ECG FEATURE EXTRACTION FOR CLASSIFICATION OF ARRHYTHMIA

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Abstract

Artificial Neural Networks (ANN) can be viewed as a collection of identical mathematical models that emulate the observed properties of biological nervous systems. Here an artificial neural network is designed which is used to classify arrhythmia. For the same, ECG parameters are firstly extracted from the digital ECG data of a patient. Then these parameters are used for the training of neural network. The output of the neural network gives the arrhythmia from which the patient is suffering.

Keywords: ECG feature extraction, ECG signal parameters, ECG signal detection, and Arrhythmia classification.

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1. INTRODUCTION

A general indication of the P-wave, QRS complex, T-wave, and U-wave as well as the PR, QT, ST, and QRS interval is shown in figure 1 for a normal ECG beat.

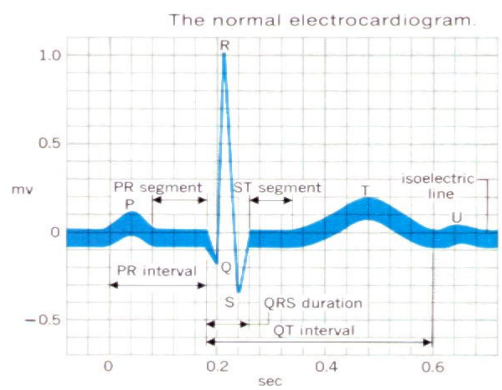


Fig. 1 ECG components

A set of efficient techniques are used to extract important features from the digital ECG data that can be RR interval & so on. The features extracted are heart rate, PR interval, P, T and Q amplitude. The R-R interval is the distance between two subsequent QRS complexes and represents the Heart Rate (HR). Normal HR is between 60 to 100 bpm. A high HR means the possibility of tachycardia, and a low HR indicates presence of sinus bradycardia .The QRS complex duration is another important parameter employed in the analysis and classification of the ECG sgnal. This parameter is defined as the time consumed during depolarization of the ventricles. Normal depolarization requires normal functioning of the right and left bundle branches and it varies from 0.04 to 0.09 seconds. Any block in either the right or left bundle branch delays depolarization of the ventricle due to the blocked bundle. In abnormal cases the QRS interval is 0.1 seconds or more. There is an intraventricular conduction delay when the QRS interval is between 0.1 to 0.12 seconds. QRS intervals greater than 0.12 seconds indicate bundle branch block [2]. The P-R interval, another useful feature, represents the time lag from the start of a trial depolarization to the start of ventricular depolarization and allows a trial systole to occur. The P-R interval is the time necessary for the **SA** node impulse to spread over the atria and through the AV node. The P-R interval within 0.12 to 0.20 is normal. When the PR interval is less than 0.11 seconds, accelerated AV conduction has occurred. There is 1st degree AV block and impaired AV conduction, when the P-R interval is greater than 0.2 seconds. Careful attention should be paid to the P wave and P-R interval when assessing ECG rhythm. After the extraction of these important parameters, they are used to train the neural network from which the arrhythmias are detected and these are Ventricular tachycardia, sinus Tachycardia, sinus Bradycardia, Prominent P, Exogenic catecholamine, Abnormal intraventricular, Heart Block.

2. MATERIALS AND METHODS

The Error Back Propagation Neural Network is used for the classification of arrhythmia. The programming is done in two parts i.e.

1) **Feature Extraction stage**:-In this stage firstly the ECG parameters are extracted from the digital ECG data using Matlab programming. The parameters extracted are P, R, and T amplitude and Heart rate. These features are extracted from ECG wave and then given to the neural network for classification of arrhythmia.

2) **Arrhythmia Classification**:-In this stage for arrhythmia classification, the neural network is designed using 5:10:8 architecture and error gradient of 0.001.Neural network is trained by considering the condition, for $P > 0.1$ output is 1; for $P = 0$ output is 0 and for $P < 0.1$ output is 0.5, where P is P wave amplitude. And for $r > 60$ & $r < 100$ output is 1, for $r1 > 100$ output is 0.5 and for $r1 < 60$ output is 0.

2.1 Electrocardiogram data

Electrocardiography (ECG or EKG) is a transthoracic interpretation of the electrical activity of the heart captured over time and recorded externally by skin electrodes. It is a noninvasive recording produced by an electrocardiographic device. It works by detecting and amplifying the tiny electrical changes on the skin that are caused when the heart muscle "depolarizes" during each heart beat. At rest, each heart muscle cell has a charge across its outer wall, or cell membrane and by reducing this charge towards zero is called de-polarization, which activates the mechanisms in the cell that cause it to contract. During each heartbeat a healthy heart will have an orderly progression of a wave of depolarization that is triggered by the cells in the sinoatrial node, spreads out through the atrium, passes through "intrinsic conduction pathways" and then spreads all over the ventricles. This is detected as tiny rises and falls in the voltage between two electrodes placed either side of the heart which is displayed as a wavy line either on a screen or on paper. This display indicates the overall rhythm of the heart and weaknesses in different parts of the heart muscle. The ECG wave forms of a 26 year male i.e. a practical ECG waveform is given in figure 2. It is having 12 different waveforms i.e. V1, V2, V3, V4, V5, V6, L1, L2, L3, AVF, AVL, AVR. These waveforms are obtained by placing electrodes on the patient body. If there is any abnormality in heart, then there will be a change in the ECG waveform. And these waveforms are used to determine arrhythmia. These waveforms can be read out either manually or using software based electrocardiograph.The ECG data used here is the real or digital ECG data of the patient and from that digital data various parameters are calculated and then given to a neural network to determine the arrhythmia .From any electrocardiograph only eight digital outputs are available and these are V1, V2, V3, V4, V5, V6, L1 and L2.Others are obtained by using the following relation:-

L3=L2-L1, - - - (1)

AVF= (2(L2)-L1)/√3, - - - (2)

AVL= (2(L1)-L2)/√3, - - - (3)

AVR=-(L1+L2)/√3. - - - (4)

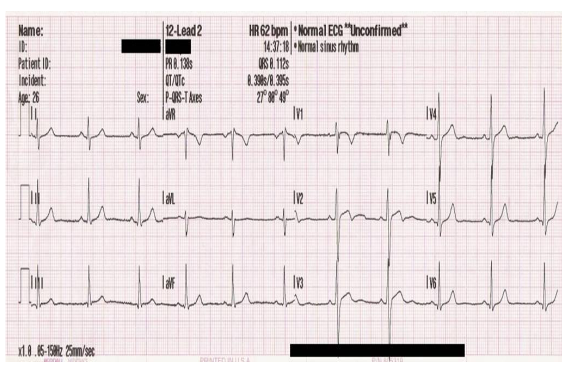
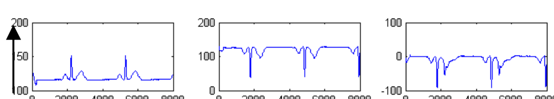


Fig.2 12 Lead ECG of a 26-year-old male

These calculations take place internally in the cardiograph. The corresponding ECG waveform is shown in figure 3.



L1…….. L2…… L3…….

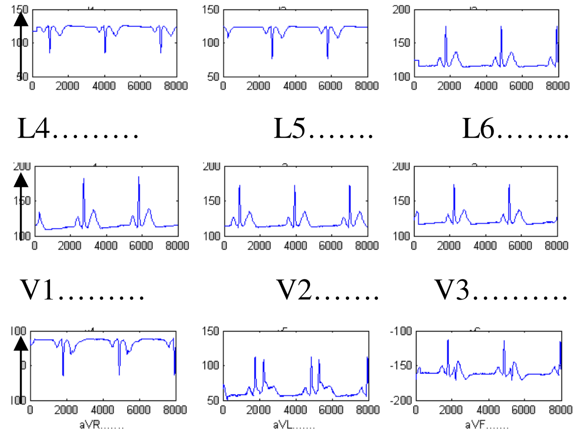


Fig. 3 Waveforms for 12 leads for digital data

3. RESULTS

3.1 Detection of R peaks

By using the peak detection method, maximum and minimum peaks are detected. This is done using Matlab program. From this peaks R,P and T amplitude is determined. The peaks for the all 12 ECG output are shown in figure 4. By using the R,T and P amplitude arrhythmia are detected as the Prominent P and Ventricular tachycardia from P amplitude, Exogenic catecholamine from T amplitude.

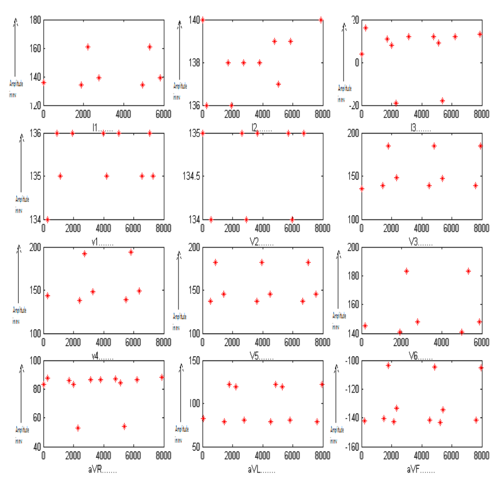


Fig. 4 R Peaks for digital data

3.2 Detection of Heart Rate

The detection of heart rate for the 12 leads of ECG is done by firstly eliminating the drift, for which filtering is done and then R wave duration is determined by using the MatLab programming. As heart rate is a very important feature it must be present between 60 and 100. For heart rate greater than 100 arrhythmia it is bradycardia and for less than 60 it is tachycardia. The following relation of Heart rate is used for the calculation purpose.

Heart rate = 1500/ (No. of small squares between two R waves)

The figure 5 shows the heart rate determination for AVR Here it shows that firstly the base drift eliminated from the original ECG wave. After that Heart rate is determined using the equation 5.

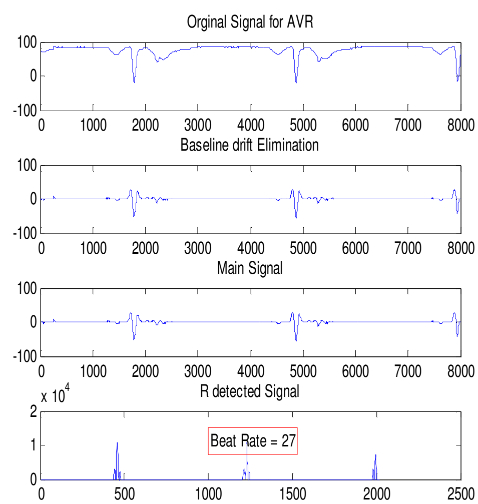


Fig. 5 Heart rate determination for AVR

3.3 Features Extracted

The features here extracted from the ECG wave are P,R and T amplitude , P-R & QRS interval and heart rate. These are extracted by using both the ways i.e. by using MatLab program and by reading the ECG wave manually. These features are extracted for all the 12 leads in order to classify arrhythmia. And this will vary from patient to patient.

3.4 Back Propagation Neural Network

To classify the arrhythmia from the extracted features, the algorithm used is Back Propagation. Back propagation is a method of teaching artificial neural networks. It is a supervised learning method, and is an implementation of the Delta rule. It is most useful for feed-forward networks. It requires that the activation function used by the artificial neurons (or "nodes") is differentiable. In this algorithm, the errors are propagating backwards from the output nodes to the inner nodes. So it is used to calculate the gradient of the error of the network with respect to the network's modifiable weights. This gradient is then used in a simple stochastic gradient descent algorithm to find weights that minimize the error. A general structure of back propagation neural network is given in figure 6, which shows four input neurons, three output and six hidden neurons.

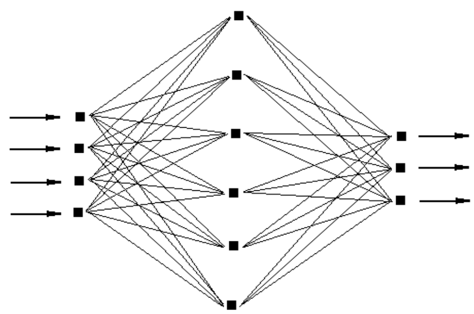


Fig. 6 Example of back propagation neural network

The Back Propagation Neural Network used in this work consists of five input nodes, eight output nodes with ten hidden neurons. Error gradient used is 0.001.The figure 7 shows the graph between error and number of iterations. It shows that as the number of iterations increases error reduces.

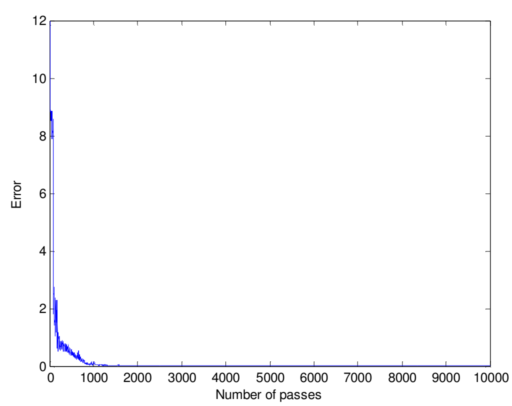


Fig. 7 Error Vs Iteration graph

4 CONCLUSION

A Back Propagation algorithm will be used here for the classification of different arrhythmia such as Ventricular tachycardia, Bradycardia, Tachycardia, Prominent P, Abnormal Intraventricular ,Exogenic catecholamine etc. For this work the digital ECG data or wave is used and then its various parameters are calculated programmatically which are PR interval, RR interval, QRS interval, Heart Rate. The Neural Network will be of 5:10:8, i.e. 5 input, 10 hidden neurons and 8 outputs which means at a time 5 ECG parameters can be used and then it will give 8 arrhythmia. This approach makes the work simpler as on just giving the ECG lead output to program the final result so obtained is the arrhythmia from which patient is suffering. This model has its scope in the field of medical.

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