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Artificial Neural Network Classifiers for Diagnosis of Thyroid Abnormalities

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Abstract: *Artificial Neural Networks find an important place in modelling non linear dynamic systems and their control because of their recurrent internal feedback connections. Data mining operations like classification, prediction and clustering became more popular tools in data analysis. This works aims at developing Feed forward and Elman network classifiers for thyroid abnormalities classification. Abnormalities of thyroid function are usually related to little thyroid hormone (hypothyroidism) production or too much thyroid hormone (hyperthyroidism) production. The data set considered for classification is a large data set with 7200 patient records, 21 attributes with 3 classes. The required simulations are implemented and the results are analysed in this paper. It is evident from the results that the Elman neural network has shown better accuracy*

Keywords: *Classifiers, Elman Neural Network, Feed Forward Network, Thyroid abnormality.*

I. INTRODUCTION

Elman Recurrent Neural Network (ERNN) was proposed by JEFFREY L.ELMAN which an additional feedback connection from the output of the hidden layer to its input layer [1]. The additional units are called "Context Units" with a fixed weight of 1.0. The context units with a fixed weight of 1 copies the activations from hidden layer to context layer as shown if FIG 1.

Classification is a multivariate technique which deals with allocating new objects (observations) into previously defined groups. In the recent years, the usage of neural networks increased for solving a wide range of problems including pattern recognition, classification and functional approximation. Many researchers employed artificial neural networks for classification applications. Nihal Fatma Gu¨ler et al. evaluated the classification capabilities of the Elman RNN on the EEG signals [2]. They obtained a total classification accuracy of 96.79%. Thyroid disease diagnosis through the proper interpretation of the thyroid data presents an important classification problem. Feyzullah Temurtas performed a comparative thyroid disease diagnosis using multilayer, probabilistic, and learning vector quantization neural networks using the thyroid disease dataset taken from UCI machine learning database [3]. Alfonso Bastias et al. employed neural networks for identification and diagnosis of nodules thyroids in which many of them are being found incidentally [4]. A neural network model was presented by them with a database of 1097 patients with an identified nodule where 703 are benign, 238 with follicular lesions and 156 was identified as carcinoma [4].

Gurmeet Kaur, Er.Brahmaleen Kaur Sidhu performed the diagnosis of thyroid problems using three neural networks Back propagation network ,Radial Basis Function (RBF) neural network and Learning Vector Quantization Network using the dataset consists of images of persons having thyroid problem [5]. Francesco Bertè et al. employed Elman Neural networks for early detection of cognitive impairment in Alzheimer's disease [6]. The multilayer perceptron (MLP) and radial basis function network (RBFN) and C

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4.5 classifier algorithm were used for the classification of thyroid abnormalities using the dataset having 3 classes, 5 features and 215 records (hypo=30, hyper=35, normal=150) by Raj kumar and Palanichamy [7]. V.Sarasvathi and Dr.A.Santhakumaran developed an artificial neural network approach using a back propagation algorithm in order to diagnose thyroid problems [8]. Qeethara Kadhim Al-Shayea perfomed an evaluation of the performance of artificial neural networks in disease diagnosis. Two cases the acute nephritis disease and the heart disease using cardiac Single Proton Emission Computed Tomography (SPECT) images. Each patient classified into two categories: infected an no-infected [9]. Feed-forward back propagation neural network is used as a classifier to distinguish between infected or non-infected person in both cases [9]. Further an Intelligent Classifier model employing Hybrid ELMAN Neural Network Architecture and Biogeography Based Optimization for Data Classification was developed by N.Mohana Sundaram S. N. Sivanandam for classification of large data sets [10].

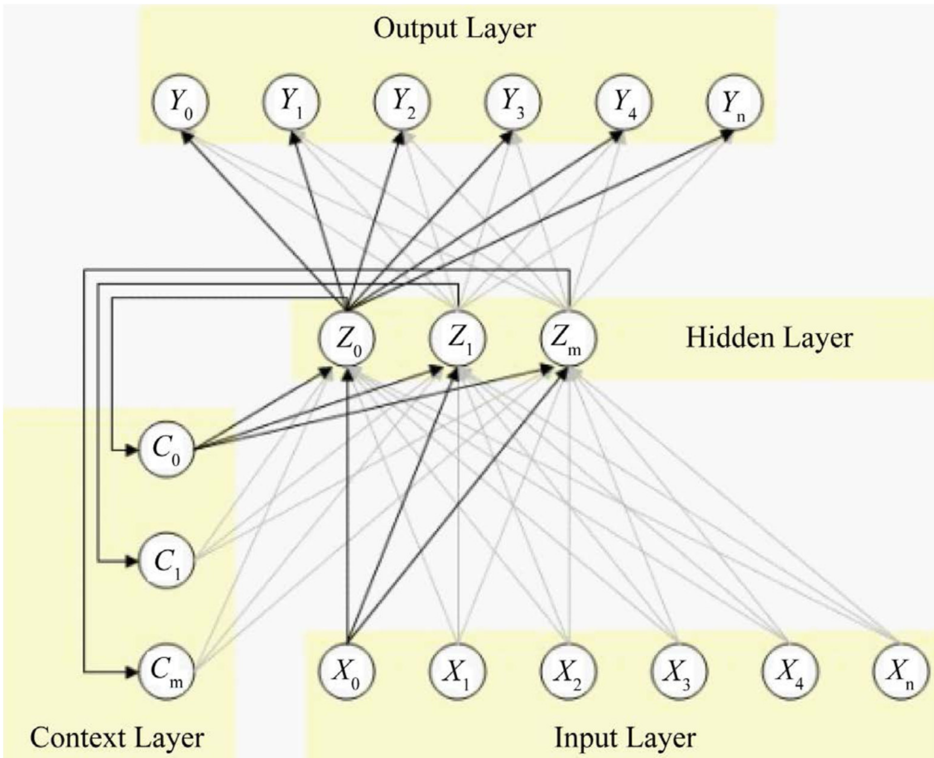

Fig. 1 ELMAN network showing different layers.

In this work, an Elman neural network and Feed forward neural network with different architectures were developed for the classification of Thyroid disorders. Their performances are analysed and the results are presented.

II. Simulations and Models

The models are simulated using the Thyroid dataset obtained from the UCI Machine Learning Repository [11]. The Data set dataset can be used to create a neural network that classifies patients referred to a clinic as

- Normal, not hyperthyroid
- Hyper function
- Subnormal functioning

The above three cases are used as classification targets. There are 7200 tuples (patient records) present in the data set. The inputs of the Neural Network are 21 attributes characterized by 15 binary and 6 continuous patients attributes. So the Neural networks simulated in this work have

Input Neurons: 21 and
Output Neurons: 3

The table 1 gives the different architectures simulated.

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Table 1. Architecture of Networks Simulated.

S No	No. of input neurons	No. of output neurons	No. of Hidden layers	No. of Hidden neurons	Activation Function	Training algorithm
Feed Forward Network						
1	21	3	1	10	Soft Max (input-Hidden layer) Linear (hidden-output layers	Trainscg - Scaled Conjucate Gradient Back propagation
2	21	3	1	15		
3	21	3	1	27		
4	21	3	1	40		
5	21	3	2	10,10		
6	21	3	2	27,27		
Elman Neural Network						
7	21	3	1	10	Soft Max (input-Hidden layer) Linear (hidden-output layers	Trainscg - Scaled Conjucate Gradient Back propagation
8	21	3	1	15		
9	21	3	1	27		
10	21	3	1	40		
11	21	3	2	10,10		
12	21	3	2	27,27		

The Figure 2. Shows the Elman architecture of two hidden layer Elman Network

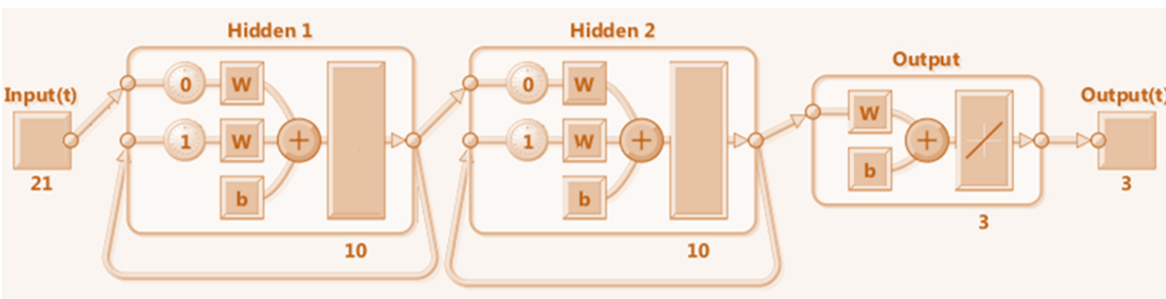

Fig 2. Elman Architecture of two hidden layers with 10 neurons each.

The Figure 3. Shows the Feed Forward Network architecture of one hidden layer with 40 neurons

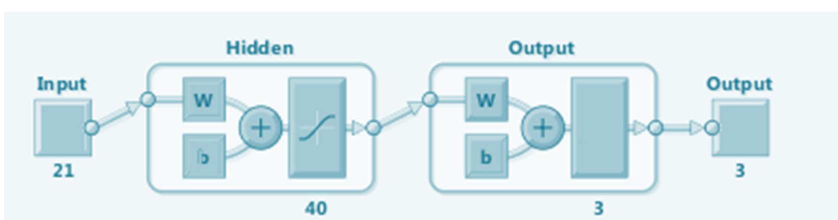

Fig 3. Feed Forward net Architecture of one hidden layer with 40 neurons

There is no hard and fast rule for selecting number of hidden layers and hidden neurons [12]. Several combinations of hidden layers and number of hidden neurons are simulated and the combinations which produce better results are chosen and tabulated in table1. In the same way different activation functions Linear, Tan sigmoid , log Sigmoid and Soft max functions are simulated and the combination of Soft max function for input-hidden, hidden-hidden layers and linear function for hidden-output layers shown better results. The different Back propagation training algorithms trainlm, traindx, trainoss, trainbr, trainr, trainscg, etc., are tried and out of which the Scaled Conjucate Gradient (trainscg) Back propagation training algorithm yields the better results.

III. Results and Discussions

The classifiers using different architectures for the classification of the thyroid disorders are simulated and the results are shown in table 2. The Cross-Entropy and Classifier accuracy are measured. Further the Confusion matrix and ROC curves are plotted for each classifier architecture.

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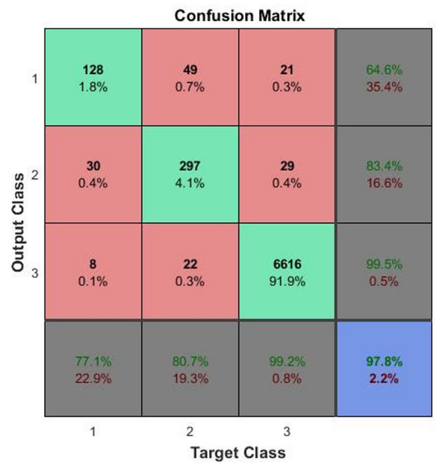

Fig 4. The Confusion matrix for the Elman classifier architecture 21-27-27-3

The confusion matrix for the Elman architecture with 2 Hidden layers and 27 hidden layer neurons each is shown in figure 4. The diagonal elements show the correct classification and the other show the incorrect classification.

Classes:

- Hyper function
- Subnormal functioning1.
- Normal, not hyperthyroid

Row 1 shows actual class1 (128+49+21=198)

Column shows predicted as class 1 (128+30+8= 166)

From the figure 4. it is deduced that

The overall accuracy = 97.8%

Percentage Correct Classification : 97.8%

Percentage Incorrect Classification : 2.2%

Total Records : 7200

Records belong to class 1 : 198

Records belong to class 2 : 356

Records belong to class 3 : 6646.

(A highly imbalanced large dataset.)

Class 1 classified as class 1 : 128

Class 1 classified as class 2 : 30

Class 1 classified as class 3 : 8

Class 2 classified as class 1 : 49

Class 2 classified as class 2 : 279

Class 2 classified as class 3 : 22

Class 3 classified as class 1 : 29

Class 3 classified as class 2 : 21

Class 3 classified as class 3 : 6616.

Class 1 correctly classified as class1=128/198 = 64.6%

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Class 2 correctly classified as class 2=297/356 = 83.4%

Class 1 correctly classified as class1=6616/6646 = 99.5%

The highlighted data shows the correct classification.

The ROC plot for the Elman (21-27-27-3) architecture is shown in figure 5.

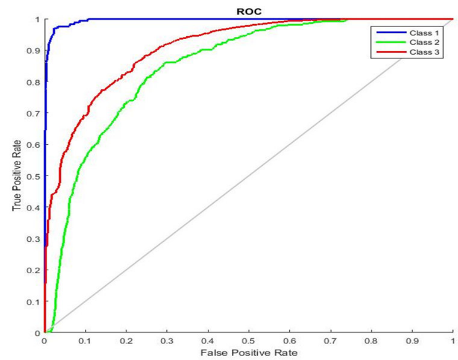

Fig5. The ROC for the Elman classifier architecture 21-27-27-3

The Table2 shows the results of the simulated networks.

SNo	Architecture	Classification Accuracy (%)	Cross-Entropy
Feed Forward Network			
1	21-10-3	93.1	0.0503
2	21-15-3	93.7	0.0637
3	21-27-3	94.6	0.0537
4	21-40-3	94.1	0.0603
5	21-10-10-3	95.3	0.0335
6	21-27-27-3	95.8	0.0267
Elman Neural Network			
7	21-10-3	94.2	0.0598
8	21-15-3	94.7	0.0510
9	21-27-3	95.2	0.0353
10	21-40-3	95.7	0.0269
11	21-10-10-3	96.7	0.0195
12	21-27-27-3	97.8	0.0120

Fig 6 shows the comparative chart of classifier accuracies of feed forward and Elman Network architectures.

Fig 7 shows the comparative chart of classifier cross entropy of feed forward and Elman Network architectures

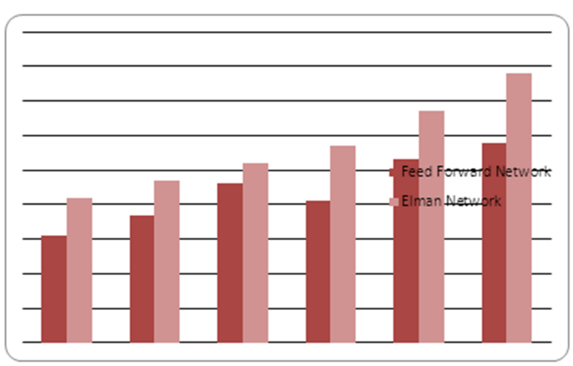

Fig 6. Comparison of Classifier accuracy(%) of Elman and feed forward network architectures

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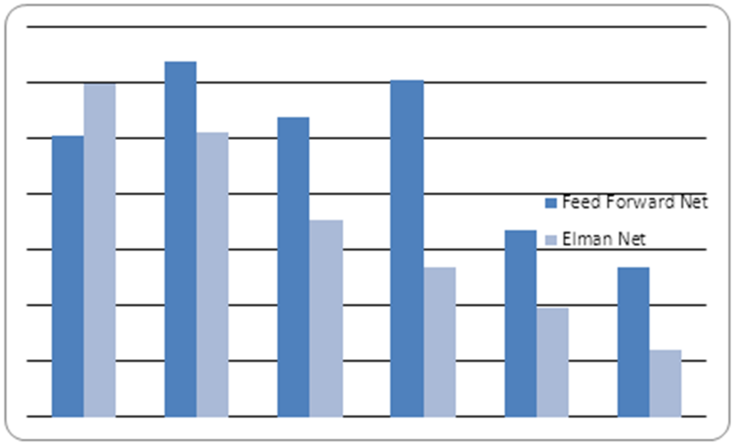

Fig 7. Comparison of Classifier cross entropy of Elman and feed forward network architectures

It is evident from the table and the charts that the Elman Neural Network with the architecture 21-27-27-3 has the best performance of accuracy of =97.8% a cross-entropy of 0.012.

IV. Conclusion

The classifier models for thyroid diagnosis using feed forward networks and Elman networks are successfully developed. The data set is a large data set containing 7200 data tuples with 21 attributes and 3 classes. Both feed forward neural networks and Elman networks could model a classifier for such a large data set with good accuracy of higher than 90%. The results indicate that the models developed by Elman Recurrent Networks have better accuracy and suitable for modelling non linear dynamic systems like thyroid

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