-peak detection process is performed on the down sampled signal which requires locating any extracted R signal in the original ECG signal. After detecting R peaks, the detection of P, T, Q and S waves can be done with respect to the R peaks. The morphological features detection is centered on the R-Peak extraction. So the correct detection of R peak is necessary.

After the morphological features like P, QRS, and T are found out the next step is feature extraction. Here the RR interval, Sum of trough and QRS area are the features used. QRS complex of a beat having PVC will be wider than a normal beat. So the QRS area of a beat with PVC will be different from a normal ECG signal .The RR ratio is calculated as the ratio of post RR interval to previous RR interval for each beat.

The sum of trough is calculated using the formula

$$sum\_trough = \sum_{n=35}^{85} y(Rloc(i) + n) \qquad (1)$$

Where Rloc(i) is the location of R-peak, n is the number of samples from the R peak of PVC, y is the amplitude of the original signal.

After extracting the features next step is classification. The classifier that is used here is SVM classifier. SVM is popular in machine learning for pattern recognition, especially for binary classification. The classification performance of the classifiers can be measured by calculating the accuracy, sensitivity, and specificity.

$$\text{Accuracy} = \frac{TP + TN}{TP + FP + FN + TN} \qquad (2)$$

$$\text{Specifity} = \frac{TN}{FP + TN} \qquad (3)$$

$$\text{Sensitivity} = \frac{TP}{TP + FN} \qquad (4)$$

IV. RESULTS

The proposed method is tested on MIT-BIH arrhythmia data base. The noises and artefacts of raw ECG signals are first removed for further processing. The signal is detrended to remove baseline wander and the high frequency component are removed by Savitzky-Golay least-squares polynomial filters .The signal before preprocessing and after preprocessing are given in Fig.3 and Fig.4.

After removing the artifacts the features are extracted. Once the features are extracted then SVM classifier is used to classify the beats in to normal and PVC. 10 normal beats and10 PVC beats are used to train the classifier.

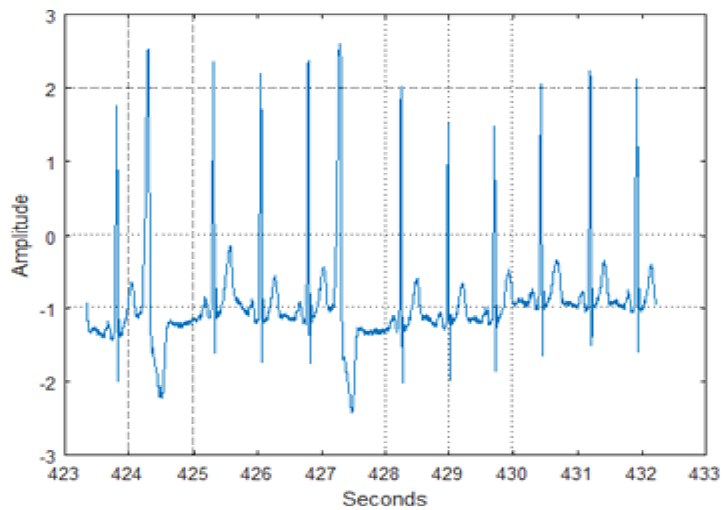

Fig.3 .An ECG signal with PVC

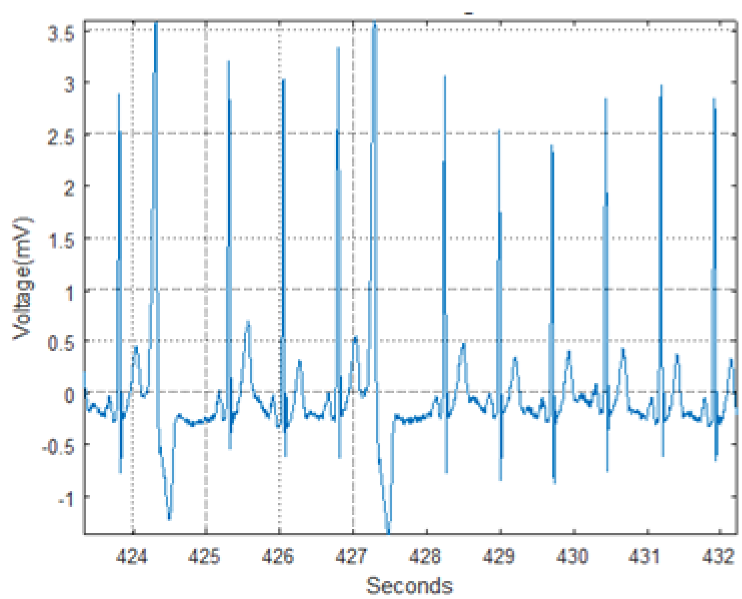

Fig.4. The signal after preprocessing

The feature RR ratio and sum of trough for the signal record 116 for 10second duration is shown in Fig.5 and Fig.6. it can be seen that at the occurrence of PVC there is a significant variation in the RR ratio and sum of trough

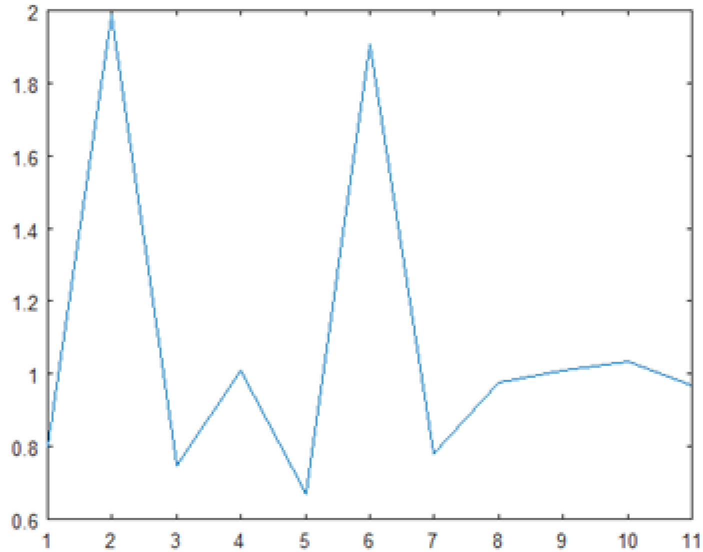

Fig.5.RR ratio

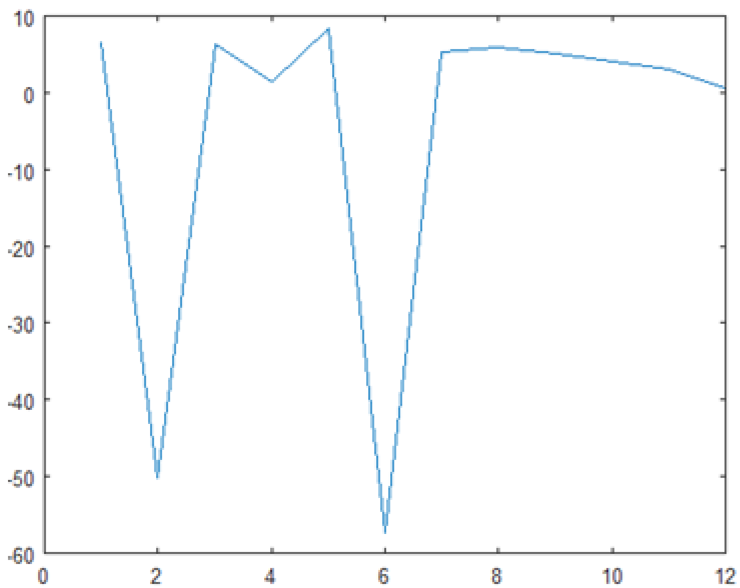

Fig.6.Sum of trough

V. CONCLUSION

In this paper a method for detection of Premature Ventricular Contraction is discussed. A 20 second ECG signal from MIT-BIH arrhythmia database is used for evaluating the algorithm. The algorithm can be used to detect arrhythmia in more number of ECG records. The proposed method can be further extended to detect the other ventricular arrhythmias like Ventricular Fibrillation and Ventricular Tachycardia

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