Volume 7, Issue 2, February 2017 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Identification of Abnormalities in ECG Signal Using Neural Pattern Recognition Tool

Praveen Kumar Rai, Deepak Chaudhary
IET Alwar, Rajasthan,
India

DOI: 10.23956/ijarcsse/V7I2/0118

Abstract: Identification of abnormal ECG now a day's needed very efficient methods and techniques to give accurate result for heart problems. In this paper we have used more powerful tool i.e. Neural Pattern Recognition Tool to identify two types of abnormal ECG known as MIT-BIH Atrial Fibrillation ECG and MIT-BIH Malignant Ventricular ECG. Our proposed model gives 100% accuracy for Atrial Fibrillation and 83.33% accuracy for Malignant Ventricular ECG detection.

Keywords : Neural Pattern Recognition Tool (nprtool), Electrocardiogram (ECG), MIT-BIH database,. Atrial Fibrillation, Malignant Ventricular

I. INTRODUCTION

The heart problems of common man are increasing at regular basis. Electrocardiogram (ECG) is a test that records the electrical activity of the heart. It is used to test for irregularities in how the heart functions. To study about ECG signals is not so easy. Its non-linear nature makes a difficult task to study it. In such cases Neural Pattern Recognition (NPR) tool is very important tool for analysis. When a signal pattern becomes non periodical in nature then it indicates about some types of arrhythmia. Atrial fibrillation (AF), Ventricular Premature Beats, Couplet, Bigeminy, Fusion beats, asystole are few types of arrhythmia. The Neural Pattern Recognition (NPR) tool objective is to use and integrate the best features of neural network. It may also be used for classify the nonlinear patterns such as ECG to analysis with accurate results [1,2].

The activity of heart is represented by Electrocardiogram (ECG) [3]. The person who do such type of work is known as cardiologist. For analysis of heart problems of a common man, millions of ECG is taken to distinguish between different types of heart problems. The analysis of ECG results may vary person to person depending upon their analysis. So, it becomes the need of some automation system which results accurate and do not vary person to person [4]. The waveform formed by recorded ECG is the result electrical depolarization and repolarisation of heart patterns. Any type of abnormality shown in heart rate or rhythm or disorder of morphological pattern shows the existence of arrhythmia, which could be recorded by ECG [5].

A typical ECG diagram is shown in Fig. 1. Physicians located some points such as P points, Q points, R points, and **S** points in the ECG. From these points we can locate the P-complexes, QRS-waves, T-complexes, and U-waves in given ECG. These waves and complexes are defined in Fig. 1. Physicians have knowledge about the shapes of those waves and complexes. Based on those parameters they can estimate that whether the ECG characteristics shows signs of cardiac disease or not. The judging parameters are the height as well as the interval of each wave, such as RR interval, PP interval, QT interval, and ST segment [6].

P wave: The P wave is the result of depolarization of atria. I this case the electrical signals moved from SA node to the direction of AV node and spreads in the direction from right to left atrium, and that's why depolarization (contraction) occurs for atria [7].

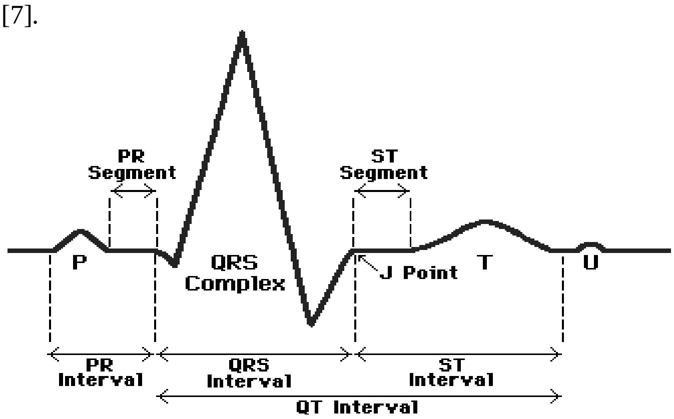

Figure 1. The different components of ECG signals [8]

QRS complex: The sequence of three waves Q wave, R wave and S wave forms the QRS complex. This complex is the result of rapid depolarization of both ventricles. The amplitude of QRS complex is much higher as compared to P wave because ventricles have bigger muscle mass compare to atria.

T wave: The T wave and the ST segment are the results of ventricular repolarisation.

U wave: The U wave are rarely visible and its not sure that it will seen or not. It only produced when there is the repolarisation of papillary muscles occurs [9].

In this paper we have taken Atrial Fibrillation Arrhythmia ECG database and Malignant Ventricular Arrhythmia database, the normal sinus rhythm gives you an idea about that rhythm is normally generated from the sinus node in a normal manner in the heart.

In most of the research paper people have taken single ECG bit for analysis, but we have taken the complete 10 sec ECG in our research which include of many ECG bit is taken for analysis which must be take care in case of heart beat variability. The heart rate values are dependent upon age factor and its also not same for all normal people i.e. normal heart rate for a infant is about maximum of 150 beats in one minute, also the child of age 5 years have heart rate is about 100 beats per minute, In adults its becomes more slower and goes to 60-80 beats in one minute. In normal condition of heart rhythm P- waves are generated and pursued after small gap by a QRS complex which again followed by T-wave of ECG. Due to quick heart rhythm of the upper chambers of heart the Supraventricular Arrhythmia has been caused.

Atrial fibrillation (AF) is a type of arrhythmia which results due to disorganized electrical activity in the atria. Even the sinus node electrical signal is normal to the atrium, the abnormal electrical signal rapidly circulating and simulate atrium. The rate of atria can exceed up to 400 beats per minute. In AF, the electrical signal coming from atrium constantly bombard the AV node. A large number of these rapid signals passed through AV node to ventricles, which beats irregularly and rapidly. The rate of ventricle can vary from 50 to 200 per minute, and also it depends upon degree of AV conduction. The rate of ventricles in fact varies tremendously,

In fact, the overall rate of the ventricles varies extremely, depending on the age of the patients, the health of the AV node, and whether medications to slow AV conduction (such as calcium-channel blockers or beta blockers) are present. Ventricular arrhythmias generally occur more frequently with advancing age, severity of heart disease and ventricular hypertrophy [10].

Malignant ventricular arrhythmias are of following forms: out-of-hospital ventricular fibrillation (VF), recurrent sustained ventricular tachycardia in the long QT syndrome. Each of these conditions has a high 1-year mortality rate. Potentially malignant ventricular arrhythmia is ventricular premature complexes (VPCs) of more than 10 per hour 10 to 16 days after acute infarction and repetitive VPCs. The most of the malignant arrhythmias occur with severely depressed ventricular function, but VPCs alone have independent prognostic significance. Benign ventricular arrhythmia occurs in patients without known heart diseases and do not require treatment. The exact effect of frequent and complex VPC in these patients needs further definition.

II. NEURAL PATTERN RECOGNITION

A neural network is defined as an interconnected group of nodes, similar to the vast network of neurons present in a brain. Here, each circular node in below given diagram represents an artificial neuron and an arrow represents the connectivity between the output of one neuron to the input of another [11].

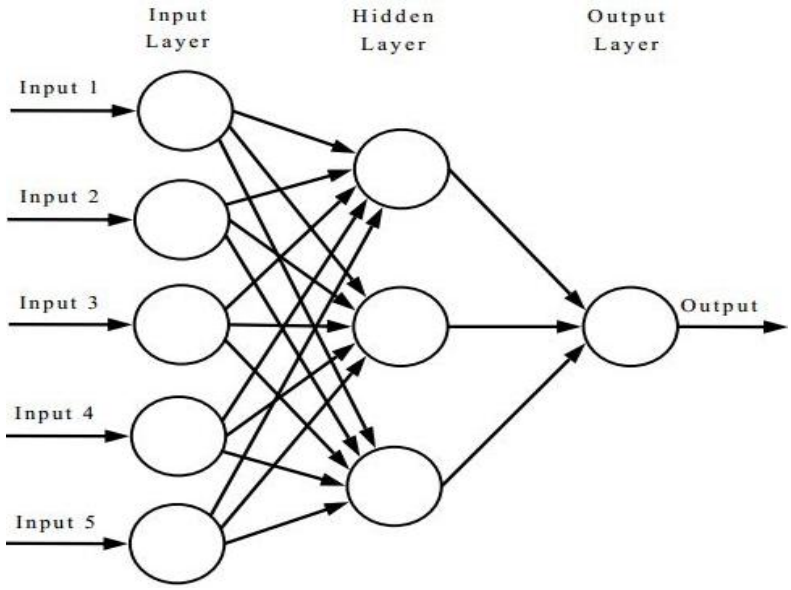

Figure 2. A simple neural network [12]

In machine learning and cognitive science, neural networks (NNs) are a family of statistical learning algorithms motivated from biological neural networks (the central nervous systems of animals, in particular the brain) and are generally used to estimate or approximate functions that can depends on a large number of inputs and are generally not known. Artificial neural networks can be represented as systems of interconnected "neurons" which can compute values from inputs, and have capability of machine learning as well as pattern recognition to their adaptive nature [13]. A neural network for handwriting pattern recognition is defined by a set of input neurons which are activated by the pixels of an input image. After being weighted and transformed by a function (designed by the network's designer), the activations of these neurons are generally then passed on to other neurons. The given process is repeated till an output neuron is activated. In this way it determines which character was read and also weights of neurons as it outputs. The Back Propagation Algorithm is a supervised algorithm, in which a sum square error function is defined, and the learning process is mainly aims to reduce the overall system error to a minimum [14].

III. METHODOLOGY USED

The MIT-BIH Database contains 48 half-hour excerpts of two channel ambulatory ECG recordings, obtained from 47 subjects studied by the BIH Arrhythmia Laboratory between 1975 and 1979. The recordings of Atrial Fibrillation ECG (ECG1) database and Malignant Ventricular ECG (ECG1) database were digitized at the rate of 250 samples per second per channel with the resolution of 11-bits over a span of 10 mV [15].

In our method we use Atrial Fibrillation and Malignant Ventricular database of MIT-BIH, in Atrial Fibrillation database we take 20 ECG Signals. Out of these 20 signals we use 14 in training and 6 in testing. The duration of one ECG is 10 Sec with sampling rate 250 Hz and total sample of an ECG signal is 2500. In Malignant Ventricular database we use 20 ECG Signals. Out of these 20 signals, 14 signal used for training and 6 used for testing. The sampling rate of Malignant Ventricular ECG signal is same as Atrial Fibrillation ECG signal.

IV. INPUT DATA

The input database is given in the matrix from shown in the following table 1.

Table 1. Shows the input database for training and testing

Name	Total	Training	Testing
Atrial Fibrillation Database	20	14	6
Malignant Ventricular Database	20	14	6

In above table total 40 signals are used for analysis. Out of these 40 signals 28 are used for training and 12 are used for testing purpose.

Training Function

Scaled Conjugate Gradient (trainscg): Each of the conjugate gradient algorithms discussed so far requires a line search at each iteration. This line search in general is computationally expensive, because it is required that the network response to all training inputs be computed several times for each search. The scaled conjugate gradient algorithm (SCG), was mainly designed to avoid the time-consuming line search. This algorithm combines the model-trust region approach, with the conjugate gradient approach [16].

The following code reinitializes the previous network and retrains it using the scaled conjugate gradient algorithm. The training parameters for trainscg are epochs, show, goal, time, min_grad, max_fail, sigma, and lambda. The first six parameters have been discussed previously. The parameter sigma determines the change in the weight for the second derivative approximation. The parameter lambda regulates the indefiniteness of the Hessian.

```
p = [-1 -1 2 2;0 5 0 5];
t = [-1 -1 1 1];
net = newff(p,t,3,{},'trainscg');
net = train(net,p,t);
y = sim(net,p)
```

The trainscg routine can require more iteration to converge than the other conjugate gradient algorithms, but the number of computations in each of the iteration is significantly reduced because no line search is performed.

Analysis

Scaled Conjugate Gradient (trainscg) is used for training the neural network. The proposed neural network diagram, algorithm and process diagrams are given below:

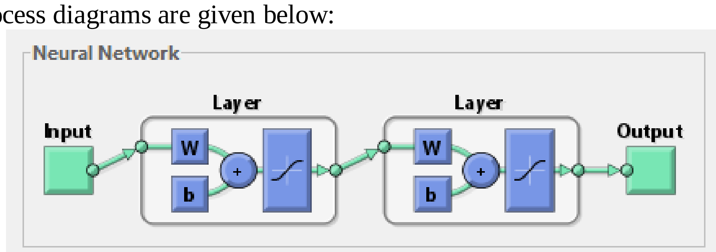

Figure 3. Diagram for Neural Network

Scaled Conjugate Gradient (trainscg) has ability to train any network as long as its weight, net input, and transfer functions have their derivative functions. Back propagation algorithm is used to calculate derivatives of performance with respect to the weight and bias variables X.

Training stops when any of these conditions occurs:

- The maximum number of epochs (repetitions) is reached.
- The maximum amount of time is exceeded.
- Performance minimized to the goal.
- The performance gradient falls down below minimum gradient.
- Validation performance has increased more than maximum fail times since the last time it decreased.

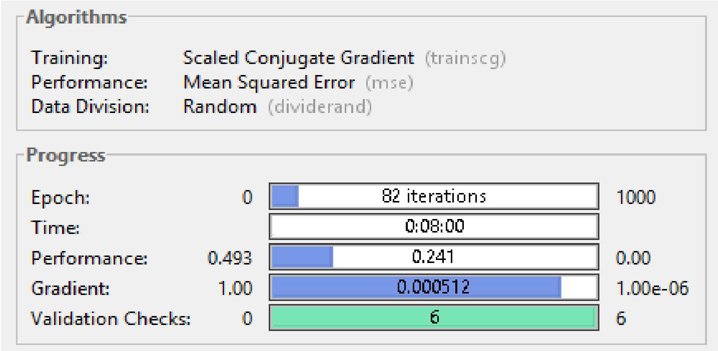

Figure 4. Algorithm and Process used

The given neural network has two hidden layer between the input layer and output layer. The performance graph of the neural network is plot between the mean square error and the epoch. Here the blue line stand for training data, green for the validation and red line for the test data. Performance graph, training state graph and the regression diagram is given below:

The coding of Neural Network is done with the help of the available book of MATLAB "An Introduction with Applications" written by writer Amos Gilat on MATLAB 7.10.0 (2010a) software.

Plot network performance plots error vs. epoch for the training, validation, and test performances of the training record. Generally, the error reduces after more epochs of training, but might start to increase on the validation data set as the network starts over fitting the training data. In the setup, the training stops after six consecutive increases in validation error, and the best performance is taken from the epoch with the lowest validation error [17].

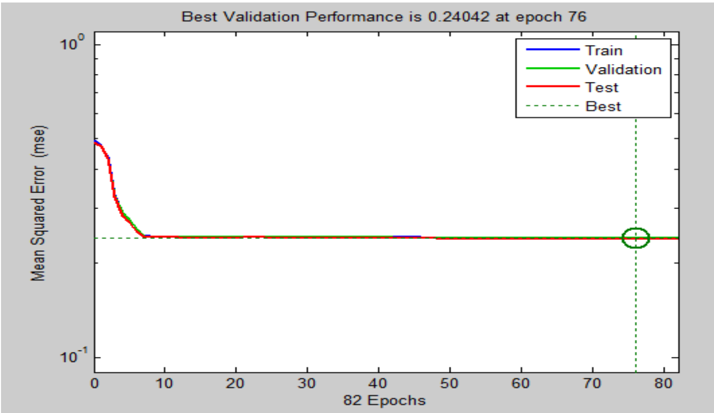

Figure 5. A Graph for Performance Plot of error vs. epoch for the training and validation

Plot training state values plots the training state from a training record [18].

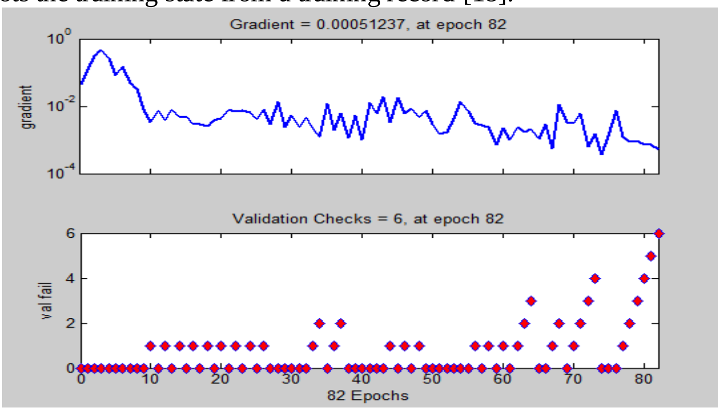

Figure 6. A plot for Training State values

The next figure is about confusion matrices for training, testing, and validation that combines the three types of data's. The network outputs in the green squares shows the very accurate and high numbers of correct responses and red squares shows the low numbers and incorrect responses. The blue squares shows the overall accuracies [19].

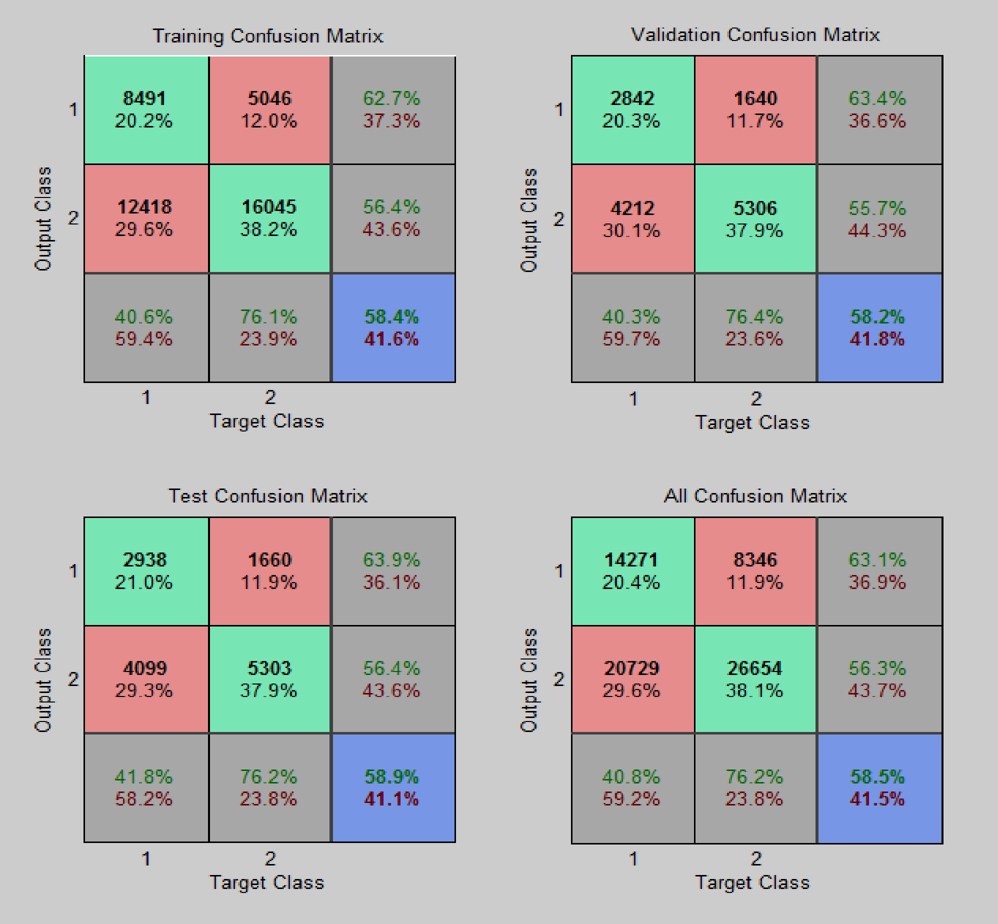

Figure 7. Confusion Matrix for training, testing, and validation

The next diagram is ROC curve which is represented by colored lines. The *ROC curve* plots the true positive rate (sensitivity) versus the false positive rate where the threshold is varied. A perfect test shows that the points in the upper-left corner, with 100% sensitivity and 100% specificity. For this problem, the network performs very well [16].

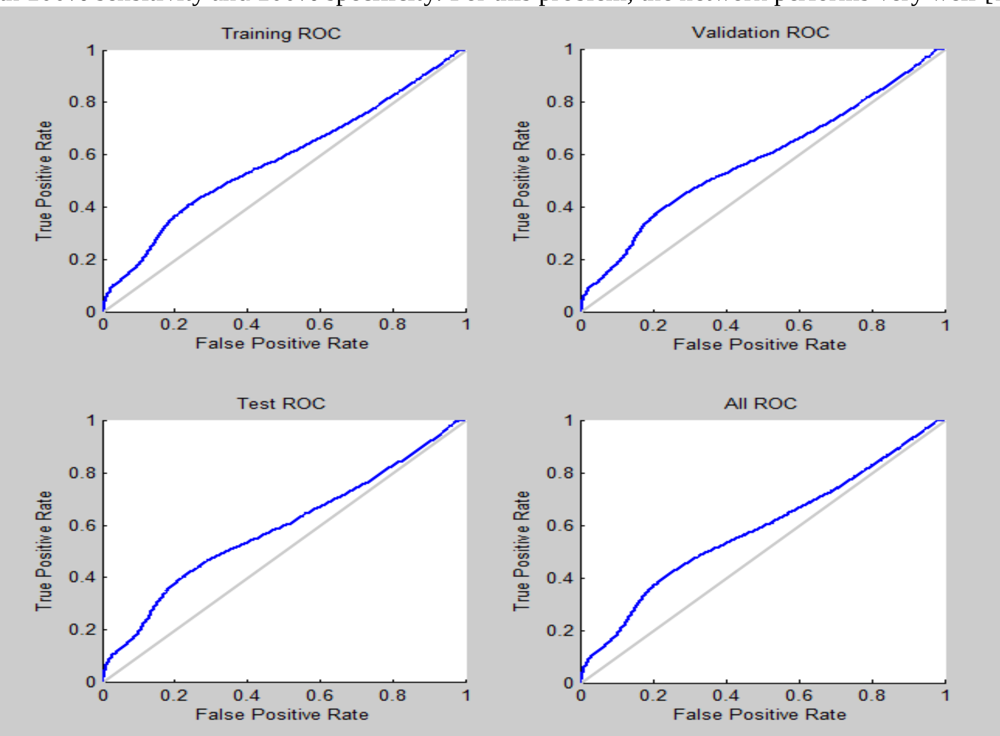

Figure 8. ROC Plot for the true positive rate versus the false positive rate

V. RESULTS

Result of processing of Atrial Fibrillation and Malignant Ventricular ECG signal is shown below in form of table 2:

Table 2. Shows the result of analysis

Name	Signal Number	Status	% Accuracy
Atrial Fibrillation ECG	05261	Verified	100
	07859	Verified	
	07879	Verified	
	07910	Verified	
	08215	Verified	
	08219	Verified	
Malignant Ventricular ECG	04043	Verified	83.33
	05261	Not Verified	
	07162	Verified	
	07879	Verified	
	07910	Verified	
	08378	Verified	

VI. CONCLUSIONS

The conclusion resulting from this work is that, by using MATLAB based the neural network recognition tool some better networks can be prepared which have the capability to understand all types of abnormal ECG database. In most of the research paper single ECG bits taken for analysis, but in our research we have taken the 10 Sec complete ECG signals with sampling rate of 250 Hz include of many ECG bits is taken for analysis which has taken a great care in case of heart beat variability. This type of network can be very reliable and provides accurate result as neural network provides a better and effective set of tools so that the network parameters can be adjusted easily, such type of network can handle a large amount of database and can work easily with random database. The accuracy obtained by such network is comparatively better. The above Neural network method for analysis of ECG signal gives 100 % accuracy for Atrial Fibrillation ECG database. Proposed network model used for detection Atrial Fibrillation ECG and Malignant Ventricular ECG is proving to be a very reliable precise method of analyzing each signal.

REFERENCES

[1] Jang, J.S.R., Sun, C.T., and Mizutani, E., Neuro-Fuzzy and Soft Computing, Prentice-Hall International, 1997.

[2] Congenital Heart Defects. March of Dimes. 2005. [Online]. Available: [http://www.marchofdimes.com/professionals/14332_1212.asp]

[3] Sanchit Ailani and Sakshi Sethi, "ECG Enhancement and Heart Beat Measurement" International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 4, April 2016.

[4] Bigger JT Jr., Definition of benign versus malignant ventricular arrhythmias: targets for treatment. American Journal Cardiol, 1983 Sep 22; 52(6):47C-54C.

[5] A.Muthuchudar and Lt.Dr.S.Santosh Baboo, "A Study of the Processes Involved in ECG Signal Analysis" International Journal of Scientific and Research Publications, Volume 3, Issue 3, March 2013 1 ISSN 2250-3153.

[6] Yukinori Suzuki, November 1995. "Self-organizing QRS Wave Recognition in ECG Using Neural Networks", IEEE Transactions on Neural Networks, vol. 6, No. 6. November 1995, 1469-1477, ISSN: 1045-9227

[7] Description about P wave present in ECG Signal. [http://en.wikipedia.org/wiki/Electrocardiography].

[8] Diagram for the different components of ECG signals. [http://www.ni.com/tutorial/6349/en/].

[9] M. Gabriel Khan, "Rapid ECG Interpretation" , 3rd edition, 2008 , *Humana press, New York*, ISBN- 978-1-58829-979-6.

[10] Benjamin EJ, Wolf PA, D'Agostino RB, Silbershatz H, Kannel WB, Levy D. Impact of atrial fibrillation on the risk of death: the Framingham Heart Study. Circulation, 1998; 98(10):946-52.

[11] Gaurav Kumar Jaiswal and Ranbir Paul, "ECG Classification with the Help of Neural Network" International Journal of Electrical and Electronics Research ISSN 2348-6988 (online) Vol. 2, Issue 2, pp: (42-46), Month: April - June 2014.

[12] A simple diagram for neural network [http://tex.stackexchange.com/questions/132444/diagram-of-an-artificial-neural-network].

[13] Ajeet Sharma and Kushagra Bhardwaj, "Identification Of Normal and Abnormal ECG Using Neural Network" *International Journal of Information Research and Review Vol. 2, Issue, 05, pp. 695-700, May, 2015*

[14] Shanxiao Yang, and Guangying Yang "ECG Pattern Recognition Based on Wavelet Transform and BP Neural Network" Proceedings of the Second *International Symposium on Networking and Network Security* ISNNS '10), ISBN 978-952-5726-09-1. P. R. China, 2-4, April. 2010, pp. 246-249

[15] Massachusetts Institute of Technology, MIT-BIH ECG arrhythmia database. [http://www.physionet.org/cgi-bin/atm/ATM].
[16] Description about scale conjugate gradient method used for training the neural network. [https://in.mathworks.com/help/nnet/ref/trainscg.html].
[17] Network performance plots error vs. epoch for the training, validation, and test performances. [https://in.mathworks.com/help/nnet/ref/plotperform.html].
[18] Plot for the training state from a training record. [https://in.mathworks.com/help/nnet/ref/plottrainstate.html].
[19] The confusion matrices for training, testing, and validation and the *ROC curve* plot of the true positive rate (sensitivity) versus the false positive rate. [https://in.mathworks.com/help/nnet/gs/classify-patterns-with-a-neural-network.html].