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An Ann Based Intelligent System with ABC-GA Optimization for the Classification of ECG Signals

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ABSTRACT

Heart is one of the most important parts of a human being. The electric signal produced by the heart is called as ECG signal or cardiac cycle. Each cardiac cycle consists of the PQRST segments. The ECG signal analysis and classification system gives overall idea about the cardiac diseases. In recent years, many research and methods have been proposed and developed for analyzing the ECG signal and extracting features such as amplitude and time intervals for classification of signals. In this research , an efficient technique to classify the five abnormal beat [Afonso et.al (1999), Kohler et.al (2002)] signals has been developed which includes Left bundle branch block beat (LBBB), Right bundle branch block beat (RBBB), Premature Ventricular Contraction (PVC), Atrial Premature Beat (APB) and Nodal (junction) Premature Beat (NPB) along with the normal beat. The proposed technique is comprised into three stages, 1) pre processing 2) Hybrid feature extraction 3) classifier. For efficient feature extraction hybrid feature extractor is used. The hybrid feature extraction is done in three steps, i) Morphological based feature extraction ii) Haar wavelet based feature extraction iii) Tri-spectrum based feature extraction. Once the feature is extracted the Feed Forward Neural Network (FFNN) classifier is used to classify the beat signal. Artificial Bee Colony (ABC) combined with genetic algorithm (GA) is used for training the neural network. To get better accuracy best cross over rate has been chosen. The proposed technique gives an accuracy of 93%, sensitivity of 90 % and specificity of 89% for the cross over rate of 0.8.

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INTRODUCTION

The cardinal function of the Electrocardiograph is the sound management of the electrical activity of the central of the blood circulatory system i.e., the heart. An ECG beat signal contains important information that can help medical diagnosis, reflecting cardiac activity of a patient, if it is normal or failing heart that has certain pathologies Oscar Castillo *et al* (2012). The ECG beat signal investigation is applied in the identification of many heart ailments such as ischemia, arrhythmias, and Myocarditis, or disorder of heart beat or rhythm, or modification in the morphological model, and for monitoring drug effects or pacemaker action. Now-a-days, Electrocardiogram (ECG) is one of the most effective diagnostic tools to detect heart diseases. The typical ECG wave form is shown in fig.1 records the electrical activity of the heart, where each heart beat is displayed as a series of electrical waves characterized by peaks and valleys. Normally, the frequency range of an ECG signal is of 0.05 – 100 Hz and dynamic range of 1 – 10 mV Owis *et al* (2002). One cardiac cycle in an ECG signal consist of the P-QRS-T waves. Most of the clinically useful information in the ECG are found in the intervals and amplitudes as defined by its features Eddie B. L *et al.* (2009). The P wave symbolizes atria depolarization, Q, R and S waves generally known by the name QRS complex signifies the ventricular depolarization and T wave stands for the repolarisation of ventricle Maglaveras *et al* (1998).

The aim of the proposed work is to develop effective algorithms to solve problems associated with arrhythmia recognition. In order to achieve following aspects of ECG analysis are discussed.

(i) The feature is extracted by three feature extraction process 1) morphological feature extraction 2) wavelet feature extraction 3) Trispectrum based feature extraction.

(ii) After feature extraction the features are group by using hybrid classifier. In hybrid classifier two optimization techniques Artificial Bee Colony (ABC) and Genetic algorithm are used along with the neural network for classification. For better accuracy best cross over rate is calculated

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Feature Extraction:

Hybrid feature techniques are used for effective feature extraction which involves i) morphological feature extraction ii) wavelet based feature extraction iii) spectrum based feature extraction**.**

Morphological based feature extraction:

Morphological feature extraction is done in three steps. (i)Find the standard deviation of RR interval, PR interval, PT interval, ST interval, TT interval, QT interval. (ii) Second the maximum values of P, Q, R, S, T peaks (iii) number of R peaks count

Haar wavelet feature extraction:

The processing of information by the heart is reflected in dynamical changes of the electrical activities in time, frequency, and space. Mostly features in time Jekova I *et al* (2008) and frequency Khadra L *et al* (2005) are extracted and combined with efficient classifiers.

Haar wavelet transform is capable of detecting and characterizing specific phenomena in time and frequency planes. In Haar wavelet the ECG beat signals are get disintegrated into coarse approximation and detail information. For this disintegrated two filters 1) Low pass filter 2) High pass filter are used. First the ECG beat signals are passed to Low pass filter in which the low frequency beat signals less than the cut off frequency is screened. Now the ECG beat signals are passed to a High pass filter which screen the high frequency beat signals beyond the cut off frequency. The resultant beat signal from the Low pass filter is down sampled by 2 to result in coarse coefficients and the resultant beat signal from the high pass filter is down sampled to produce detail coefficients Muthuvel K *et.al* (2014), which is shown in fig 2.

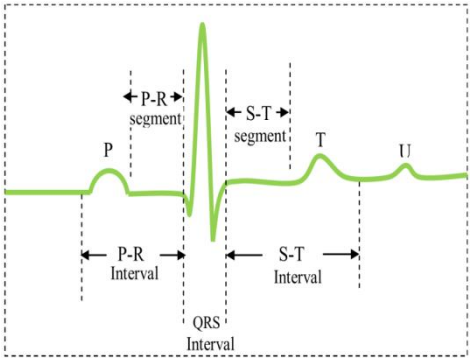

Fig. 1: ECG wave form

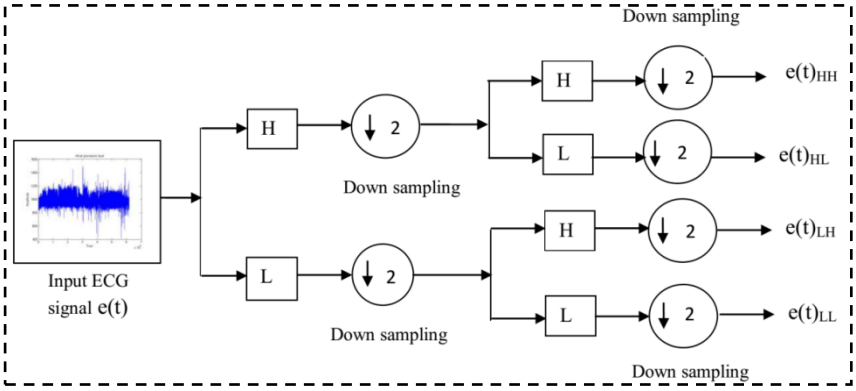

Fig. 2: Architecture of two dimensional haar wavelet decomposition occurring at level 1.

Then the mean value of the coarse coefficients is calculated by taking the average of the coarse coefficient.

Extraction of nonlinear activities through tri spectrum:

The objective of this section is to apply trispectral analysis for classification of ECG beat.

Tri-spectrum is type of statistics used to identify the output beat signal which is not directly proportional to the corresponding input beat signal. Tri spectrum can also obtain by taking Fourier transform for fourth cumulant function of random process Ge D, Srinivasan *et al* (2002).

In the trispectrum method, expectation of the frequency is obtained by taking the average of the three frequencies. It is a three dimensional structure. The resultant image is obtained in 512 * 512 pixels Muthuvel K *et al* (2014).

By using tri spectrum based feature extraction 12 features can be extracted from the input ECG beat.

ECG beat classification:

After extracting the features from ECG beat signal classifier is used to classify the ECG beat signal. The classifier use both ABC algorithm and genetic algorithm to train the beat signals in the neural network. For training purpose five abnormal beat signals are used along with the normal beat signal. The five abnormal beat signals includes Left bundle branch block beat (LBBB), Right bundle branch block beat (RBBB), Premature Ventricular Contraction (PVC), Atrial Premature Beat (APB) and Nodal (junctional) Premature Beat (NPB). The hybrid classifier involves the following steps:

Feed Forward Neural Network Layer Generation:

In the artificial neural network Anagnostou *et al* (2003) number of neurons required in the output layer depends on the target solutions in each sequence. Initially generate an output layer Muthuvel K *et.al* (2013) model to optimize the weights.

Training Phase of FFNN:

In our proposed method five abnormal beat signals are trained along with normal beat signals by using both ABC and genetic algorithm. Most of the neural network uses back propagation algorithm for training but it has many disadvantages such as it consumes more time to find the minimum error [Muthuvel K *et.al* (2015)] To avoid these defects we use both ABC and genetic algorithm. In our proposed method first train the FFNN by using the ABC algorithm. Then use genetic algorithm to train the FFNN by initializing the optimized weight obtained from ABC algorithm. For training the neural network 24 features extracted from the hybrid feature extraction is given as input layer. After optimizing the weights used in the hidden layer the six beats of ECG beat signals are get grouped in the output layer

Step1: Initialization of population:

In neural network data are mainly trained to optimize the weight and to detect the minimum error. To optimize the weights, ABC algorithm initially creates arbitrary population of solution

Step 2: Fitness evaluation:

After the generating the initial population, the fitness of the solution is evaluated. The fitness of the solution is determined by calculating the error between the target and the output obtained.

Step 3: Modification of food source by employed bee:

After initializing the solution, employed bees are allowed to search the neighbouring food source. Employed bee examine the nectar quantity i.e. fitness of the new food source. Based upon the nectar quantity and the visual information employed bee update the food source.

Step 4: Fitness selection by onlooker bee:

After collecting the information of new food source all the employed bees return to the hive and reveal the datas to the onlooker bees. The onlooker bees examines all the food source data's provided by the employed bees and select an food source based upon the nectar quantity & distance. Then onlooker bee stores the new food source in its memory and forgets the exiting data. Mean while the employed bees check the selected food source and updates its memory.

Step 5: Generation of new food source by scout bee:

After few iteration if there is no change in the food source location, the scout bees are allowed to find the new food source. If the nectar amount of the new food source is high, then the onlooker bee forget the old one and store the new food source in the memory. If the nectar quantity is not high no modification is made. In our method to generate random solution cross over technique is used.

Step 6: Cross over:

In this step randomly generate solution based upon on the optimized weight obtained from ABC algorithm. To generate random solution pair cross over technique is used in which the cross over rate is multiplied with the length of the solution. In our proposed work chromosome length as 10 and best cross over rate is calculated. After generating random solution the fitness value of the solution is examined and the best solution is given for testing.

RESULTS AND DISCUSSIONS

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In this section we discuss the result obtained from the propose technique. In our proposed work MIT-BIH Arrhythmia Database have chosen from the physiobank ATM. The Arrhythmia Database contains almost 109,000 beats. In our proposed work we have taken six beats including normal beat, abnormal beat such as Left bundle branch block beat (LBBB), Right bundle branch block beat (RBBB), Premature Ventricular Contraction (PVC), Atrial Premature Beat (APB) and Nodal (junction) Premature Beat (NPB). For our proposed work we have taken 45 beat signals in the dataset.

The evaluation of proposed ECG beat classification technique in MIT-BIH Arrhythmia Database are carried out using the following metrics.

Sensitivity:

The sensitivity of the feature extraction and the feature classification is determined by taking the ratio of number of true positives to the sum of true positive and false negative.

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Specificity:

The specificity of the feature extraction and the feature classification can be evaluated by taking the relation of number of true negatives to the combined true negative and the false positive.

Accuracy:

The accuracy of feature extraction and the feature classification can be calculated by taking the ratio of true values present in the population.

In this section we discuss the experimental result obtained by using feature extraction and classification for grouping the beats in the ECG beat signals. The figure 3 shows the two sample input ECG beat signals taken for classification. Figure 4 shows the marked P, Q, R, S, T for input beat signal. Figure 5 shows the tri spectrum plot and Figure 6, 7,8 shows for the accuracy, sensitivity, specificity of different crossover rate.

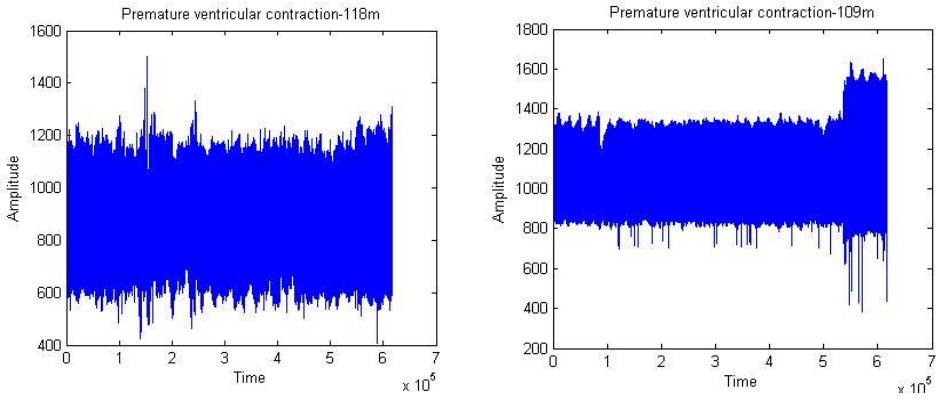

Fig. 3: Input ECG signal

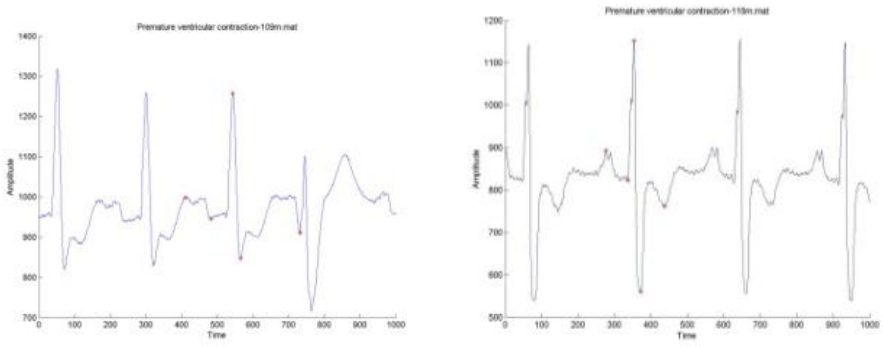

Fig. 4: Marked P, Q, R, S, T for input beat signal.

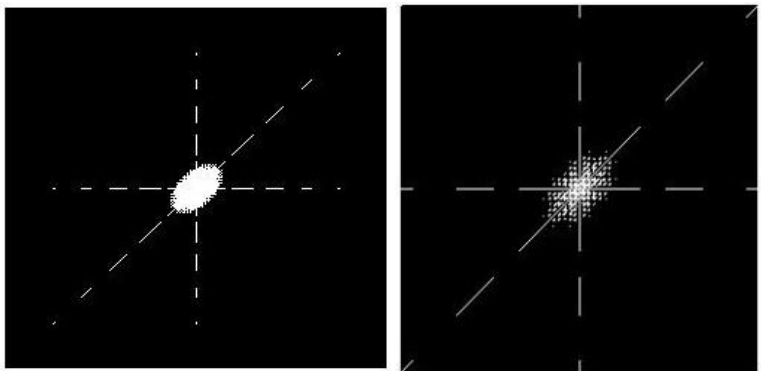

Fig. 5: Tri Spectrum plot.

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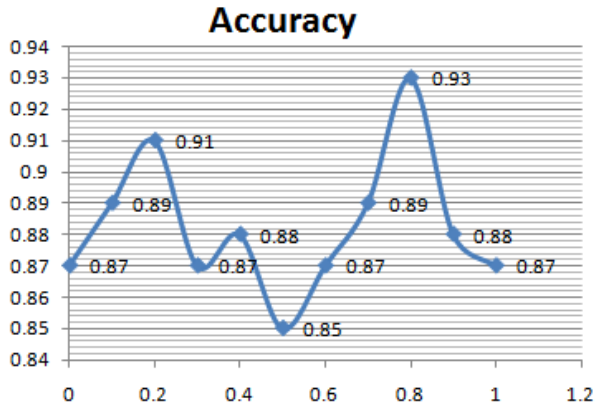

Fig. 6: Accuracy plot for different cross over rate.

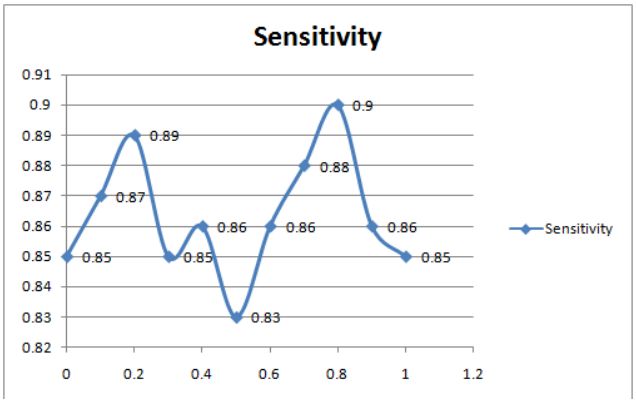

Fig. 7: Sensitivity plot for different cross over rate.

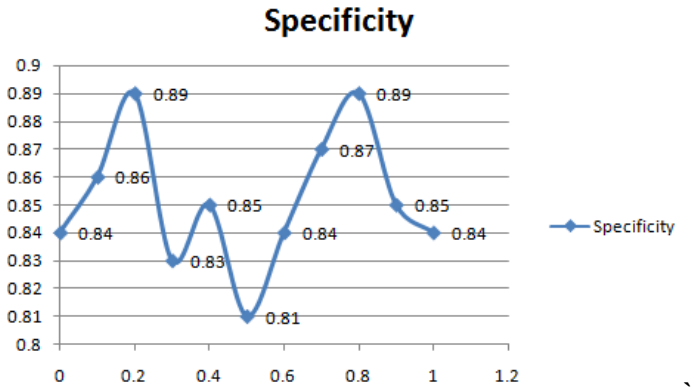

Fig. 8: Specificity plot for different cross over rate.

From the chart, it can be seen that the maximum accuracy, sensitivity, specificity occurs when the cross over rate is 0.8. By using this crossover rate accuracy, sensitivity and specificity is calculated. An accuracy of 93% sensitivity of 90 % and specificity of 89% is obtained for the cross over rate of 0.8.

Conclusion:

In this work, Tri spectrum technique for the classification of ECG signals has been proposed. Here algorithm to detect the five abnormal beat signals includes Left bundle branch block beat (LBBB), Right bundle branch block beat (RBBB), Premature Ventricular Contraction (PVC), Atrial Premature Beat (APB) and Nodal (junction) Premature Beat (NPB) along with the normal beats are classified and collected from MIT-BIH data base and these sample signals are extracted. This extracted sample signals are plotted by using matlab. The finally decisional output is obtained by using the software. The proposed technique gives an accuracy of 93%, sensitivity of 90 % and specificity of 89% for the cross over rate of 0.8.

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