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Proficient Technique for Classification of ECG Signal

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ABSTRACT

ECG's are one of the most important biomedical signals; these are usually used to determine the insightful of an electric activity of the heart. ECG gives the statistics about the electrical functionality of heart, with help of its constituent waves shape, that is the P, QRS, and T waves. Features of the ECG have a noteworthy role in detection of the various cardiac syndromes. P-QRS-T waves are the components of one cycle of ECG signal. The heart functionality can be determined with the help of the intervals and amplitude of the P -QRS-T segment. This paper proposes an approach to examine electrocardiogram (ECG) signal. The working of proposed classifier is based artificial neural network (ANN), In this feature extraction is done by means of discrete wavelet transform (DWT) whereas for classification purpose neural network is used and the classification is done in five different types of arrhythmias viz. Left Bundle Branch Block (LBBB), Right Bundle Branch Block (RBBB), Paced Beat (PB), Atrial Premature Beat (APB) and First degree AV Block (AVB) beats apart from normal (NS) beats.

The anticipated neural network (NN) based comprehensive classifier gives an enriched performance of classification the performance measures obtained are: sensitivity is95%, specificity is 99.01% and classification accuracy is98.35%.

Keywords: ANN (Artificial Neural Network), ECG (Electrocardiogram), discrete wavelet transform (DWT)

1. INTRODUCTION

The patients with various kinds of heart syndrome are very large in number so there is a necessity of efficient technique for attempting large number of patients. During recent tenure Medical science in collusion with Computer Science has, developed various techniques that could be used for expert analysis by the cardiologists. Electrocardiogram (ECG) is a priceless tool that can be used for diagnosis of heart sicknesses. The standard hearts ECGs have a distinguishing shape. Several abnormalities in the rhythm of heart or impairment in the muscle of heart can alter the hearts electrical action, so the ECG's nature gets altered [1]. The regular ECG waveform with its several segments is shown in Figure.1

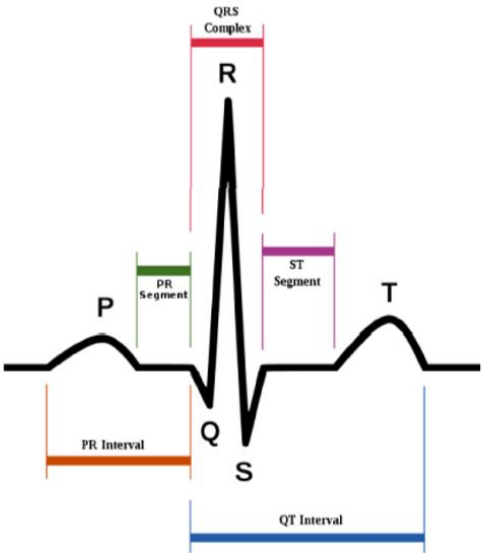

Figure 1 A Sample of ECG

The heart beat's electrical property can be represented with the help of ECG footage and the electrocardiogram has turned out to be one of the supreme imperative tool for finding the heart syndromes. During the recent time the mortality rate due to heart diseases is significantly high, recognizing the abnormality with in time and precise perception of ECG signal is needed for handling the patient. The doctors can use the input obtained from machine learning techniques for categorization of ECG signals to ratify the diagnosis [4]. Cataloguing and recognition of type of arrhythmia can provide the assistance in detecting the aberration exists in Patient's ECG signal. Once ascertaining the aberration is done, the determination of the heart ailments can be done and the patient's treatment can be done in a better way. Correct ECG categorization into arrhythmia categories gives adequate statistics to identify the heart disorders whereas the doctor gets help in determining the preeminent psychotherapy for patients.

In this proposed work a classifier is developed based on neural network to categorize arrhythmias of five types , that is, left bundal branch block (LBBB), right bundle branch block (RBBB), atrial premature beat (APB), paced beats (PBs) and first degree AV block (AVB) beats along normal (N) beats.[10]

This paper constitutes six sections, in this elementary introduction of ECG is given in section I. Section II represents the overview of the framework , Network topology used for the experiment is given in section 3, whereas section 4 summarizes the performance measures ,followed by results in section 5 and finally the paper presents conclusions (section-6).

2. FRAMEWORK

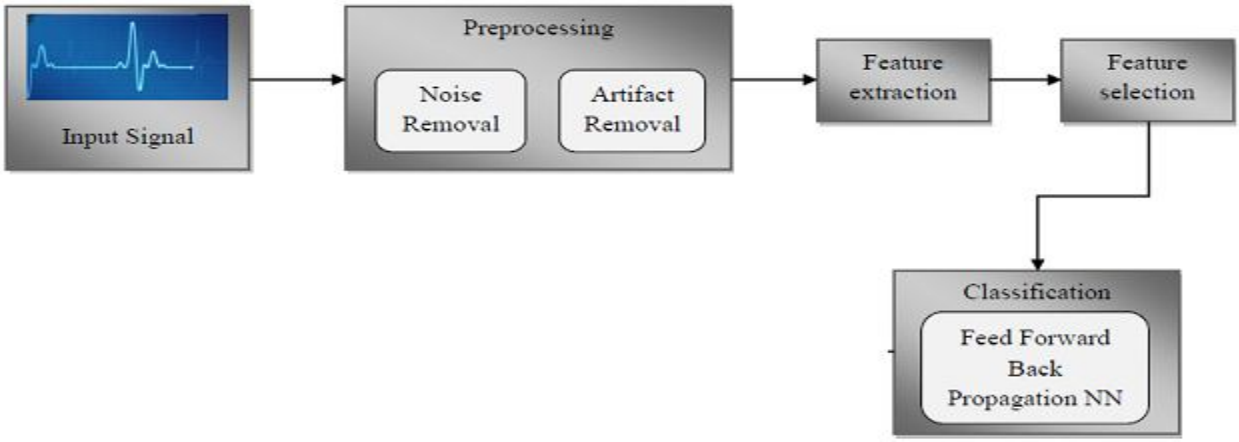

Figure 2 Block Diagram for Classification Methodology.

Figure 2 represents the complete approach used for categorization of ECG signal. This framework comprises stages like preprocessing, Extraction of Feature, selection of Features and classification. The classifier's performance is evaluated using different parameters.

1. Preprocessing:

This is the first step involved in the complete system flow. As the ECG signal will contaminated with noise, the signals need to be processed to remove noise form the signal. So while preprocessing the signal, the signal is filtered to get the undesirable noise free signal. Filtering of ECG signal is done using a band pass filter within range of 0.05HZ-100Hz to eradicate the gesture artifact, baseline wander whereas notch filter of 50Hz utilized to remove power line noise.

2. Feature Extraction:

This is the second step in the processing. From the preprocessed signal desired features need to be considered for the further processing so feature extraction need to be done. The Wavelet Transform (WT) intended to elucidate the problem of ECG signals. Itis derivative of a single generating function called the mother wavelet by translation and dilation processes. The changeable window size is the leading advantage of the WT, it is far-reaching at low frequencies whereas at high frequencies it is narrow, and therefore it is at foremost position in an optimal time-

frequency resolution in all frequency ranges. The WT of a signal is the decomposition of the signal over a group of functions found after dilation and translation of an analyzing wavelet [2]. It is possible to compress a small number of features of the ECG signals that contains a lots of data points by carrying out the signal's spectral analysis along with the WT. These features can be used to perform the categorization of ECG signals.

With purpose of recognition and diagnostic, few selected features can be used to epitomize the ECG signal [3]. The ECG signal's decomposition in time-frequency representations can be done by means of DWT. In the recent time the DWT method is being extensively used in signal processing. The most important in DWT is that at high frequency it gives good time resolution as well as at low frequency provides good frequency resolution. As DWT's time and frequency localization ability is good, input signal's local characteristics disclosure can be done by it. The DWT represents a 1-Decompodition signal s(t) in terms of shifted versions of a low pass scaling function $\varphi(t)$ and shifted and dilated versions of a prototype band pass wavelet function $\psi(t)$.

$$\Psi_{j,k}(t) = 2^{(-j/2)}\, \psi\,(2^{-j}\, t - k) \quad (1)$$

$$\varphi_{j,k}\,(t) = 2^{-j}\, \varphi\,(2^{-j}\, t - k) \quad (2)$$

In this: j controls the dilation or translation and k represents the wavelet function's position.

As DWT decomposes the signals into different scales using two filters, that is a low pass filter (LPF) and a high pass filter (HPF), Discrete Wavelet Transform is cited as decomposition by wavelet filter banks. The LPF's output coefficients are termed as approximations while the HPF's output coefficients are named details. The signal's approximations can be anything that describe its identity whereas the details gives nuance.

The consecutive low-pass and high-pass filters calculating three levels of DWT is shown below

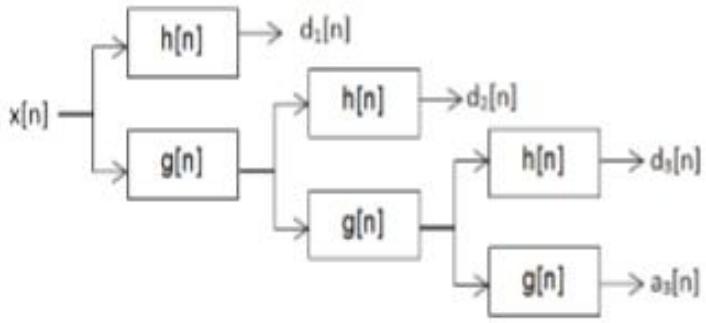

Figure 3 Three Level Wavelet Decomposition tree

The schematic presentation of DWT decomposition process with signal x[n] as input is presented in given figure. Each phase comprises two down samplers and two digital filters to yield the digitized signal. The high-pass filter g [n], is the discrete mother wavelet, whereas the h[n] is low-pass filter. The first high pass filters as well as low-pass filters down sampled outputs provide the detail, D1 as well as the approximation, A. A1 the first approximation, is decomposed again and this process is continued. The decomposition of the signal into different frequency bands is obtained by successive high pass and low pass filtering of the time domain signal [7].

3. Feature Selection:

From a the extracted features selected features need to be considered as an input to the classifier so the next step in sequence is feature selection which is optional. Various possibilities have been anticipated about features selection for describing the ECG. It's features based on not only different transforms, e.g. principle Component Analysis (PCA), Wavelet transform (WT), Hermits functions but also on the features, like, mean, variances. The dimensionality of the classification algorithm can be reduced using proper feature selection algorithms. The selection procedure estimates the subset of existing features and selects the best one for application. The best subset features consists of the least number of dimensions that most contribute to applications performance; the left behind trivial dimensions will be unused. This work gives the comparison of three different methods of feature selection i.e. genetic algorithm, BAT and IBAT.

4. Classification:

This is the concluding step of this processing technique. Various types of neural network have been used by number of researchers for the classification purpose of ECG signals. ANN has been used for the classification purpose in this work, as ANNs are self-adaptive, data driven, non-linear, accurate, and fast. It is easily scalable and also robust to noise. ANN have various advantages to list a few : 1) By using activation functions such as sigmoid it gives non-linear mapping amongst inputs and outputs for solving problems like classification of ECG signals. 2) The results obtained by it are similar or improved than deterministic or statistical approaches. For linear problems the Statistical approaches performance is good however cannot produce virtuous results in case of non-linear problems since statistical methods settled based on the hypothesis of given linear time series. 3) The inferior frequencies of the ECG can be adaptively modeled by ANN which are characteristically non-linear. 4) ANN confiscates time varying and nonlinear noise physiognomies of ECG signal [6].

The different measures such as specificity, sensitivity and accuracy have been utilized to measure the performance of given classification method.

3. NETWORK TOPOLOGY

3.1 Body paragraphs

The classification is done with the help of Feed forward back propagation neural network [9]. It contains three layers i.e single input, single output as well as single hidden layer. According to the selected features being used in classification six neurons are taken in the input layer. A single neuron was used in Output. Sigmoid activation function is used. The total number of neuron in hidden layer are 20.

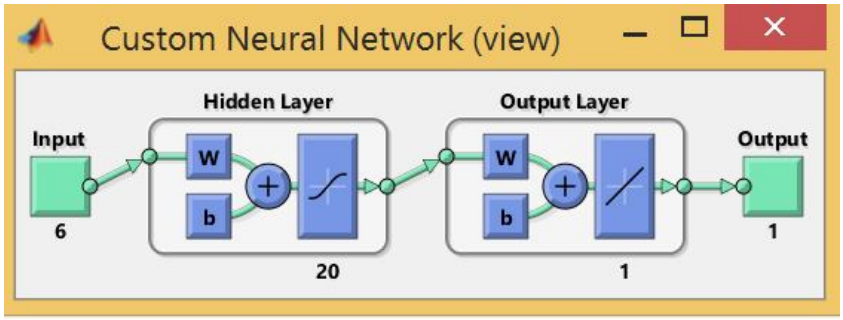

Figure 4: Neural Network view

4. PERFORMANCE MEASURES

Specificity, Sensitivity as well as accuracy are the parameters considered to measure the performance of the suggested system. True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN) decision values used for describing the used measures.TP happens when arrhythmia recognition of the classifier is in correspondence with a conclusion of the physician. TN result happens when nonexistence of arrhythmia is recommended by both the classifier and the physician. FP arises when an arrhythmia is suggested by the system for a healthy case. Lastly, FN happens when arrhythmia case is indicated as healthy by the system.

4.1 Accuracy of classification

Classification accuracy can be represented as the relation between correctly classified cases number TP and TN divided by the total number of cases N. [5]

$$Accuracy = (TP+TN)/N \quad (1)$$

4.2 Sensitivity

Sensitivity ratio of properly classified positive cases i.e. TP and the sum of TP and FN. it may be denoted as a True Positive Rate. [5]

$Sensitivity$ = (TP)/($TP+FN$) (2)

4.3 Specificity

Specificity indicates the ratio of properly classified negative cases i.e. TN and the sum of TN and FP.
$Specificity$ = (TN)/($FP+TN$) (3)

5. RESULTS

The experimental results of ECG analysis have been obtained by means of MATLAB programming. The classification of the signal is done with the help of artificial neural network. The performance measures of the system are as: sensitivity is 95.06%, specificity is 99.012 whereas the accuracy is 98.35%.

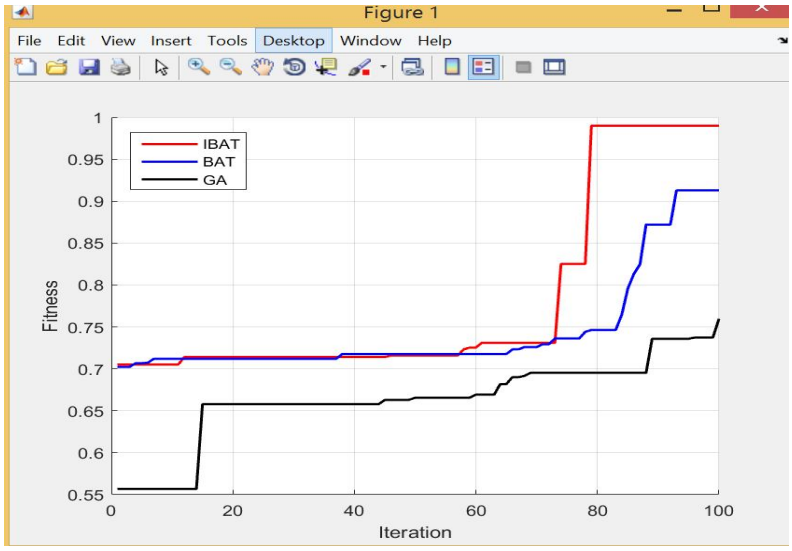

Figure 5: Performance comparison of GA, BAT and IBAT in feature selection

The figure 5 represents the performance of GA, BAT and IBAT and figure6 and figure 7 shows the classification result for the signal. The selected signal is preprocessed using band-pass and notch filter then from the preprocessed signal is features are extracted followed to this among extracted features few features are selected as an input to the classifier.

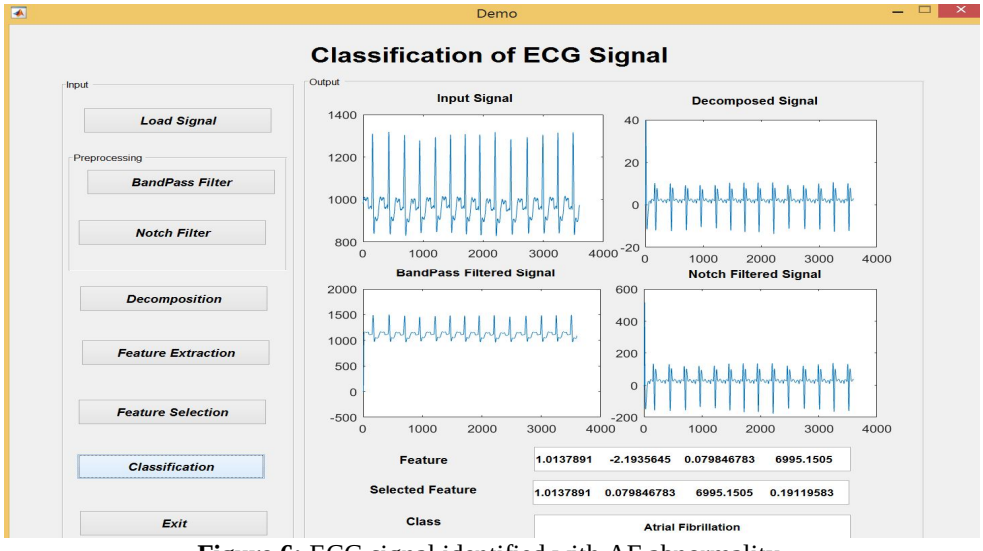

Figure 6: ECG signal identified with AF abnormality.

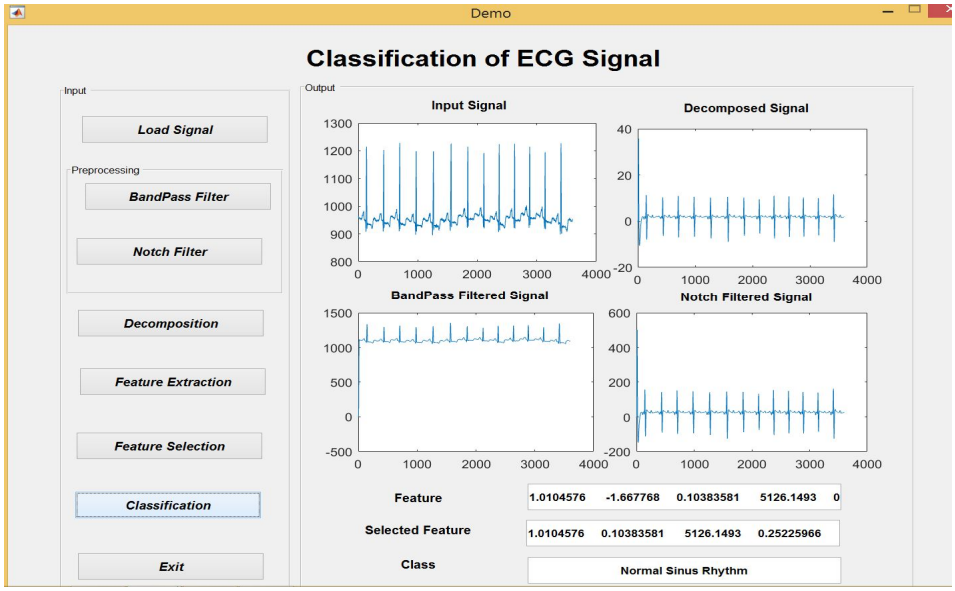

Figure 7 : ECG signal identified as Normal.

6. CONCLUSION

The proposed system can be utilized for categorizing the ECG signals automatically based on selected features. To perform the categorization of the normal and arrhythmia types use of Neural Network (NN)is done.98.35% classification accuracy is shown by the system presented. An effective and reliable classification technique for analyzing the ECG signals is proposed in the given work. The proposed method gives a computation less technique to doctors for assessing the ECG signals. The observation from the result shows that Neural Network (NN) gives the well performance.

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