Arrhythmia Discrimination Using Support Vector Machine

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Abstract–**In this paper support vector machine (SVM) classifier is developed for the classification of two types of arrhythmias i.e. premature ventricular contraction (PVC) and atrial premature contraction (APC). Discrete wavelet transform (DWT) is used for feature extraction of the ECG signal. For the classification purpose MIT-BIH arrhythmia database is used from the physionet.org. The aim of the work is to develop a technique which classifies the arrhythmia with higher accuracy. MATLAB 7.8.0(R2009a) is used for the simulation purpose.**

Index Terms– Arrhythmia; ECG; Wavelet Transform; features; SVM.

I. INTRODUCTION

Heart is a vital organ of the human body. Its function is to deliver oxygen to all cells of the human body. Any irregularity of the heart function is called arrhythmia. There are various types of irregularities are present in the heart function but here only premature contraction of atria and ventricles are considered. Electrocardiogram (ECG) is a diagnostic tool to detect various types of heart abnormalities. Single cycle of ECG signal contains P, QRS and T waves as shown in figure 1. Physicians for the manual analysis used duration and amplitude of these waves of the.ECG signal. But manual analysis are time consuming and inaccurate. Hence it is necessary to develop automatic arrhythmias detection technique. Number of technique has developed for the classification purpose. An arrhythmia classification technique based wavelet transform has been reported in [6], which consists of Median Absolute Deviation and Shannon Entropy features.

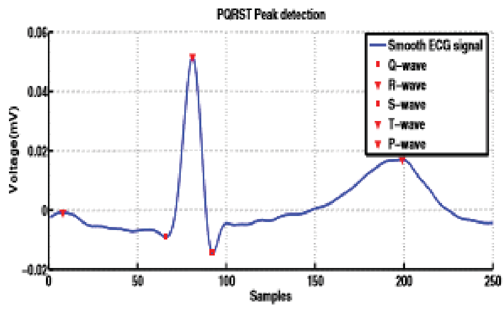

Figure1. ECG signal waveform

The Median Absolute Deviation presented the PVC arrhythmia classification efficiency 62% and Shannon entropy presented 61% efficiency, which is much lower than the technique used in [4]. Another classification technique developed in [13] based on wavelet transform and Back Propagation Neural Network presents the 97.8% accuracy. In the present work, discrete wavelet transform (DWT) is used with SVM classifier.

II. METHODOLOGY

The overview of the methodology is shown in figure2. The complete methodology consists of foursteps: ECG signal collection, preprocessing to denoise the ECG signal, feature extraction and arrhythmia classification. In the present work DWT is used for the feature extraction and SVM classifier is used for the classification purpose.

A. Dataset

For the classification of arrhythmias, the ECG records are taken from the MIT-BIH (Massachusetts

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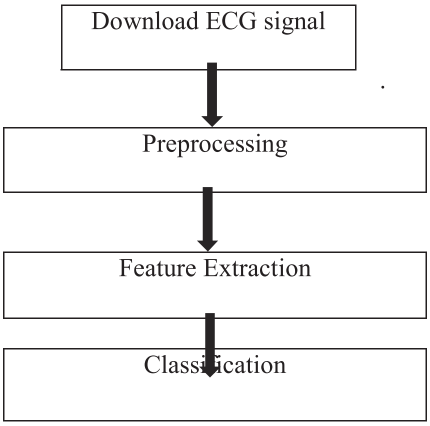
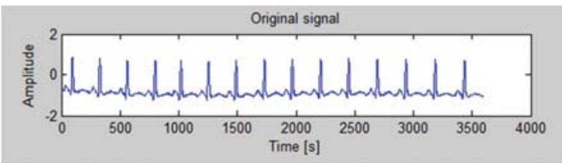


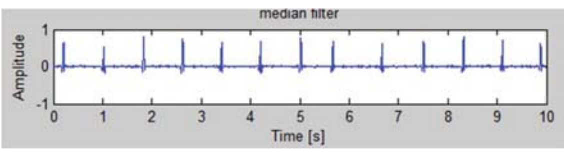
Figure2: Block diagram for the method of arrhythmia prediction.

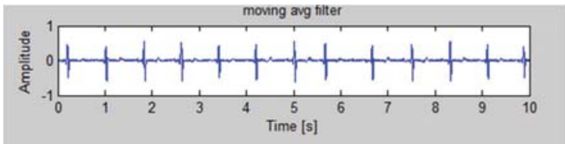
Institute of technology and Beth Israel Hospital) arrhythmia database.The database contains 46 ECG records, each record has been selected the 30 minute duration ECG signal. Each record has two channel i.e. MLII and VI (modified limb lead II and modified lead VI). The proposed work focus on the MLII lead signals and all records are used for the classification purpose.

B. Pre-processing

The ECG signal collected from the MIT-BIH database is corrupted by different types of noises like baseline drift, power line interference and muscle contraction etc. In this paper three different denoising techniques i.e. median filter, moving average filter and notch filter are compared and find out that moving average filter gives the better output. Moving average filter gives the best result, so in this paper moving average filter is used to denoise the ECG signal.







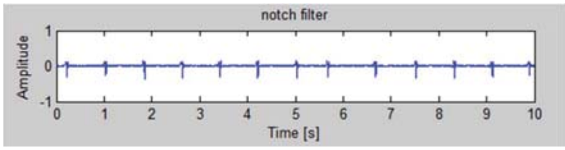


Figure3: Output of three noise removal techniques

C. Feature Extraction

In the literatures authors use different techniques i.e. FFT, CWT and DWT etc. for the extraction of different features from the denoised ECG signal. In this paper discrete wavelet transform technique used for the feature extraction.

Discrete Wavelet Transform (DWT):

The DWT is easy to implement and provide fast computation. Expression for DWT calculation is given below:

$$C_{m,n}=\frac{1}{\sqrt{a}}\int_{-\infty}^{\infty} s(t)\Psi_{mn}(t)\mathrm{d}t \qquad (1)$$

Here Ψ_{mn}(t) is defines the dyadic scale and translation parameters [3].

Low pass and high pass filters are used for the decomposition of the signal. Three level decomposition tree is shown in figure3.

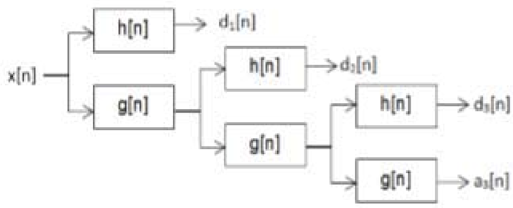


Figure4: Three level wavelet decomposition tree [3]

In the figure4h(n) represents the high pass filter and g(n) represents the low pass filter. The output of the high pass filter gives the detail coefficient denoted by

d_i(n) of the wavelet and low pass filter output gives approximation coefficient (a_i(n)).

Four features are extracted from the denoised ECG signal using DWT i.e. entropy, mean, variance and mean energy.The values of these features for ECG signal of record no. 100 with different decomposition levels are shown in tables 2.

TABLE 1: Different features of ECG record no. 100.

Decomp. Level	Entropy	Mean	Mean Energy	Variance
1	1.5996	3.9185e-04	9.2805	4.8346e-05
2	2.5004	-4.4608e-04	9.2805	0.0016
3	2.6710	3.8258e-04	9.2805	0.0164

D. Classification

Support Vector Machine (SVM) classifier is used for the classification purpose. In this paper a linear SVM classifier is used for the classification of arrhythmia. A hyper plane is used in the middle of the two classes, for the separation of these data.

In the beginning linearly separable patterns are used (Figure5). A linear function for this pattern is given below:

f (x) = w^Tx + b (7)

There are many hyper planes exist that classify the two classes. But SVM classifier chose that hyper plane which has maximum margin between the two classes. The SVM algorithm can be summarized as the following [12]

$$min_{w,b,\xi}\ \{\frac{1}{2}w^T w + C(\sum_{i=1}^{l}\xi_i)\} \quad (8)$$

Where w and ξ_i are the weight vector and slack variable respectively [12]. C is a constant that is used for the nonlinear data.

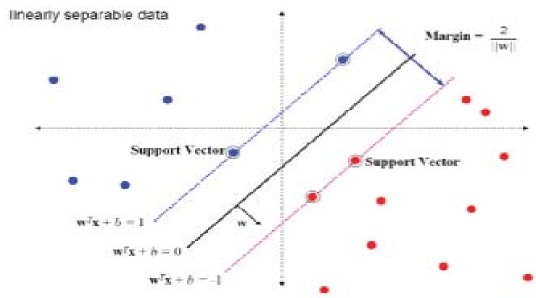


Figure5: Linear SVM classifier [4].

III. EVALUATION

For the ability evaluation of the proposed method accuracy (AC), sensitivity (SN), specificity (SP) and precision (P) are used. The equations of these parameters are given below:

Accuracy (AC): It is ratio of the true predictions and total predictions.

$$AC = \frac{TP+TN}{TP+TN+FP+FN} \quad (9)$$

Where TP refers the true positive i.e. correctly predict the arrhythmia, TN refers the true negative means correctly predict the normal signals, FP refers the False positive means incorrectly predict the arrhythmia and FN is stands for the false negative i.e. incorrectly predict the normal ECG signal.

Sensitivity (SN): Sensitivity is the ratio of true positive to the total number or positives.

$$SN = \frac{TP}{TP+FN} \quad (10)$$

Specificity (SP): It is defined as the ratio of the true negative to the total negative.

$$SP = \frac{TN}{TN+FP} (11)$$

Precision (P): It is a ratio of the true positive to the predicted positives.

$$P = \frac{TP}{TP+FP} (12)$$

For the evaluation of the proposed method AC, SN, SP and P are computed for the SVM classifier.

TABLE 2: Run the program by means of SVM classifier.

Classification Type	TP	TN	FP	FN
Normal & Abnormal	22.5	22.5	0.5	0.5
PVC & APC	20	20	1	1

IV. RESULTS AND DISCUSSIONS

ECG records of the 42 patients are taken from the MIT-BIH arrhythmia database. Sample test ECG signals are shown in Figure 6.

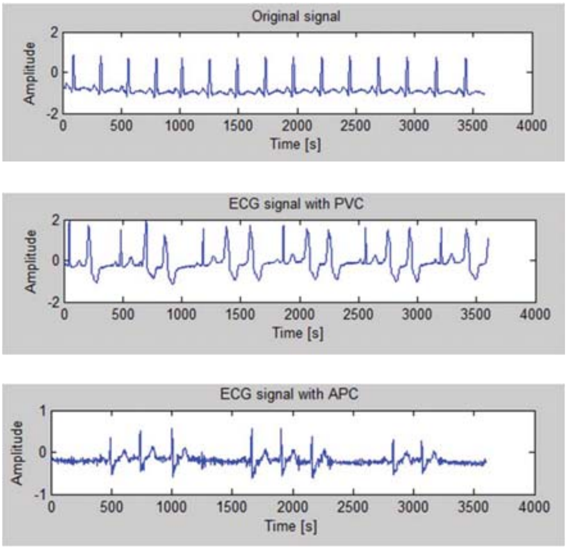


Figure 6: Examples of the Test Signal.

Matlab 7.8.0 Mathwork, is used for the proposed work. Here SVM is used in cascade form, firstly it classify the normal ECG and ECG with arrhythmia & after that SVM classify the PVC and APC arrhythmias.The SVM classifier classifies the normal ECG and arrhythmias with the accuracy of 98% and the classifier accuracy for PVC and APC classification is 95%.

Comparisons of the proposed method with other arrhythmia classification methods are shown in table 4.

TABLE 4: Comparison Table of the Proposed Method with other Methods.

Method	Key Technique	Acc	Se	Sp
Proposed	DWT+SVM	98%	98 %	98%
Gawde et al., 2017[20]	Integrating Markov Model	91.8 %	89 %	99.7 %
Islam et al., 2016[16]	Entropy of normalized RRI's + Thersholding	96.38 %	96.39%	96.38%
Zhou et al., 2015[17]	Shannon Entropy symbolic dynamic of RRI's + Thersholding	97.99 %	97.37%	98.44%

V. CONCLUSION

Arrhythmia diagnosing requires ECG of the patient and other clinical information. Automatic detection of different arrhythmias is a difficult task. In the given work SVM classifier is designed for the arrhythmia classification using Matlab software. The system was developed for the APC and PVC arrhythmias classification using discrete wavelet transform (DWT) and SVM classifier. Four features are extracted using DWT and these features are used by the SVM classifier for classification purpose. Here SVM shows high accuracy for the PVC and APC classification.

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