Neural Network based Classification of ECG signals using LM Algorithm

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Abstract—Electrocardiogram is one important physiological signal, which is used in assessing cardiac health. The extraction of features used for identification of the state of ECG is discussed in this paper. Using MATLAB programs/tools, different statistical features are extracted from normal and arrhythmia spectra. These features include differentiation and count of spikes for different thresholds, mean, standard deviation, energy, residuals on curve fitting, LPC coefficients etc. The values of the feature vector reveal information regarding cardiac health state. Then a classical multilayer feed forward neural network with back propagation algorithm is employed to serve as a classifier of the feature vector, giving 100% successful results for the specific data set considered.

Keywords — Neural Networks, Electrocardiogram, Linear Prediction Coefficients.

I. INTRODUCTION

There are many instances in which it is necessary to monitor and transmit physiological events from a distance for convenient Biotelemetry. Electrocardiogram is one important physiological signal, which is used in assessing cardiac health. In general the cardiologist looks critically at the various time intervals, polarities and amplitudes of the ECG to arrive at the diagnosis. Different features are extracted from these ECG spectra. This feature vector for both normal and arrhythmia spectra can be used for classification using ANN. PCA technique can also be implemented on the same data and a comparative study on performance of both ANN and PCA can be tabulated.

The proposed study is done on KMC arrhythmia ECG database, sampled at 360 samples per second. As the frame size is 400 samples, this method achieves a bit rate of 45bits per second, which is very much less in comparison of other methods. A large amount of data produced by ECG monitoring and recording facilities needs to be analyzed for classification of normal and arrhythmia conditions.

For further analysis using Matlab@6.1 algorithms, these data are recorded as sample points. Using MATLAB programs/tools, features are extracted for different spectra.

These features include differentiation and count of spikes for different thresholds, mean, standard deviation, energy, residuals on curve fitting, LPC coefficients etc.

The features like 10th degree polynomial curve are fitted onto ECG spectra and residuals values are plotted as shown in Figure 1.
II. THE ANN DIAGNOSTIC SYSTEM ARCHITECTURE

An ANN structure is employed for the classification of spectra. It consists of four modules as shown in Figure 2.

![Signal Acquisition][Normalize/Filtering][Feature Extraction][Artificial Neural Network][Recognition Normal Malignant]

Fig.2. The model of ANN scheme used to perform diagnosis on human oral tissue samples.

The signals are filtered with 21 ordered median filters to eliminate undesirable spikes due to noise and other disturbances. The signal is then fed to the feature extraction module and different features were extracted.

III. FEATURE EXTRACTION

1) Differentiation

DIFF (X) for a vector X is \([X (2) - X (1), X (3) - X (2), ... , X (n) - X (n-1)]\). DIFF (X) for a matrix X is the matrix of row differences, \([X (2: n, :) - X (1: n-1, :) ]\) \([13, 14]\). 1st order differentiation was carried out on QRS of each normal and arrhythmia spectra.

After completion of finding the number of peaks at thresholds 100, 250, 500, 750 for 25 normal and 25 arrhythmia spectra, the mean, standard deviation and variance were determined and are tabulated in Table 3.1 and Table 3.2.

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Mean</th>
<th>Std.deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>TH&gt;0.005</td>
<td>444.0635</td>
<td>64.0907</td>
<td>3.9 x 10^3</td>
</tr>
<tr>
<td>TH&gt;0.012</td>
<td>101.9282</td>
<td>45.1736</td>
<td>1.637 X 10^3</td>
</tr>
<tr>
<td>TH&gt;0.005</td>
<td>10.1</td>
<td>11.7606</td>
<td>93.4243</td>
</tr>
<tr>
<td>TH&gt;0.01</td>
<td>2.6556</td>
<td>2.8365</td>
<td>8.0169</td>
</tr>
</tbody>
</table>

2) Energy

For vectors, SUM (X) is the sum of the elements of X, for matrices, SUM (X) is a row vector with the sum over each column that corresponds to energy.

The energy was obtained for different windows of data points for normal and arrhythmia spectra where significant variations in energy distributions were observed.

3) 4th order linear prediction coefficients (LPC)

4th order linear prediction coefficients for normal and arrhythmia spectra are determined and are found as one of the prominent discriminating factor between these two cases. The coefficients like radius and angle are the features that are obtained as per the equation given below.

The radius and the angle in radians are taken from the polar diagram.

IV. ANN IMPLEMENTATION

A. Design of ANN with Back Propagation Algorithm:

Three layer networks are sufficient to design any nonlinear network. Input is a layer of nodes with three feature vectors as input. Single second and third layers have same activation function for all neurons. Activation function is a tan sigmoid function as shown in Figure 3.

LM Back propagation algorithm, is used for training.

![Activation function – Tan sigmoid](Fig 3. Activation function – Tan sigmoid)

Single hidden layer is considered. An optimum number of seven neurons are considered in hidden layer and one neuron in output layer. The performance goal is set at 0.0001 accuracy. Number of epochs is set for 15,000. The learning cycle updates the weights of output layer and progress backwards. Error function is MSE and updating in negative gradient.
B. Training of ANN:

Data from normal and pathology were obtained from KMC Hospital, Manipal. Data of 50 normal and 50 arrhythmia are used to train the network.

Feature vector is constructed and training program is executed. The training of ANN stops once the performance goal is met, as shown in Figure 4. The convergence is achieved in 156 epochs.

V. RESULTS

Feature vector of 16 test data of Normal and 16 test data of arrhythmia are given to network to classify. The results are shown in Table 5.1.

VI. CONCLUSION

Our method achieves the discrimination between normal and arrhythmia ECG spectra. Furthermore, a small time needed to acquire and analyze the spectra together with the high rates of success, proves our method very attractive for real—time applications. The results of ANN has been verified with the results of PCA and found satisfactory. This gives us to firmly decide on the pathology. Further, performance parameters can be accurately judged if the tests are carried out on large number of spectra. As less number of features is used, computational delay in training the ANN is reduced. Gradient descent algorithm is too slower and convergence depends on learning rate. Hence high performance algorithm (Levenberg – Marquardt algorithm) which operates in batch mode is used for fast training. Specificity, Sensitivity and Accuracy obtained are 100%, 87.5% and 94% respectively.

REFERENCES


Mr. G. Subramanya Nayak has B.E degree in E&C Engineering from Mysore University and M.Tech in Biomedical Engineering from Manipal University. He is presently pursuing his PhD in the area of Biomedical Engineering. Under the guidance of Co-Author Dr. Puttamadappa C, Mr. Nayak has published more than 10 papers in National / International Journals and conferences, with some papers published as Book Chapters in Springer online.

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