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# Classification of ECG Abnormalities using ANN

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**Abstract**

*Anelectrical activity of the heart is recorded as Electrocardiography (ECG) using 12 lead standard of recording. Pattern of ECG and heart rate can be used as the parameters to indicate cardiac health. The statistical features are extracted from the Electrocardiography (ECG) under study. There is a significant difference between normal heart rhythm and the different arrhythmia types. The classification of ECG signals using discriminating features is of crucial importance in the detection of cardiac diseaseand consequently in deciding path of treatment in the cardiac system. Heart rate, ST elevation, Amplitude and Duration of P wave and QRS complex are the parameters used for detection of arrhythmicactivity of cardiac cycle. The coverage of larger spectrum of arrhythmia is possible with introduction of Artificial Neural Networks (ANNs). ANN classifier is implemented for the classification and an accuracy of 92.23% is achieved.*

## 1. Introduction

The electrical activity of the heart showing the regular contraction and relaxation of heart muscle signifies as Electrocardiogram (ECG). The analysis of ECG waveform is used for diagnosing the various heart abnormalities. The heart conditions are used to diagnose by an important tool called Electrocardiography. ECG signal processing techniques consists of, de-noising, baseline correction, parameter extraction and arrhythmia detection. ECG waveform consists of five basic waves P, Q, R, S, and T waves and sometimes U waves. The P wave represents atrial depolarization, Q, R and S wave is commonly known as QRS complex which represents the ventricular depolarization and T wave represents the repolarization of ventricle [1]. The most important part of the ECG signal analysis is the shape of QRS complex. The ECG signal may differ for the same person such that they are different from each other and at the same time similar for different types of heartbeats [2].The pacemaker cells inside the sinoatrial (SA) node used to generate and regulate the rhythm of the heart, which is located at the top of the right atrium. Normal heart beat is very regular, and atrial depolarization is always followed by ventricular depolarization. In the case of arrhythmia this rhythm becomes irregular, that is either too slow or too fast. The frequency range of an ECG signal is [0.05 -100] Hz and its dynamic range is [1- 10] mV. A good performance of an ECG analyzing system depends heavily upon the accurate and reliable detection of the QRS complex, as well as the T and P waves. Figure-1 shows ECG waveform characteristics and their corresponding positions in heart and a typical normal ECG signal is as shown in Figure-2 [1].

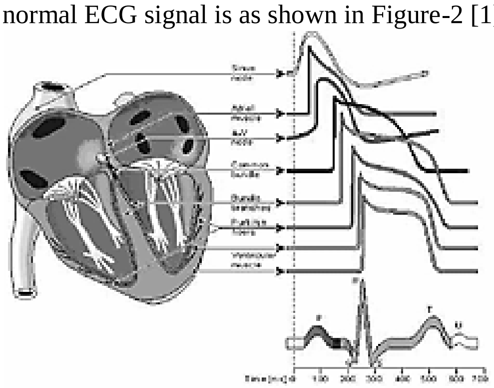

**Figure-1.**ECG waveform characteristics and their corresponding positions in heart.

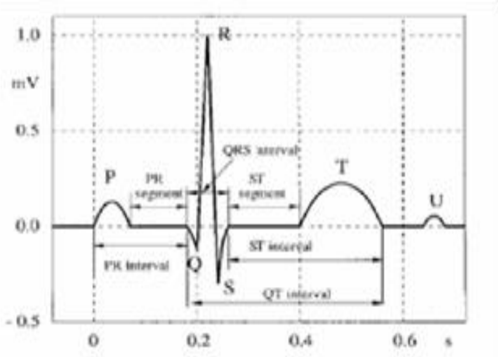


**Figure 2:**The ECG Signal and its different components

**2. ECG feature extraction**

Discrete Wavelet transform are used to extract features from an electrocardiogram (ECG). Better detection can be achieved by the wavelet filter with scaling function similar to the shape of the ECG signal.The wavelet is similar in shape to QRS complex and their energy spectrums are concentrated around low frequencies [3].Excluding the high frequency component we get approximated ECG signal. The ECG signal and the details for components of it are used for better illustration. The detection of R peaks is shown in Figure-4.

**3. ECG data used**

All the ECG data required for this work is used from the MIT-BIH dataset [7].

**4. Non-linear dynamics for ECG**

A cardiovascular system seems complex because of the random appearance of fluctuations in the constituting components.The dynamics of the cardiovascular system will provide details about the complex. Significant information on the dynamic characteristics can be obtained by studying fluctuations in the frequency and time domain. Characteristics can be varied with routine averaging or linear spectral methods. Extracted features are forwarded to ANN for classification [5]. The cardiac arrhythmia classification using ANN is based on:

1. Heart Rate.
2. P Wave.
3. QRS complex.
4. ST elevations.

**Heart Rate**

R Wave is the most dominant wave in ECG complex. The synchronization between the two pace making nodes can be reflected with the normal R-R interval. The time measurement between two consecutive R with the successive averaging will lead to calculation of heart rate. To validate the results, simulations of various arrhythmic conditions are compared with heart rate variability (HRV) data obtained from various conditions under study.

**P Wave**

Function of atrium and sino-atrium (SA)node will detect the shape and the time interval of Pwave.It intern will provide the pace to the following components of ECG complex. This provides a theoretical link between frequency-domain spectral analysis techniques and time-domain analysis.

**QRS Complex**

Maximum energy is stored in the component named QRS complex in ECG waveform. It provides reasonably good amount of information about the functioning capability and the pacing ability of human heart. The variation of amplitude or/and time of QRS complex can help in detailing of the symptoms to be studied.

**STElevation**

The preceding part of ECG waveform consists of S wave and T wave and a line joining these two ends. The amplitude and time duration of both S and T wave along with ST segment provides accurate information about ventricular polarization and depolarization. The extremities in ECG will be reflected in continuous fashion through ST elevation.

**5. Arrhythmia classification**

Arrthymia considered for the purpose of this study were classified into eight categories, namely

i. Left bundle branch block (LBBB)
ii. Normal sinus rhythm (NSR)
iii. Pre-venticular contraction (PVC)
iv. Artial fibrillation(AF)
v. Ventricular fibrillation(VF)
vi. Complete heart block (CHB)
vii. Ischemic dilated Cardiomyopathy
viii. Sick sinus syndrome(SSS).

For the classification of cardiac arrhythmias using ANN we have taken analysis of heart rate, P wave, ST elevation, QRS complex as the input variables which are derived from heart rate signals.

**6. Neural Network Classifier**

A method is proposed to accurately classify cardiac arrhythmias through a combination of wavelets and artificial neural network (ANN) [11]. The ability ofthe wavelet transform to decompose signal at various resolutions allows accurate extraction/detection of features from non-stationary signals like ECG. A set of discrete wavelet transform (DWT) coefficients, which contain themaximum information about the arrhythmia, is selected from the wavelet decomposition [12]. These coefficients in addition to the information about RR interval are utilized in this work. These are fed to the back-propagation neural network which classifies the arrhythmias. They are trained with supervision, using gradient-descent training techniques, called back propagation which minimize the squared error between the actual outputs of the network and the desired outputs. Each output node computes a non-linear discriminant function that distinguishes between one class and all other classes [11]. The BPA is a supervised learning algorithm, in which a sum square error function is defined, and the learning process aims to reduce the overall system error,it is desirable that the training data set be uniformly spread throughout the class domains. The weight updating starts with the output layer and progresses backward.

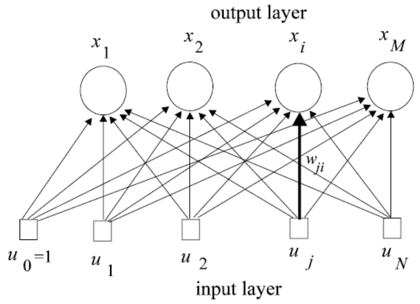


**Figure-3.**Single layer feed forward neural networkclassifier.

The non-linear parameters are used as inputs to ANN and the classification is done. The output of the classifier is a graphical representation. A few of them are shown in results. The classification results are tabulated in Table-1.

**Table-1.**Classification of cardiac arrhythmia using ANN.

| Cardiac Signal condition | data sets testing | correctly classified | sets mis-classified | % Accuracy |
|---|---|---|---|---|
| LBBB | 24 | 22 | 2 | 91.67 |
| NSR | 31 | 30 | 1 | 96.77 |
| PVC | 65 | 61 | 4 | 96.77 |
| AF | 28 | 24 | 4 | 85.71 |
| VF | 43 | 39 | 4 | 90.69 |
| CHB | 29 | 26 | 3 | 89.66 |
| ISCH | 38 | 36 | 2 | 94.74 |
| SSS | 51 | 47 | 4 | 92.16 |
| **Total** | **309** | **285** | **24** | **92.23** |

## 7. Results and Conclusions

Time frequency analysis of ECG waveform can provide the details of nonlinear parameters of constitute elements of electrocardiogram. The collective study of symptomatic parameters can be used for classification of the waveform under study. R-R interval dynamics provides the basis for statistical analysis of variability of heart rate. The HRV signal can be used as a reliable indicator of heart diseases. A trained ANN model is suitable for classification of abnormalities using input variables and rules. The ANN classifier can be a diagnostic tool to aid the physician in the analysis of heart diseases. The results show that the proposed method is effective for classification of cardiac arrhythmia with an overall accuracy of 92.23% (Table-1). The results conclude that it is possible to classify the cardiac arrhythmia with the help of ANNgoverned by BPA. Thesimplicity and ease of implementation are the advantages of the ANN classifier.

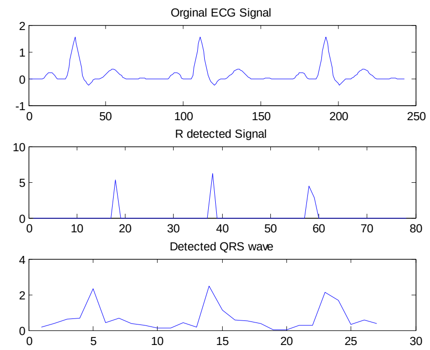


**Figure-4.**R peak and QRS detection.

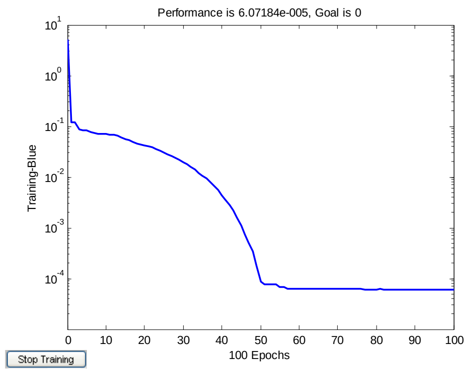


**Figure-5.**The training performance ANN.

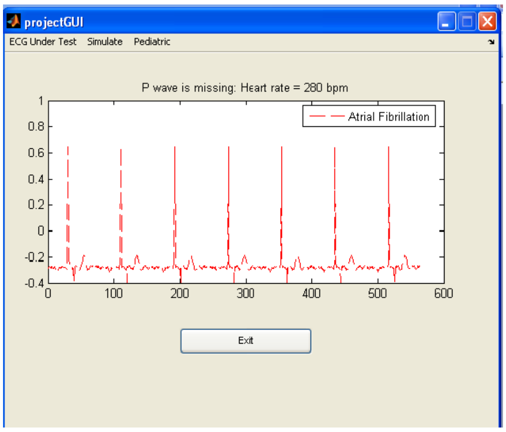


**Figure-6.**The output of cardiac signal-AF

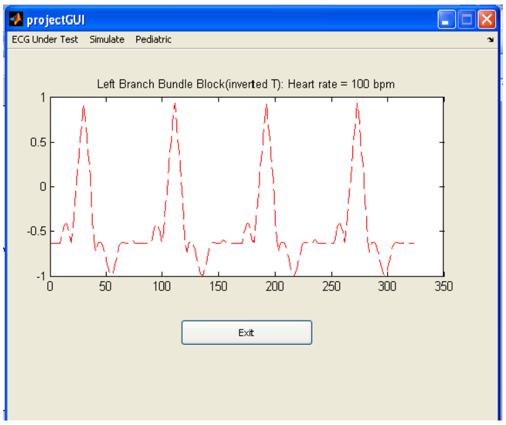


**Figure-7**The output of cardiac signal- LBBB.

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