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Electrocardiogram Signal Detection for Automatic Cardiac Abnormality Detection using SVM

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Electrocardiogram (ECG) signals are commonly used to assess the health of the human heart, and the resulting time sequence is frequently physically broken down by a medical specialist to identify any arrhythmias that the patient may have experienced. Much work has been done to automatize the way toward examining ECG signals,yet the greater part of the exploration includes broad pre-processing of the ECGinformation to infer vectorized highlights and in this manner design a classifier toseparate between healthy ECG signals and those demonstrative of an Arrhythmia. This process needs understanding the knowledge about the varied forms of arrhythmia. The heart is an unpredictable organ, and a broad variety of and new types of arrhythmia can occur that were not included in the first preparation set. It could be possible in this fashion.

Keywords: Electrocardiogram (ECG),Support Vector Machine (SVM), Arrhythmia, Cardiac disorder, Machine Learning Technique.

1. Introduction

Electrocardiogram (ECG) is a tool used to know the graphical and mathematical information of the heartbeat. It is a graphical representation of voltage with respect to time which can be obtained from the hardware which contains electrodes on the chest area that respond to the depolarization and re-polarization of the muscle [1]. It generally consists of different peaks namely P, Q, R, S, T as shown in the figure1.1. Of them, compared to any other peak, R peak is mostly considered for analysisbecause it is a sharp peak of large magnitude and can be used with ease to know thepresence of abnormality. If the rhythm of ECG signal differs from the normal sinusrhythm, it can be termed as Arrhythmia. There are different types of arrhythmia likebradycardia, tachycardia, premature ventricular contraction, atrial fibrillation etc.In this work, two parallel jobs were done: R peak detection, extractionof temporal features and classification using the temporal features. Java languagewas used in the back-end of the android studio. The discovery of cardiovasculararrhythmias is a difficult job since the little varieties in ECG signal can't be recognizedexactly by the human eye [2]. The target of this work is to distinguish heartarrhythmias with maximum possible precision. Heart arrhythmias are characterizedutilizing DWT. The DWT highlight set involves factual highlights removed from thesub groups got after disintegration of QRS complex waves up to 4 levels.

1.1 Parts of the ECG signal

The ECG is a continuous signal which contains a set of repetitive waves the collection of the set of waves is known as cardiac cycle. These set of waves are: P, Q, R, S, T and U.

- P wave: The first small wave of duration 0.04 sec and is in upward direction [2].
- Q wave: Q peak is a part of QRS complex. It is sharp downward wave of small magnitude appears after certain period of P wave. The magnitude of Q wave is very small.

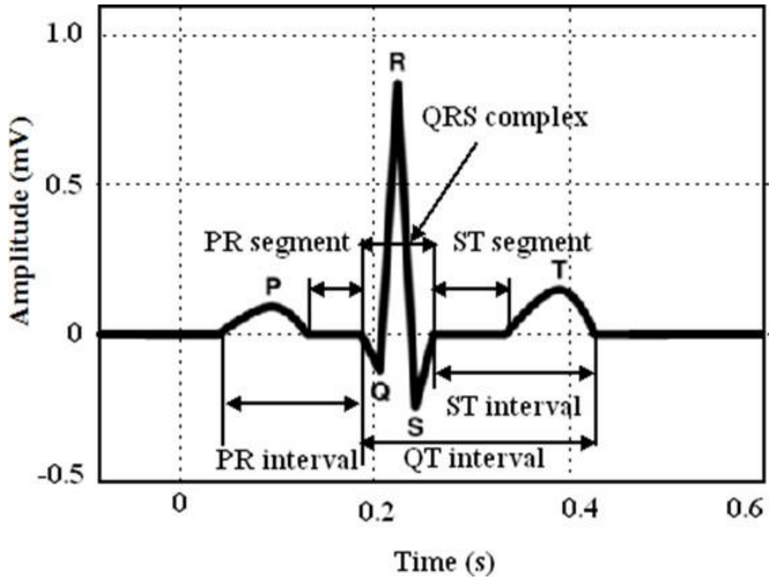

Fig: 1.1 Basic ECG Signal

- R wave: R peak is the highest and the most important peak in the ECG signal pro- cessing. It is
a sharp peak of high magnitude and it is followed by negative swing of S wave [3].
- S wave: The negative swing after R peak is known as S wave. It is of very less duration and has
very small magnitude.
- T wave: T peak occurs because of repolarization of ventricles and is an upward wave.

Generally, QRS complex wave is considered rather than different waves of Q, R and S waves. It occurs because of depolarization activity of ventricles. The general time duration of QRS width is 80-120 m sec.A normal sinus rhythm (NSR) reflects a cardiac disorder free ECG signal, with a heart rate of 60-100 beats per minute (BPM). A heart rate above 100 BPM shows tachycardia while a heart rate below 60 BPM shows bradycardia which stresses the internal organs.The Sino atrial (SA) node of the heart is the source for this kind of arrhythmias. The distinctive characteristic of this form of

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arrhythmias is that the ECG signals P wave morphology is still normal. Sinus arrhythmia, Sinus bradycardia and Sinus arrest are various types of arrhythmias found in this category.Bundle branch blocks result in myocardial infarction as the movement of the impulse signal from the AV node to the whole conduction system is restricted. There are two types of Bundle Branch Blocks (BBB) groups. The right BBB stops the depolarization of the right ventricle from the impulse signal originating from AV node while the left BBB stops depolarization of left ventricular muscles. Such blocks induce an infarction of the myocardial.

2. Database

The database required for this project was obtained from MIT-BIH database (which can be obtained from physionet.org website). The path is: physio bank, physio bank ATM [20]. The database taken is MIT-BIH arrhythmia database. The files taken were in the 'txt' format. It consists of 3600 samples from 0th sample to 3599th sample with their respective magnitudes. The MIT-BIH database consists of 48 ECG recordings with normal and few cardiac arrhythmia datasets. Among these 48 files, four records of the database comprise of maximum paced beats. These four files were excluded from the performance evolution process because they don't have adequate signal quality. Proposed classifiers performance were evaluated using 44-ECG recordings [21]. Furthermore, re-searchers have used the MIT-BIH database as a standard database for the ECG signal analysis and cardiac arrhythmia detection. MIT-BIH ECG recordings were digitized at 360 Hz and band-pass filtered at 0.1-100 Hz.

3. Proposed Methodology

MATLAB is a high-performance, scientific programming language. It combines calculation, simulation and scripting into an easy-to-use environment where common mathematical nota- tion communicates problems and solutions. It is a dynamic language platform for computing: it has complex data structures, provides built-in editing and testing software, and promotes object-oriented programming. Such elements render MATLAB an outstanding teaching and testing resource. It basically provides hundreds of interconnected functions for a broad variety of computations and various toolboxes tailored for particular study areas, including statistics, optimization, partial differential equation solution, data processing [1].The implementation consists of three parts: QRS complex detection, feature extraction and classification. As mentioned earlier, for implementation of this work, two parallel paths were followed. The implementation carried out was QRS complex detection using Pan-Tompkins algorithm, feature extraction using Hilbert Haung transform method [2]. Normalization is the technique used to remove the baseline wander i.e., for the baselinenoise removal. The mathematical equation of the Normalization is such that the meanis subtracted from the raw ECG signal so as to obtain the balance of weights ofmagnitude with respect to the X-axis.In part, the path followed was QRS complex detection using Pan-Tompkins algorithm [23], features extracted were the temporal features like RR distance, QS distance, AC power, kurtosis, and skewness. The classification part that was carried out was supervised classification i.e., the detection of four types of arrhythmia is done using the conditions of the heart-rate. Morphological features were extracted by using Hilbert Haung transform with four levels. At each level, the samples obtained were down-sampled by 2. These coefficients are Detail coefficients and Approximation coefficients. The calculation of R peak locations helps in determining the temporal features ofthe ECG signal. The QRS complex recognition i.e., finding the R-peak and it isa significant advance to extract features. When the R-peak is resolved, all othersignificant pinnacles of the ECG were resolved as for the R-peak [26]. In thisway, QRS recognition of the ECG signal was a significant undertaking for ECGanalysis.

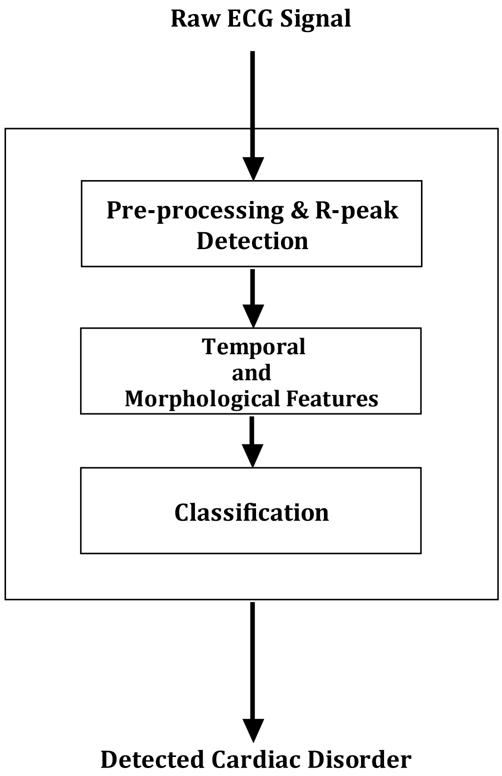

Fig: 3.1 Proposed Methodology

a. Temporal featureextraction

In this work, the algorithm for calculation of temporal features is:

1. Selection of the window of 260 samples around the R-peak i.e., with R-peak as the center 130 samples were taken left of R peak and 130 samples were taken

right of Rpeak.

2. Detection of Q peak and S peak around R peak i.e., to the left and right of R peak in the selected windowrange.
3. Calculation of distance between the successive R peaks and distance of Q and S peaks of the same R peak which gives us two sets of features with RR distance and QSdistance.
4. Calculation of average RR distance and average QS distance of the overall ECG signal i.e., up to 3600samples.
5. Calculation of other temporal features like AC power, skewness and kurtosis of the raw ECGsignal.

Feature extraction part was implemented using HHT with four levels at each level the signal was decomposed into high-pass and low-pass filter coefficients.

4. Results

To detect these four arrhythmia's, the temporal features which were extracted earlier were used [5]. Especially, in the case of bradycardia and tachycardia which can be detected based on the heart-rate. The heart-rate is connected to RR distance [6]. So, one can derive the equation connecting these two parameters. In case of premature ventricular contraction, a condition based on the average RR distance and QS average distance which was obtained. In this work support vector machine is used to classify the different types of cardiac disorders. The performance of the classifier is estimated using accuracy, sensitivity, specificity, and positive predictivity. The confusion matrix can be defined as the correctly classified instances out of total applied instances. Feature vector is used to train the network. After training network is tested and cross validated using testing vector. The confusion matrix of the classifier is shown in Table 1.

Table 1: Confusion Matrix

Method	**Class**	**N**	**P**	**L**	**R**	**V**
Classifier	**N**	53062	627	556	367	373
	P	5	5043	413	50	09

	L	38	53	5300	25	43
	R	45	71	7	6645	84
	V	43	15	47	17	6885

The performance matrix of the classifier is shown in Table 2 which shows better performance than state of the art techniques.

Table 2: Confusion Matrix

Method	**Class**	**Acc(%)**	**Sen(%)**	**Spe(%)**	**Ppr(%)**
Classifier	**N**	98.00	98.65	94.30	98.23
	P	99.23	83.45	99.12	86.12
	L	97.45	89.12	98.14	80.12
	R	97.32	90.23	94.45	89.32
	V	98.34	81.23	96.23	83.20

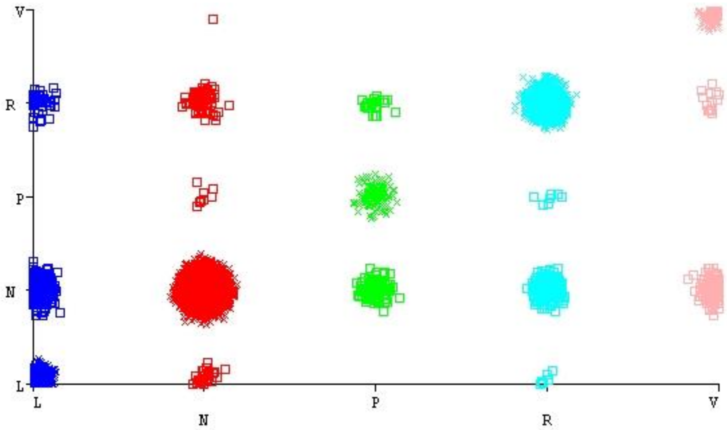

Fig.4.1 Classification of cardiac disorders

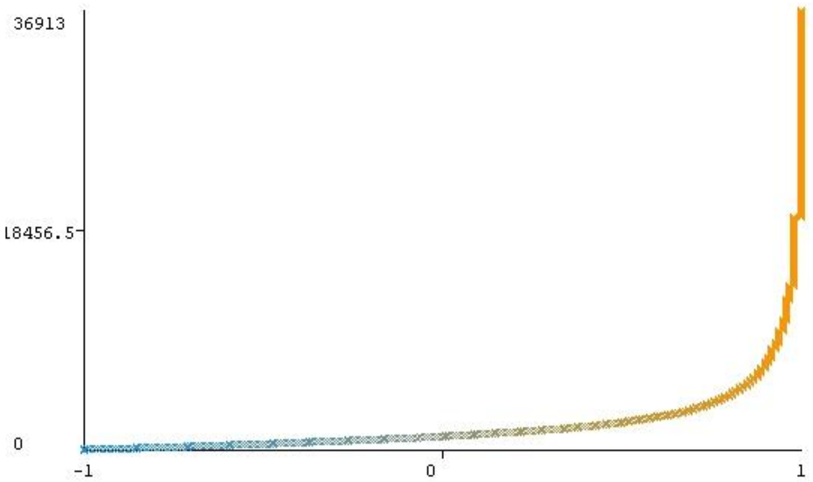

Fig.4.2 Marginal curve of the classifier

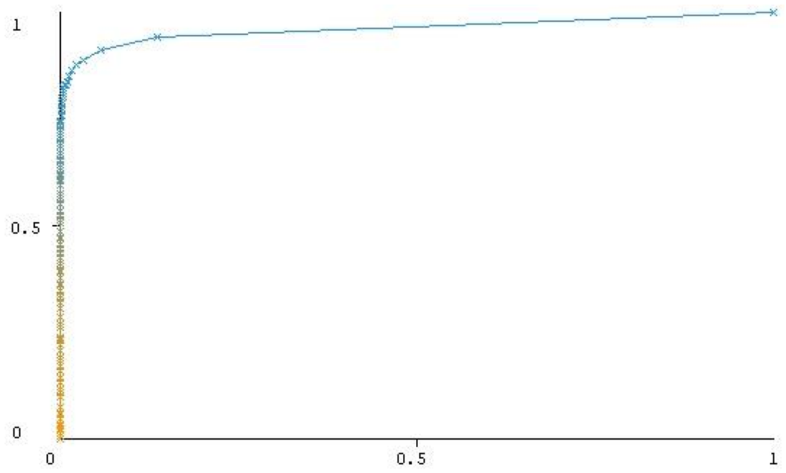

Fig.4.3 Threshold curve of the classifier

Fig. 4.1, 4.2, 4.3 are shown classifier errors, marginal, and threshold curves respectively which shows better performance than other literature.

5. Conclusion

In this work, main focus was done on implementation of android application for arrhythmia detection of ECG signal. The main work continued in the implementation of software part of the application design. The work involved in the design of android application was implemented by using the basic algorithms for each step like Pan-Tompkins algorithm for QRS complex detection, HHT for extracting features and some other time domain features, and at last the classification was done using the basic conditions which were obtained from different available literature on supervised classification.This work was carried only for the existing database i.e., MIT-BIH database. SVM attained better accuracy than other methods with 98.30% accuracy.

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