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Monitoring of ECG Signals by using Neural Network

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***Abstract*: Cardiac arrhythmias are classified by abnormal activities in the heart. These abnormalities can be analyzed by an electrocardiogram (ECG). Details from this electrical signal can be used to classify what type of arrhythmia, if any, the patient has by analyzing the PQRST wave properties. Multiple data samples of normal ECG characteristics also were read by an artificial neural network (ANN) and analyzed for the differences between a normal signal and an irregular signal. The data was extracted from the MIT-BIH Arrhythmia database. A typical method used to analyze cardiac arrhythmias is to take the Fast Fourier Transform (FFT) of the signal. In this study, an alternate method is used to predict cardiac arrhythmias. A neural network is designed and programmed with this data and then tested to validate the data set. The pattern recognition tool in MATLAB is then used to analyze and predict the data. The program results were tested to validate the data set. The ANN achieved 98.6% accuracy on the test data. The findings and outcome probabilities from this study are more accurate than some current methods of analysis used today. When neural networks are further used to analyze and test medical data samples, the medical community and patients will experience improvements in the diagnosis of heart abnormalities and early detection of debilitating medical conditions.**

***Keywords*: ECG classification; preprocessing; neural network; mit-bih database; feature extraction, Disease Classification.**

1. Introduction

The Electro Cardio Gram (ECG) signal is an important signal among all bioelectrical signals. Analysis of the ECG signal is widely used in the diagnosis of many cardiac disorders. It can be recorded from the wave passage of the depolarization and repolarization processes in the heart. The potential in the heart tissues is conducted to the body surface where it is measured using electrodes.

Figure 1 illustrates two periods of the normal ECG signal. The P, Q, R, S and T waves are the most important characteristic features of the ECG. The peaked area in the ECG beat, commonly called QRS complex, together with its neighboring P wave and T wave, is the portion of the signal through to contain most of the diagnostically important information. Other important information includes the elevation of the ST segment and heartbeat rate, the RR or PP. The shape of ECG conveys very important hidden information in its structure. The amplitude and duration of each wave in ECG signals are often used for the manual analysis. Thus, the volume of the data being enormous and the manual analysis is tedious and very time-consuming task.

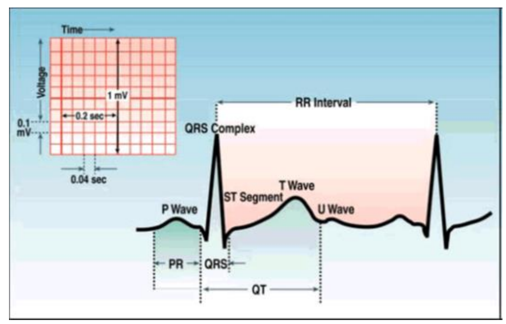

Fig. 1. Two periods of the normal ECG signal

Naturally, the possibility of the analyst missing vital information is high. Therefore, medical diagnostics can be performed using computer-based analysis and classification techniques [1]. Several algorithms have been proposed to classify ECG heartbeat patterns based on the features extracted from the ECG signals. Fourier transform analysis provides the signal spectrum or range of frequency amplitudes within the signal; however, Fourier transform only provides the spectral components, not their temporal relationships. Wavelets can provide a time versus frequency representation of the signal and work well on non-stationary data [8-10]. Other algorithms use morphological features [16], heartbeat temporal intervals [11], frequency domain features and multifractal analysis [12]. Biomedical signal processing algorithms require appropriate classifiers in order to best categorize different ECG signals. . Computer-based diagnosis algorithms have generally three steps, namely: EGC beat detection, extraction of useful features from beats, and classification. In this paper, we propose a Neural Network (NN) based algorithm for classification of arrhythmias as well as the normal signal. Our algorithm uses some features obtained by NN. We extract some important features to achieve both an accurate and a robust NN based classifier by using a number of training patterns.

2. Methodology

The analysis of this data is done by an artificial neural network. An ANN is a computer network consisting of artificial neurons that are used to solve problems without creating a model of a real system. This is used by a computer program MATLAB to create the desired results. Data is inputted and trained by this neural network and then some of the data is used for validation and actual testing. For the data in this project, This division was chosen based on prior cases. Typically, one uses about 15% of the data to train, 15% to validate, and 70% to test the dataset. These are the default percentages suggested in MATLAB. These percentages can be manipulated based on the user, but these default percentages were chosen because it gave enough data for each category while still having a large amount of data to test the network.

Physicians make a correct diagnosis with the help of certain physical signs present during arrhythmias but electrocardiography is the standard method that has been adopted by the medical institutes for recognizing cardiac arrhythmias. Therefore ECG has become the most common and powerful clinical diagnostic tool to detect the cardiac diseases. ECG gives invaluable information about the workload of the different chambers of the heart. The shape and size of the ECG signals provide information which helps us to determine the nature of the cardiac disease. The analysis of the ECG signals are computer assisted as the information from the signals are difficult to be analysed visually by the human eye. ECG samples are taken from MIT-BIH Arrhythmia database for computer aided detection and classification. Tachycardia, Atrio Ventricular Block, Normal Sinus Rhytmn and Bradycardia are the classes of ECG signals which are used for classification task. The samples in the MIT-BIH database have a sampling frequency of 360 Hz. Matlab software is used for detection process. It provides required information about the amplitude and interval between the peaks of the ECG signals [1]. Total 55 ECG data subjects were analyzed.. 05 subjects from Normal set and 05 subjects from arrhythmia set were analyzed for feature extraction and classification and data were divided in training, testing and validation of proposed algorithm.The features from the ECG samples are extracted and multiple sets of PQRST waves are taken from different locations of the ECG sample so that the data obtained is accurate. The features are extracted by means of wavelet transform. The components of the ECG signal used for classification are PR interval, QRS complex, RR interval. After the parameters are extracted they are feeded into the neural network as input. The output provides us with the weights of each signal which helps to determine the disease accurately. Figure 1 shows the process flow. Adaptive filtering is used in Pre-processing stage and Wavelet transform is used in the processing stage.

A. Pre-processing

Noises from the ECG signal have to be removed for accurate analysis of the signal. We use adaptive filter since it removes the noise power spectrum which changes over time and it has a self-learning ability which is not present in normal digital filters. The filter coefficients are modified regularly to improve the performance of the system. The adaptive filter takes two input signal, the input signal mixed with noise and the desired signal. The filter setup has a feedback loop which varies the filter parameters to reduce the error. Error output is the difference between the desired signal and the filter output. This process is iterated few times until an optimum error rate is reached although reaching zero error is practically impossible. The samples from the MIT-BIH databases for several arrhythmia types are passed through this adaptive filter with the introduction of noise and the output of the filter gives the desired signal after removing the noise adaptive filters have the capacity to adjust its parameters to make the error in the affected signal zero thus removing the noise in the signal. There are several algorithms that can be implemented in adaptive filters; broadly they are classified into Least Mean Square algorithm and Recursive Least Square algorithm. The performance of different algorithm is measured by parameters like rate of convergence, computational complexity and cost. RLS algorithm has several advantages over other algorithms [2]. It can handle any type of noise for example; DC noise such as abrupt change in signal cannot be handled by LMS. RLS have faster convergence rate, however there is trade-off between the faster convergence and complexity of the computations. The samples that are downloaded from the MIT-BIH database are imported to the mat lab. Relevant mat lab functions have been used to implement the adaptive filter algorithm.

3. Classification – neural network

The number of processing elements per layer and the number of layers are very important for NN classification. The number of the processing elements in the hidden layer should increase if there is an increase in complexity between the desired output and the input. The upper bound for the elements in the hidden layer is set by the amount of Training Set available. For new data sets additional network is useless if the processed model can be separated into multiple stages. Back- propagation network always has an input layer, at least one hidden layer and an output layer. In our project classification of the ECG signals is done using two layers feed forward back propagation neural network pattern recognizer The hidden layer contains 'sigmoid' activation function and output layer consists of softmax neurons. Scaled conjugate gradient back propagation is used for the training. Figure 2 below shows the architecture of the neural network pattern recognizer used for the training. 10 neurons are used in the hidden layer.

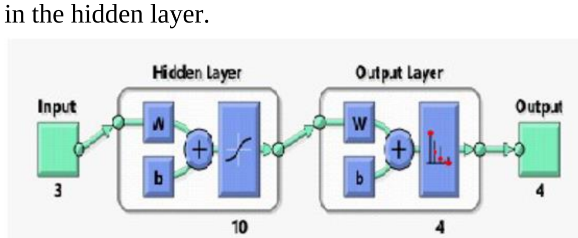

Fig. 2. Neural Network architecture for the ECG classifier.

Neural network has a very high tolerance to noisy data and can also classify patterns which are not well trained. Initial weights can be chosen randomly. Errors are back propagated to the system so that the weights can be adjusted and it can be applied for next record. Weights are tweaked so this process is repeatedly done. The error should be minimized so the connection weights should be continually refined during the training of the network. This can be achieved only when same set of data's are processed many times. Validation is a measure of the network generalization and the training will stop when generalization stops improving. With the test data the network performance during and after training is evaluated. Testing data is not connected with training.

4. Results & discussion

Using MATLAB R2013a the overall classification was done using Neural Network Classifier. The design of the system is depicted. The overall samples are divided into three categories-

- Training Data-50 % of total dataset.
- Testing Data- 50 % of total dataset.

Fig. 3 shows the sample of 16272.m QRST wave detection for Normal ECG signal.

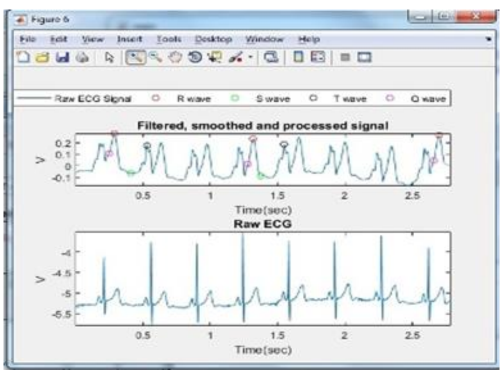

Fig. 3. QRST wave detection

Fig. 4 shows the sample of 100.m QRST wave detection for Arrhythmia ECG signal.

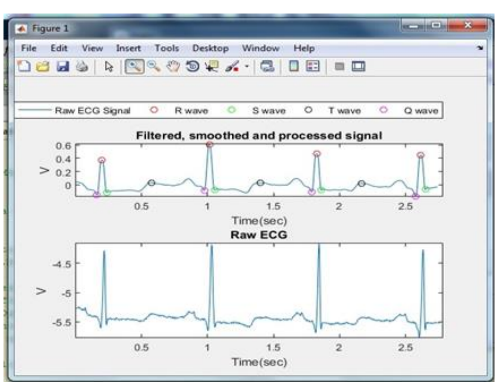

Fig. 4. QRST wave detection

The overall Confusion Matrix for the given neural network is shown below in table 1 with number of hidden nodes =10

Table 1
Performance of Neural Network with number of hidden nodes =10

Type of Neural Network	Percentage of Correct Classification	Percentage of Incorrect Classification
Pattern net	100%	0%
Feed forward Net	75%	25%
Cascade forward net	75%	25%
Fit net	100%	0%

As per above evaluations fitnet was found to give the best performance for 10% of seen data only.

We have also evaluated the performance of the system using Neural Network. The Neural Network also gives better accuracy of 100% for the classification of Arrhythmia Using ECG.

5. Conclusion

An efficient ANN system is automated for classification of arrhythmia using a set of ECG signal data is done in this paper. The results show that parameter extraction using feed forward neural network classifier outperforms other classifiers. The proposed system could aid cardiologists in improving the efficiency of detecting and classifying arrhythmia. The accuracy of the classification can be improved by selecting more parameters to train the neural network. A MLP model for classifying all arrhythmia classes using this approach can be made. This system can be further developed for practical application.

References

[1] Vuksanovic B, Alhamdi M, "ECG based system for arrhythmia detection and patient identification, Information Technology Interfaces (ITI). Proceedings of the ITI 2013 35th International Conference. pp: 315- 320 (2013).
[2] Islam SZ, Islam SZ, Jidin R, Ali, "Performance study of adaptive filtering algorithms for noise cancellation of ECG signal," Information, Communications and Signal Processing, 2009. ICICS 2009. 7th International Conference (2009).
[3] Abibullaev B, Seo H, "A new QRS detection method using wavelets and artificial neural networks, "Journal of Medical Systems 35: 683-691 (2010).
[4] Jadhav SM, Nalbalwar SL, Ghatol A A, "Arrhythmia disease classification using Artificial Neural Network model," Computational Intelligence and Computing Research (ICCIC), 2010 IEEE International Conference, Coimbatore. Pp. 1-4 (2010).
[5] Sahoo SK, Subudhi AK, Kanungo B, Sabut SK, "Feature extraction of ECG signal based on wavelet transform for arrhythmia detection," Electrical, Electronics, Signals, Communication and Optimization (EESCO), 2015 International Conference, Visakhapatnam. pp. 1-5 (2015).
[6] Sabarimalai MM, Soman KP, "A novel method for detecting Rpeaks in electrocardiogram (ECG) signal," Biomedical Signal Processing and Control 7: 118-128 (2012).
[7] R. Acharya, P. S. Bhat, S. S. Iyengar, A. Roo and S. Dua, "Classification of heart rate data using artificial neural network and fuzzy equivalence relation," The Journal of the Pattern Recognition Society, vol. 130, pp. 101–108 (2002).
[8] K. Minami, H. Nakajima and T. Toyoshima, "Real-Time discrimination of ventricular tachyarrhythmia with fourier-transform neural network," IEEE Trans. on Biomed. Eng, vol. 46, pp. 179-185 (1999).
[9] I. Romero and L. Serrano, "ECG frequency domain features extraction: A new characteristic for arrhythmias classification," in Proc.23rd Annual Int. Conf. on Engineering in Medicine and Biology Society, pp. 2006-2008 (2001).

[10] P. de Chazal, M. O'Dwyer and R. B. Reilly, "A comparison of the ECG classification performance of different feature sets", IEEE Trans. on Biomed. Eng, vol. 27, pp. 327-330 (2000).

[11] P. de Chazal, M. O'Dwyer and R. B. Reilly, "Automatic classification of heartbeats using ECG morphology and heartbeat interval features", IEEE Trans. on Biomed. Eng, vol. 51, pp. 1196- 1206 (2004).

[12] C. Alexakis, H. O. Nyongesa, R. Saatchi, N. D. Harris, C. Davis, C. Emery, R. H. Ireland and S. R. Heller, "Feature extraction and classification of electrocardiogram (ECG) signals related to hypoglycemia", Proc. Computers in Cardiology, vol. 30, pp. 537-540 (2003).

[13] P. Ivanov, M. QDY, R. Bartsch, et al, "Levels of complexity in scale invariant neural signals", Physical Review (2009).

[14] S. Z. Mahmoodabadi, A. Ahmadian, M. Abolhasani, P. Babyn and J. Alirezaie, "A fast expert system for electrocardiogram arrhythmia detection", Expert system, vol. 27, pp. 180-200 (2010).

[15] S. Osowski, L. T. Hoai and T. Markiewicz, "Support vector machine-based expert system for reliable heartbeat recognition", IEEE Trans. on Biomed. Eng, vol. 51, No. 4, pp. 582-589. (2004)

[16] T. H. Linh, S. Osowski and M. Stodolski, "On-line heart beat recognition using hermite polynomials and neuro-fuzzy network", IEEE Trans. on Instrumentation and Measurement, vol. 52, pp. 1224-1231. (2003)

[17] Y. H. Hu, W. J. Tompkins, J. L. Urrusti and V. X. Afonso "Applications of artificial neural networks for ECG signal detection and classification", The Journal of Electro cardiology, vol. 26, pp. 66-73, (1994).