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Extraction of Ventricular Premature Beats from ECG using Soft Computing Technique

Shahanaz Ayub[1] & J. P. Saini[2]

[1]Department of Electronics & Communication Engineering, Bundelkhnad Institute of Engineering & Technology, Jhansi, Uttar Pradesh, India

[2]M.M.M. Engineering College, Gorakhpur, Uttar Pradesh, India

Abstract: The ECG (Electrocardiogram) i.e. electrical activity of the heart records taken during the diagnosis of various classes of patients, where ECG can provide a lot of information regarding the abnormality in the concerned patient, are analysed by the physicians and interpreted depending upon their experience. The results and treatment both may vary if they interpreted by different patients. Hence this work is all about the automation and consistency in the analysis of the ECG signals so that they must be diagnosed and interpreted accurately irrespective of the physicians. This would help to start an early treatment for the problems and many lives could be saved. Many works have been done previously but this paper presents a new concept by application of MATLAB based tools in the same weighted neural network algorithms where the results obtained are 98.5% for ventricular premature beats. To do so various networks were designed using the MATLAB based tools and parameters. Two classes of networks were designed, but with different training algorithms, namely Perceptron and Backpropagation. They were provided training inputs from the data obtained from the MIT-BIH Arrhythmia database After training different forms of networks, they were tested by providing unknown inputs as patient data and the results in the whole process from training to testing were recorded in the form of tables. In this paper only ventricular premature beats have been discussed and so results associated with it only has been given.

Keywords: ECG, Ventricular Premature Beats, Neural Network, MATLAB, MIT-BIH, Arrhythmia

1. INTRODUCTION

More than 3 million ECGs are taken worldwide each year for the patients with different cases, right from heart rhythm anomaly to the hormonal imbalances due to organ failures. All the samples taken have one thing in common and that is, they are analysed by the experienced doctors who depending upon their knowledge predict out the problem(s) associated with the patient which is disturbing the normal morphology of the signal. If this morphological disturbance becomes somewhat complex (such as the case of fusion beats) then it is analysed by them depending upon their experience. This experience based analysis gives different interpretations and hence different treatment procedure when they are made by different persons. Hence there is a need of a system that could analyse the ECG signals properly and with a great accuracy so that there is a less chance of mistake as well as the problem is spotted in time so that an early treatment could be started.

So to achieve this objective many works have been done in this field based on image processing, Digital Signal Processing etc and prominent among them is the use of Artificial Neural Networks [3] which has given promising results to such complex problems. Neural network based analyses made were either weight based or weightless. This work is based on weighted neurons with bias adjustments but with the application of MATLAB based algorithms and neural network structure.

The excellent features of the MATLAB [4] such as wide range of tools for network structure development and adjustment according to requirements as well as tools to analyse the results, makes it a good option to solve this complex problem in a simple way, especially the case of fusion beats. In this abstract the case of ventricular arrhythmia will be discussed so as to have an insight into the concept of identification of ventricular premature beats using neural networks (MATLAB based).

2. OBJECTIVE OF THE WORK

The objective of this work is to make the analysis of ventricular premature beats from given ECG signal easy so that the patient could be diagnosed for the heart problems in less time as well more accurately so that the medical practitioners have primary information about the ailment and could start a treatment early. Apart from this the project has been targeted towards the rural community and so we are also considering hardware implementation of this work but in low cost and greater efficiency. MATLAB based [1] Neural Network tools are used to identify the ventricular premature beats.

*Corresponding Author: shahanaz_ayub@rediffmail.com[1], jps_uptu@rediffmail.com[2]

3. METHODOLOGY

The database provided by the MIT-BIH arrhythmia database [2] regarding different kinds of heart rhythm abnormalities for different class of patients, is the source of data used for training and testing of the neural networks. The data from the patient number 208 was preferred and taken out for different cases of heart beats. Other patient data were also taken so as to enhance the prediction capability of the trained neural network and make it more accurate.

The data taken was used to make training inputs which represented the whole ECG cycle as well as for making test inputs. The MATLAB based Perceptron and back propagation [3,4] networks were developed and training parameters were fixed for certain quantities and varied for others. The network trained were analysed using the test inputs first for all unknowns which were not used for training and then for all inputs which included both training inputs and test inputs. Analysis plot tools [4] were also used to understand the network capability and other properties such as Mean Squared Error (MSE) value and learning capability.

TRAINLM: Levenberg marquardt backpropagation Training algorithm.

TRAINBFG: BGFS Quasi Newton Backpropagation training algorithm The following images are the analysis plots for this work where each of them interprets different properties about the network. This result is obtained for network trained with ventricular premature beats and trainbfg algorithm.

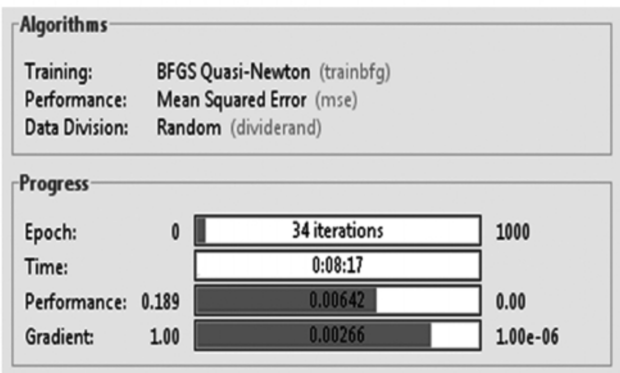

Figure. 1: Training Process Results

Fewer epochs means network learns in small repetitions. Less time means network has achieved goal easily and shortly. Performance indicates the final MSE achieved. Lower value is associated with higher network accuracy.

The below Mean squared error Plot shows the achieved error value. Lower value means the less probability of false predictions. Here network has achieved quite low error probability.

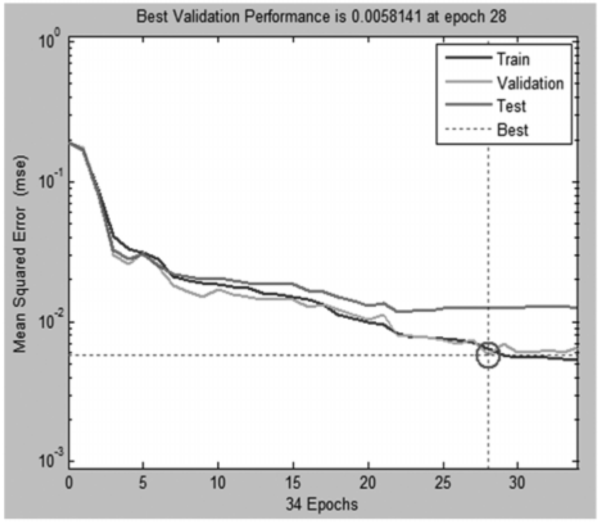

Figure. 2: Mean Squared Error (MSE) Plot

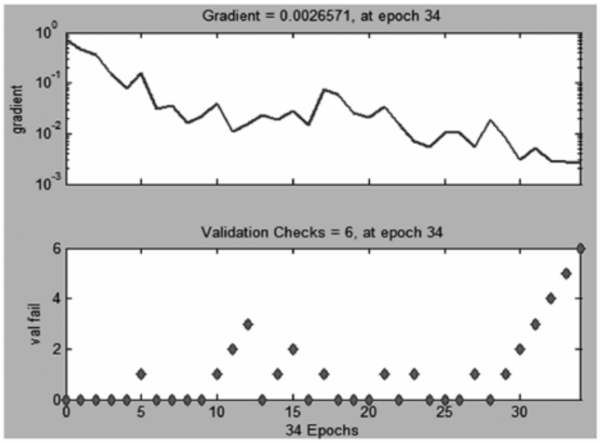

Figure. 3: Training (Gradient and Validation) Check Plots

Low value of gradient plot indicates that the network is learning upto a large extent which means finer adjustments in the weights and bias. This in turn makes network more accurate and reliable, avoiding chances of false predictions. Validation plot shows the point where the network learned sufficiently and passed validation without. The point where the failures cross the defined limit is the stoppage point of training and indicates the starting of the over fitting of the data.

The following tables provide the results related to various beats analysed, among them the results for the ventricular beats should be observed carefully. TRAINLM and TRAINBFG are training algorithms. Where,

HN: Hidden neurons, representing the number of neurons in the Hidden layer.

SUFFIXES V, N, F, AND U: In the P (cc) columns indicate respectively Ventricular, normal, fusion and unclassified beats and their percentage of correct classifications.

Table 1
Backpropagation:Elman Network('trainbfg')

Network	INPUTS (stage2 only)	HN	TIME(in SEC)	P(cc) (%, min=97each) unknown	P(cc) (%, min=97 each) all	EPOCHS(MAX=1000)	MSE-0.0001	
Ventricular	792V/2921T	5	497	97.5V,100N,98F,100U	97.9V,100N, 98.6F,98.2U	34	0.00632	PASSED
		10	2464	97.5V,100N,97.3F, 100U	97.8V,100N, 97.8F,99.1U	26	0.00842	PASSED

Table 2
Backpropagation:Elman Network('trainlm')

Inputs	*HN*	*TIME (in SEC)*	*P(cc) (%, min = 97 each) unknown*	*P(cc) (%, min=97 each) all*	*EPOCHS (MAX = 1000)*	*MSE-0.0001*	*Result*
528V/1809T	5	38	100V,95N,4.7F,37.5U	99.7V,92.2N,8.9F,63.1U	10	0.1869	failed
	10	183	98V,100N,93.3F,98.7U	98.4V,100N,97.4F,98.2U	17	-0.0000989	Passed
792V/2921T	5	139	98V,99.7N,96.7F,100U	98.6V,99.7N,97.7F,99.1U	23	0.00569	Passed
	10	256	97.5V,100N,96F,95U	98.4V,99.9N,98.9F,97.9U	14	0.00119	Passed

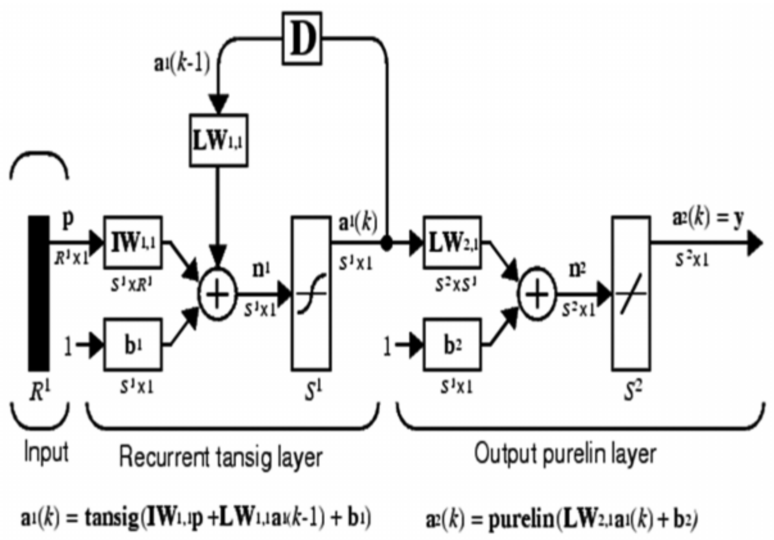

Figure. 4: Elmen Netwok Structure

The Figure 4 shows the Elmen Network Structure where,

TANSIG- the tansigmoid transfer function

PURELIN- purelinear transfer function

4. INFERENCES

- This network gives quite low value of MSE and it is near 0.0058 in just 25 epochs. Time taken for training may be large but it is giving good results especially for fusion and unclassified bits also.
- Though one can see the trainlm case also gives good result but again we are considering this one due to its low memory usage.
- Validation error plot shows the fitting confusion which is seen in the form of two different elevations or increase in validation error. But near about 25 iterations it comes to the desired adjustments.
- Performance is also quite low with value of 0.00642 which is good indication for true predictions and networks reliability.

5. CONCLUSION

The network based on Elman network algorithm with trainbfg training algorithm was best for the case of ventricular beats analysis because it was giving accuracy of about 98% as well as the memory requirements were also low. Hence we preferred this network for the premature beat analysis.

The conclusion derived from this work is that, by using the MATLAB based neural network design [5]; such networks can be made which have capability to understand different class of inputs when they are fed to be analysed. Such networks can be very reliable as MATLAB provides a good set of tools so that the network parameters can be adjusted easily and precisely by just adjusting values for them and change in full length code, as was done previously, is not required.

More work in this regard must be done so that this project could be made practically reliable and feasible.

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