Neuro-Fuzzy System for Classification of Bio-Medical Signals

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Abstract— Clinical results are often made based on doctors heuristics experience and intuitions rather than on the information concealed in the database. This rich data can be used to detect the cardiac diseases like Arrhythmia which is the irregularity in the heart beat. For reliable recognition of cardiac Arrhythmia the analysis of the electrocardiogram (ECG) signal plays a vital role. This paper deals with the acquisition of the ECG signal from MIT-BIH Arrhythmia Database Directory. The acquired signals are pre-processed and features are extracted using Fast Fourier Transform (FFT), which helps in the detection of the peak of the ECG signal. These extracted features are given as the input vector to train the Artificial Neural Network (ANN). Back propagation neural network is used to classify the signals into normal and abnormal.

Keywords— Electrocardiogram, **cardiac arrhythmia, fast Fourier transforms, feature extraction, back propagation neural network**

I. Introduction

Electrocardiogram (ECG) discloses the function of the heart, which is a significant non-invasive tool for cardiologists to diagnose numerous Cardiac diseases. If electrical activity of the human heart is slower, faster or irregular than normal signal, it results in Cardiac arrhythmia. The life span and the quality of living can be increased by the early and accurate detection of human heart abnormalities. The data from the time interval and peak of signal are used for the analysis. The ECG signals are non-stationary in nature due to which the disorders of the heart may not appear all the times. For the accurate detection of the disorder like arrhythmia, observation of signal for several hours is important.

To identify arrhythmias online or offline computerized ECG interpretations are utilised. The process consists of data acquisition, pre-processing, feature extraction and analysing the features. Ample progress has been made to find different kind of techniques used for the analysis and classification of rhythm. In circumstances like uncertainty and noise the nonlinear models such as the artificial neural networks (ANNs) are used to enhance the accuracy of reconstruction and the weakness of the conventional linear approaches are compensated.

Enormous number of research has been done on the detection and classification of the ECG Arrhythmia signals. Based on the previous research by Hassan H. Haseena [1] Pre-processing was done using the FIR filters. The parameters were considered using the spectral entropy and auto regressive model. Feature reduction was done by Fuzzy C mean clustering. The artificial neural network was a hybrid network consisting of the multi-layer feed forward network and Probabilistic neural network which was used to discriminate 8 types of the arrhythmia using the local expert classifier. This model was patient specific which resulted in the need for a less complex system for the classification of the signals. In the work done by Jeen-Shing Wang [2] linear discriminant analysis (LDA) and principal component analysis (PCA) was used for feature reduction. Classification of 8 types of arrhythmia was done using probabilistic neural network. Helton Hugo de Carvalho Junior [3] used fuzzy cluster algorithm for the classification of the signal and was implemented on XILINX FPGA. Dingfei Ge [4] used auto regressive model to classify the signal into 6 different types of arrhythmia. Roshan Joy Martis [5] worked on classification of arrhythmia ECG signal into five different categories in PCA frame work using discrete cosine transform. Similar works are carried out in which the pre-processing techniques, feature extraction and the type of the artificial network varied.

For the smart computer based systems, a lot of new techniques are employed due to the advancement of the Artificial Intelligence (AI). There are various number of (AI) methods such as genetic algorithm, expert system and fuzzy system, modular neural network[6], artificial neural network[7][8]. ANN's are widely used for the classification of the bio medical signals .ANN's have inherent capability of real time performance and pattern recognition.

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In this, paper the data is acquired from the MIT-BIH Arrhythmia Database. These obtained normal and abnormal signals are pre-processed using the Fast Fourier method which helps in detection of the peak. Back Propagation is used as the artificial neural network which helps to gain higher accuracy and increases robustness of the classification. This model classifies the signal as normal signal or abnormal signal which has the signs of Cardiac Arrhythmia.

II. Materials and Methods

A. Data acquisition

In this study, different normal and abnormal signals were considered from the Normal sinus rhythm database and Massachusetts Institute of Technology – Beth Israel Hospital (MIT-BIH) arrhythmia database which contains sets of normal and abnormal signals from the human heart. This database consists of two channel ambulatory electrocardiogram signals. These signals are sampled with 11bit resolution over 11mV range at 360hz also their corresponding beat and annotations of rhythm. For the analysis the signals were recorded from ML II(Mason-Likar) leads system . For this study 20 sets of normal and abnormal signals were chosen for classifying them into normal and abnormal signals.

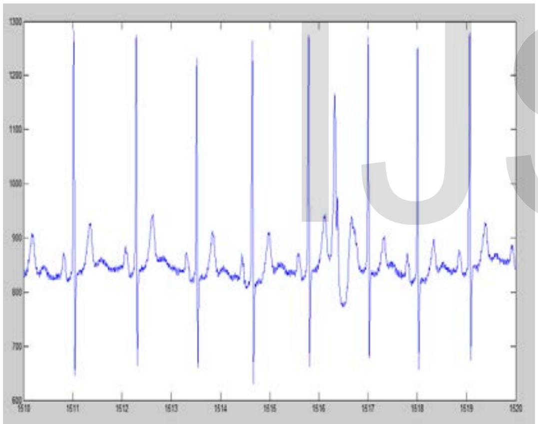


Fig 1: signal with arrhythmia

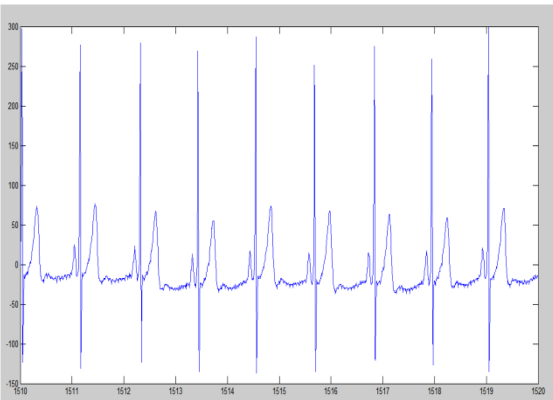
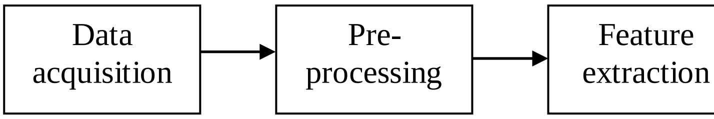


Fig 2: Normal ECG signal



B. Pre Processing and feature extraction

Block diagram of the proposed model

The recor... d signals wh... skin interference, motion artefacts from electrodes and Electromyogram (EMG) signals because of interference in power line. These unwanted signals should be removed before the signals are used for feature extraction. Fast Fourier transform is used for the removal of noise and the result from this is used for the feature extraction.

It is necessary to extract suitable metrics from the acquired signal. Q, R, S deflections are identified initially before the features are extracted. Initially the R peak is detected which helps in the detection of the Q and S points. Due to R peak's distinctive characteristic and QRS complex's idiosyncratic nature, the peaks are easily identified from the maximum distorted ECG signal. These points can be used as the basis for feature identification. To identify the deflections the Digital Signal Processing methods were implemented which is Fast Fourier Transform (FFT).

In FFT the computational complexity is less when compared to the conventional methods [10]. FFT is applied on the ECG signal using the below equation:

$$X_k = \sum_{n=0}^{N-1} xn e^{\frac{-2\pi i\, nk}{N}} \quad , k = 0 \ldots N-1$$

From the values obtained from the FFT of the signal the central tendency and the dispersion of the data was found by calculating the mean and the standard deviation. Based on the values, the significant 10 values were used to create the input vector for the neural network.

Mean of the samples is given by the following formulae:

$$\mu = \frac{\text{sum of all the samples}}{\text{Total number of samples}}$$

Standard deviation of the samples is given as:

$E[X] = \mu$

$$\sigma = \sqrt{\left(E(X^2) - \left(E(X)\right)^2\right)}$$

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C. Back propagation neural network

Back propagation is the learning rule for the nonlinear differentiable transfer function and multiple-layer networks. To train the network the input and the corresponding target vector are used .the train of the network happens until it can approximate a function. Based on the error that is generated the weights are adjusted to obtain maximum efficiency. Without knowing the system's mathematical model the learning happens based on the desired mapping between the output and input signals of the system.

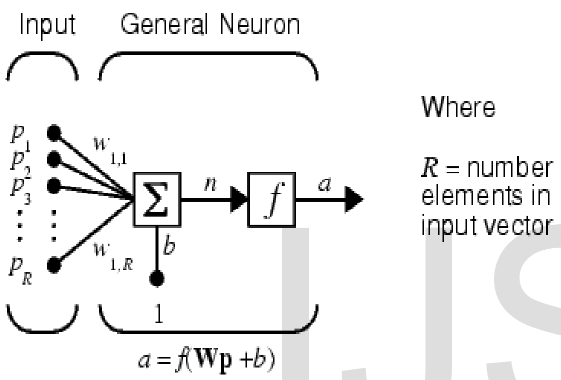

Fig 3: Artificial neuron

Feed forward networks have one or more hidden layers of sigmoid neurons trailed by an output layer of linear neurons. To learn the linear and nonlinear functions between the output and input vectors, neurons with multiple layers of nonlinear transfer function is used.

The values from linear output layer is between the range -1 to 1.sigmoid function can be used at the output layer to have value from 0 to 1.

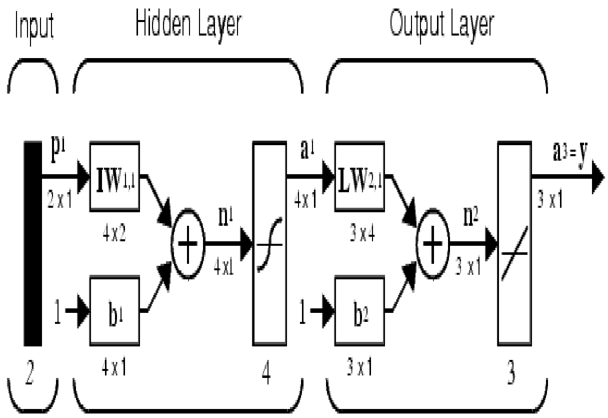

Fig 4: neural network

The table below consists few of the input vectors that are obtained after the feature extraction and the corresponding target vector.

The initial 10 values are from the abnormal signal and the next 10 values are normal signals. The neural network is trained with the corresponding values.

Input vector	Output target
0 0 0 1 1 1 0 1 0 0	1
1 1 0 0 1 0 1 0 0 1	1
0 0 1 1 1 1 1 0 0 0	1
0 0 1 1 0 0 0 0 0 1	1
0 1 1 0 1 1 0 1 0 0	1
1 1 0 0 0 0 1 1 1 0	1
0 1 1 0 0 0 0 1 1 1	1
1 0 1 1 1 0 0 0 1 0	1
0 1 1 0 0 1 0 0 0 1	1
0 0 0 0 1 1 1 1 1 1	1
1 0 0 1 1 0 0 0 0 0	0
0 1 1 1 0 0 0 0 0 0	0
0 1 1 0 1 0 0 0 0 0	0
0 1 1 1 1 0 0 0 0 0	0
0 0 0 1 0 1 0 0 0 0	0
1 0 1 0 1 0 0 0 0 0	0
0 1 1 1 1 0 0 0 0 0	0
0 0 1 1 0 0 0 0 0 0	0
1 1 1 1 0 0 0 0 0 0	0
0 1 0 0 1 0 0 0 0 0	0

Table 1: list of input vector and corresponding target vector

III. RESULTS

The neural network created consists of 10 input neurons.. The hidden layer also contains the 10 neurons. The output is a single neuron which tells if the signal is abnormal or normal. The activation function used in the input layer and the hidden layer is logsig. If the output is 1 then it symbolises that the

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signal is an abnormal signal else it is a normal signal. The learning rate to train the network is 0.2.

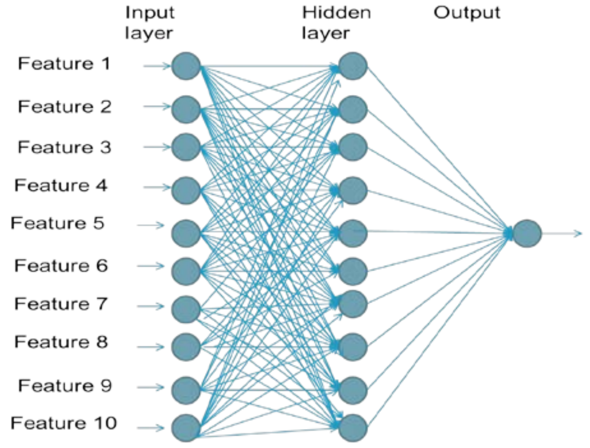

Fig 5 Architecture of the neural network created

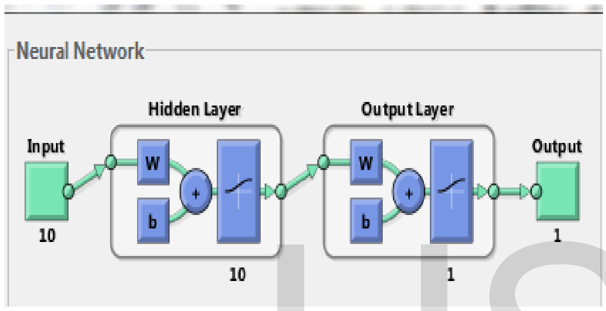

Fig 6: Neural netowork created from the MATLAB neural netwrok tool

The Fig 7 is the graph of epochs versus the mean square error value. The network reaches the mean square value of 0.1 after 164 epochs.

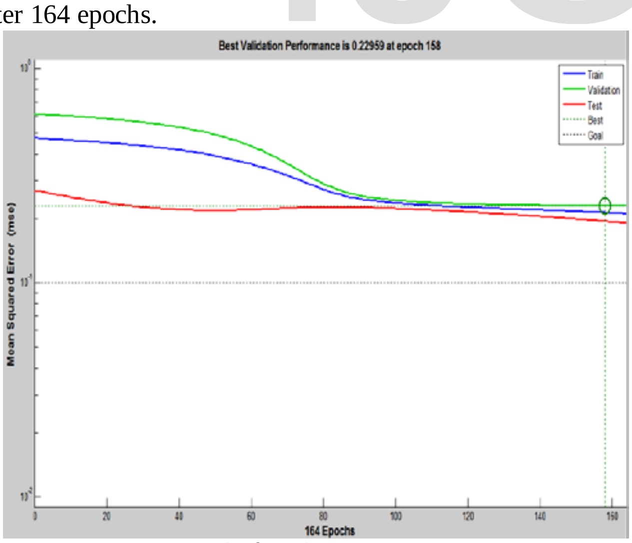

Fig 7: graph of epochs v/s mean square error

IV. Conclusion

A system that helps the doctors to predict cardiac arrhythmia in advance. Use of fast Fourier transform gives significant features for the classification. Back propagation gives better classification results. By changing the techniques for pre-processing, algorithms for feature extraction and the learning rule for the neural network greater accuracy can be obtained. This work used 50 data sets to train the network; more number of data sets can be used to increase the efficiency of the system.

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