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ARRHYTHMIA CLASSIFICATION USING NEURAL NETWROK AND EFFECT OF COLOR LIGHT THERAPY

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Abstract— This paper presents an effective application of artificial neural network for diagnosis of cardiac arrhythmia. Comparison of the result generated by Bacpropagation and Conjugate gradient algorithm. The classifier was developed and tested with the MIT-BIH Arrhythmia Database. Automatic analysis is performed by using artificial neural network. Following three consecutive steps are required for automatic detection: 1) R-R interval detection 2) Heart Rate Calculation and 3) Classification.

This work is not only limited to the diagnosis of cardiac arrhythmia but also it suggest the effect of colored light therapy on heart rate variability.

Keywords
ECG, Neural Network, Back propagation algorithm, Training, Learning parameter, Testing, color therapy.

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INTRODUCTION

The diseases that affect the cardiovascular system are the main cause of deaths in developed countries. Most of these deaths are due to sudden cardiac arrest and severe cardiac arrhythmia. Therefore, the automatic detection of cardiac arrhythmias from the bedside or ambulatories ECG becomes an important tool for risk assessment

Computer based diagnostic system hold promising mean to meet the challenges of the clinical situation. The application of Artificial finds its use to supplement the decision making of the clinician. Artificial neural network capture the basic knowledge that allows the clinician to act as an expert while dealing with such complicated problem [1].

Hyper tension and low heart rate is a common clinical diseases and major risk to the human health.

One emerging type of anti-aging treatment has recently gained popularity, but has shown amazing results for years. Red light therapy is characterized by light, which is a unique type of light that has a stronger wavelength than other types of light. This enables it to penetrate deeper into the skin and provide many therapeutic benefits

METHODOLOGY

The classifier is developed using artificial neural network for analysis of cardiac arrhythmia. From the standard ECG database MIT-BIH data is selected for analysis. All samples of RR intervals are collected from the data base. All RR intervals are converted in terms of corresponding heart rate. Out of total RR intervals and heart rate the minimum and maximum samples of RR intervals and heart rate are extracted and extracted heart rate is given as input to the train neural network for further analysis. Neural network perform the analysis and classify the input data either as normal heart when heart rate is in between 60 to 100 BPM or high heart rate if heart rate is more than 100BPM (Tachycardia) , slow heart rate if heart rate less than 60 BPM (Bradycardia).

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A model is developed which focus red light with high intensity, which penetrate extremely in body. Person setting in front of this red light is continuously monitored by measuring its blood pressure and heart rate with the help of automatic BP apparatus and ECG machine.

CARDIAC ARRHYTHMIA

An arrhythmia is a disorder of the heart rate (pulse) or heart rhythm, such as beating too fast, too slow or irregularly. Normally, your heart is able to pump blood out to your body without working any harder than is needed. To help this happen, your heart has an electrical system that makes sure it contracts (squeezes) in an orderly way. The electrical impulse that signals your heart to contract begins in the sinoatrial node also called the sinus node or SA node. This is your heart's natural pacemaker.

Arrhythmias are caused by problems with the heart's electrical conduction system. Electrical signals are not able to move as easily or at all. When an arrhythmia is present, your heartbeat may be too slow called Bradycardia and too quick called Tachycardia

This electrical activity is plot by electrograph and can be used to determine and diagnose heart abnormalities and arrhythmias.

The arrhythmias themselves are very dangerous. For example, patients with a very slow heartbeat, called bradycardia, can experience light-headedness and fainting spells. If the arrhythmia is not treated, the heart could stop beating.

NEURAL NETWORK CLASSIFICATION

Artificial Neural Network (ANN) has been train to perform complex function. In mathematical terms we may describe a neuron K by writing the following pair of equitation.

$$Uk = \sum_{j=1}^{m} Wkj\ Xj$$

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Yk = Ψ (Uk + Bk)

Where X1------Xm are the input signal, Wk1---Wkm are the synaptic weight of neuron K, Uk is the linear combiner output due to the input signal. Jbk is the bias, Ψ (.) activation function and Yk is the output signal of the neuron.

This output signal representing the only output of neural network of neuron K is denoted by Yk(n) . This output signal representing the only output of neural network is compared to a desired response or target output denoted by Dk(n) consequently an error signal denoted by Ek(n) is produced.

CONJUGATE GRADIENT ALGORITHM

The basic backpropagation algorithm adjusts the weights in the steepest descent direction (negative of the gradient), the direction in which the performance function is decreasing most rapidly. It turns out that, although the function decreases most rapidly along the negative of the gradient, this does not necessarily produce the fastest convergence. In the conjugate gradient algorithms a search is performed along conjugate directions, which produces generally faster convergence than steepest descent directions. .

In most of the training algorithms, a learning rate is used to determine the length of the weight update (step size). In most of the conjugate gradient algorithms, the step size is adjusted in each iteration.

Fletcher-Reeves Update (traincgf)

All the conjugate gradient algorithms start out by searching in the steepest descent direction (negative of the gradient) on the first iteration.

$$\mathbf{p}_0 = -\mathbf{g}_0$$

A line search is then performed to determine the optimal distance to move along the current search direction:

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$$\mathbf{x}_{k+1} = \mathbf{x}_k + \alpha_k \mathbf{p}_k$$

Then the next search direction is determined so that it is conjugate to previous search directions. The general procedure for determining the new search direction is to combine the new steepest descent direction with the previous search direction:

$$\mathbf{p}_k = -\mathbf{g}_k + \beta_k \mathbf{p}_{k-1}$$

The various versions of the conjugate gradient algorithm are distinguished by the manner in which the constant β_k is computed. For the Fletcher-Reeves update the procedure is

$$\beta_k = \frac{\mathbf{g}_k^T \mathbf{g}_k}{\mathbf{g}_{k-1}^T \mathbf{g}_{k-1}}$$

This is the ratio of the norm squared of the current gradient to the norm squared of the previous gradient.

TRAINING AND TESTING OF NEURAL NETWORK

As our aim is to diagnose of Arrhythmia disorder, hence for training and testing of the artificial neural network, various samples of ECG data is obtained from MIT-BIH Standard ECG data base. The database created is divided into two parts, one for training the artificial neural network and the other for testing. Training of Artificial neural network for the diagnosis of Arrhythmia disorder, using Backpropagation algorithm is implemented with following values of training parameters:

df = Frequency of progress displays (in epochs) = 100,

me = Maximum number of epochs to train = 2000,

Mse = Mean squared error goal = 0.001

lr = Learning rate = 0.00001

Two non-linear activation functions namely, Tan-Sigmoid, Purelin are chosen to train neural network.

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ANN is trained using backpropagation algorithm.

The backpropagation algorithm updates neuronal activation in the network as follows.

For Input layer

$$\delta(X_i^k) = X_i^k \qquad i = 1----n$$

$$\delta(X_o^k) = X_o^k = 1$$

Where X_i^k is the i th component of the input vector X_k presented to the network and $\delta(X_o^k)$ is the input layer bias neuron signal that is independent of iteration index.

For hidden layer

$$Z_o^k = \sum_{i=0}^{n} W_{ih}^k \, \delta(X_i^k) = \sum_{i=0}^{n} W_{ih}^k \, X_i^k$$

$$\delta(Z_h^k) = \frac{1}{1 + e^{-Z_h^k}} \qquad h = 1-----q$$

$$\delta(Z_o^k) = 1$$

W_{0h}^k are the biases of the hidden neurons $\delta(Z_o^k)$ is the hidden layer bias neuron signal which is once again independent for out put layer

For output layer

q

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$$Y_j^k = \sum_{h=0} W_{hj}^k \, \delta(Z_h^k)$$

$$j = 1 \text{-------} p$$

$$\delta(Y_j^k) = \frac{1}{1+e^{-Y_j^k}}$$

Where W_{0j}^k are the biases of the output neurons.

COLORED LIGHT THERAPY

Colored light therapy involves the use of colored light such as red light that the practitioner shines directly on the patient and its body parameters B.P and heart rate are monitor continuously.

Colored light therapy involves the use of colored light such as red light that the practitioner shine directly on the patient and its body parameter like blood pressure systolic, diastolic are monitor with the help of automatic B.P. apparatus and patient heart rate is measured with the help of ECG machine. The aim of this study was to investigate the effect of colored light on human health. This study shows the effect of red light on blood pressure and heart rate variability by stimulating patient.

RESULT AND DISCUSSION

Result1:

Figure(1) show 10 min sample of ECG wave from standered ECG MIT-BIH data base. Analysis is perfored on the basis of RR intervals availeble from standered database which are converted into corresponding heart rate and given as input to train neural network

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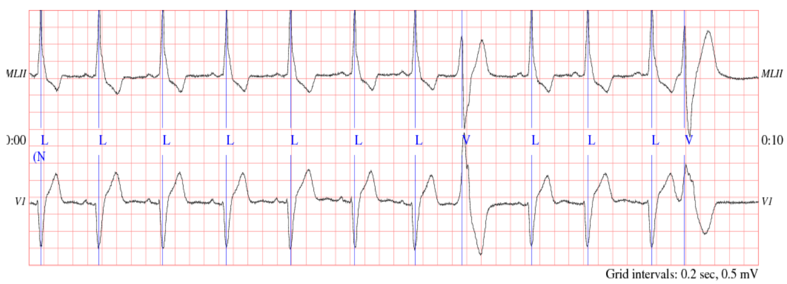

Figure (1) ECG wave form

Extracted RR intervals are converted into corresponding heart rate and applied as input 'P' to the train neural network for analysis

Extracted Minimum Heart Rate 39 Bpm

Extracted Maximum Heart Rate 177 Bpm

Extracted Maximum Heart Rates 40 values

Columns 1 through 27

177 168 167 165 164 162 159 159 159 158 158 158 158 157 157 157 157 157 157 156 156 156 156 156 155 155 154

Columns 28 through 40

154 154 154 154 154 153 153 153 153 153 152 152 152

Extracted Minimum Heart Rates 40 values

Columns 1 through 27

39 40 41 42 43 43 43 44 44 44 44 44 44 45 45 45 45 45 45 45 45 45 46 46 46 46 46

Columns 28 through 40

46 46 46 46 46 46 46 46 46 46 46 46 47

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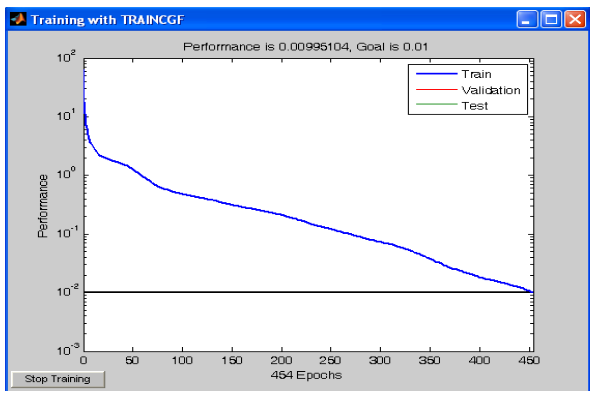

Figure (2) Error Graph for Testing of Neural Network

TRAINGD, Performance goal met.

Figure (2) shows testing error graph of neural network. Figure (1) shows 10 min sample of ECG wave form, for which complete RR intervals are from Columns 1 to columns 2260 are converted into corresponding heart rate hence heart rate columns are also from 1 to 2260. Out of total 2260 only 40 samples of high heart rate and 40 samples of low heart rate are extracted. These extracted 40 samples of high heart rate and low heart rate are given to the input P of the neural network for testing. After performing the analysis of given input sample network generate output 'a= 10.0412. Network required 454epochs out of 2000, it reduces the error up to set error 0.299998/0.3 and for that it required 2.50 sec time. As most of heart rates from given input are above 100 BPM and below 60 BPM i.e High and Slow heart rate, network perform the analysis and observer symptoms of tachycardia and bradycardia.

Result: 2

Figure(3) show 10 min sample of ECG wave from standered ECG MIT-BIH data base. Analysis is perfored on the basis of RR intervals availeble from standered database which are converted into corresponding heart rate and given as input to train neural network

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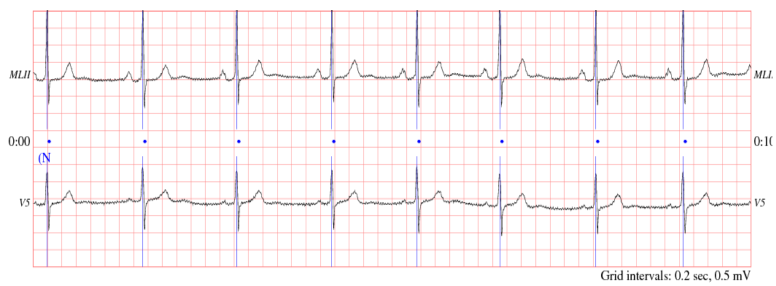

Figure (3) ECG wave form

From the wave form 40 samples of minimum and maximum RR intervals are extracted and they are converted into corresponding heart rate.

Maximum Heart Rates 40 values

Columns 1 through 27

115 113 111 100 89 82 71 67 66 65 65 65 65 65 65 64 64 64
64 64 64 64 64 64 64 64 63

Columns 28 through 40

63 63 63 63 63 63 63 63 63 63 63 63 63

Minimum Heart Rates 40 values in increasing order

Columns 1 through 27

40 40 40 40 41 41 41 41 42 42 42 42 42 42 42 42 42 42
42 42 42 43 43 43 43 43 43

Columns 28 through 40

43 43 43 43 43 43 43 43 43 43 43 43 43

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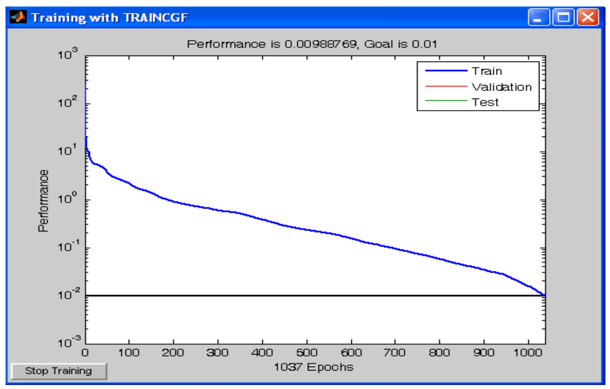

Figure (4) Error Graph for Testing of Neural Network TRAINCGF, Performance goal met.

Figure (4) shows testing error graph of neural network. Figure (3) shows 10 min sample of ECG wave form, for which complete ECG wave RR interval are from columns 1 to columns 1516 are converted into corresponding heart rate hence heart rate columns are also from 1 to 1516.Out of total 1516 only 40 samples of high heart rate and 40 samples of low heart rate are extracted. These extracted 40 samples of high heart rate and low heart rate are given to the input P of the neural network for testing. After performing the analysis of given input sample network generate output 'a=6.3130'. Network required 1037 epochs out of 2000, it reduces the error up to set error goal 0.01 and for that it required 70.75% time of given time. As most of heart rates from given input are below 60 BPM i.e slow heart rate, network perform the analysis and observer the symptoms of Bradycardia.

Result3:

Colored red light shines directly on the patient and its body parameters like B.P and heart rate are monitor continuously. Figure (5) shows ECG wave form before a person is subjected to high intensity red light.

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Figure (5) ECG wave before colored light effect

From the above ECG wave form before colored light RR intervals are calculated which are in the range of 0.60sec to 0.64 sec which average RR interval is 0.61 and its corresponding average heart rate is 97 BPM. Correspondingly second parameter blood pressure of patient is measured with the help of automatic BP apparatus which is 132:82 systolic and diastolic respectively. After this patient is subjected to red colored light for 30 min. and corresponding changes in heart rate and BP are monitored.

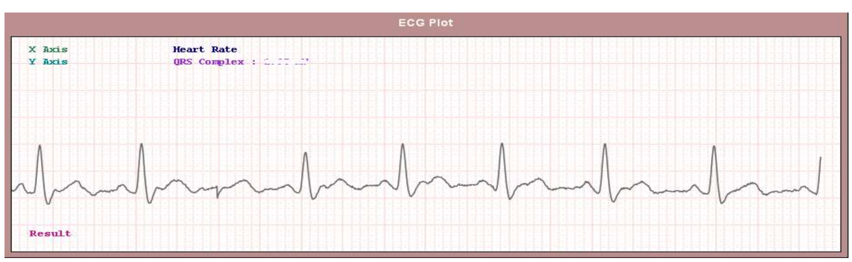

Figure (6) ECG wave after colored light effect

Figure (6) shows ECG wave form after red light effect form which RR intervals are calculated which are in the range of 0.52 sec to 0.56 sec which average RR interval is 0.52 and its corresponding average heart rate is 113 BPM. Correspondingly second parameter blood pressure of patient is measured with the help of automatic BP apparatus which is 125:74 systolic and diastolic

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respectively. After colored light therapy heart rate is boost up by 16 BPM and blood pressure is settled by 07:08 systolic and diastolic respectively.

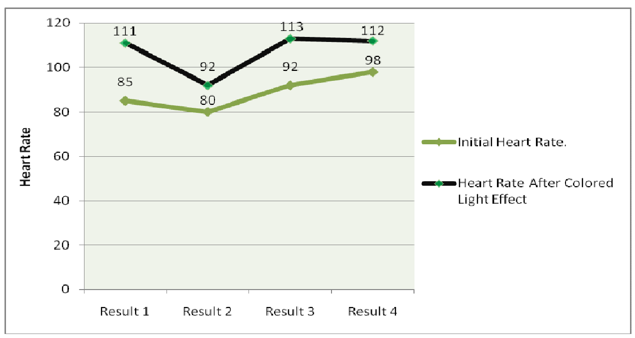

Figure (7) change in Heart rate after colored light effect

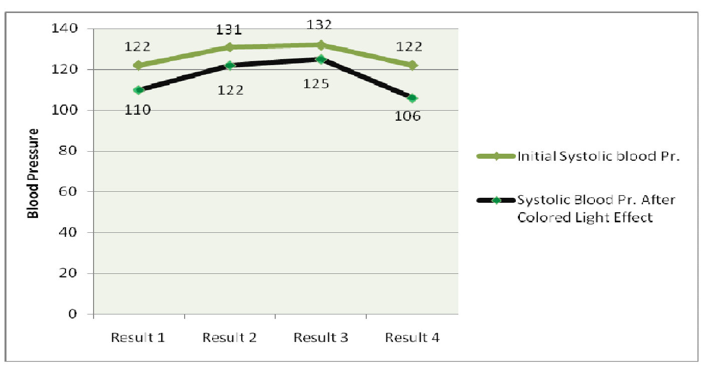

Figure (8) change in systolic and diastolic blood pressure after colored light effect

CONCLUSION

A fundamental architecture of ANN based arrhythmia diagnosing consists of signal feature extraction, automatic ECG signal detecting, and criteria modelling for arrhythmia diagnosing

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Feed forward multilayer neural networks trained with Back-propagation algorithm and conjugate gradient algorithm, have been reported to exhibit improved clinical diagnosis. The main advantage of this approach is that it is simple algorithm, faster convergence and effective result. The conjugate gradient algorithms are much faster than variable learning rate backpropagation algorithm.

From these result it is observe that the colored light therapy is effective for boosting up the heart rate, which can be use as emergency first line treatment from instant bradycardia attack. At the same time it can also settling high blood pressure up to certain extent.

It can be said that this research work is a small step in the direction of developing an extremely useful technology.

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