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An Improved Elman Neural Network Classifier for classification of Medical Data for Diagnosis of Diabetes

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Abstract:
The computer aided medical diagnosis became popular in all the important areas of medical sciences and studies. The classification plays a vital role in medical diagnosis and became an important tool for diagnosis and treatment planning of various diseases. The artificial neural networks are widely used in building the classifiers because of their parallel and accurate data processing capabilities. In this research paper the Elman recurrent neural network is employed to build a classifier for the diagnosis of diabetes disease. The proposed Elman Neural network classifier employs soft max activation function to have a better performance and accuracy and the proposed classifier exhibited a better accuracy. The results of the implementation are compared with other methods available in literature.

Keywords: Artificial Neural networks, Classifier, diabetes diagnosis, Elman Neural Networks, large data sets, medical diagnosis.

I. INTRODUCTION

The Artificial neural networks are best suited for modeling nonlinear systems for data mining applications. The classification process has emerged as an important tool in various fields of medical sciences. The classifiers can be effectively applied to diagnosis of various diseases including diabetes based on the medical data. The classification can be implemented by various mathematical, statistical and neural networks methods. The Elman neural network proposed by Jeffery L. Elman [1] is a recurrent network with an additional feedback layer called Context unit. The Elman Network with context units are shown in fig 1. The contents of the Hidden layer neurons are copied to the context layer neurons and in the next cycle the context unit contents are feedback to hidden layer. Hence a sort of feedback mechanism is implemented. Further it can be considered a small memory of previous time data. Hence the output depends on the current state inputs along with the previous state outputs making the learning process more dynamic and effective

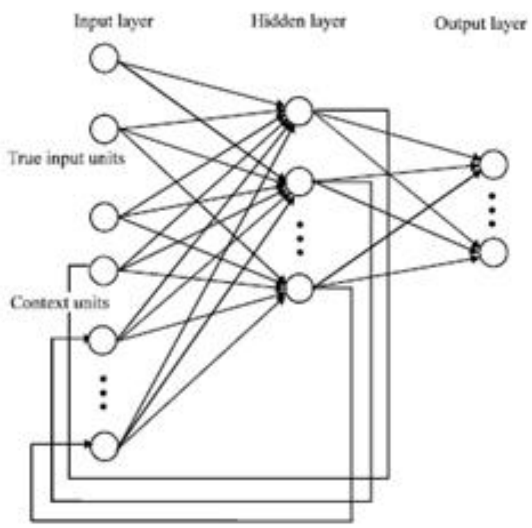

Figure.1. Elman Neural Network

II. RELATED WORK.

Several researches have used various statistical and machine learning approaches for data classification. Dogantekin E, et al. [2] proposed a diagnosis system for diabetes based on Linear Discriminant Analysis and Adaptive Network Based Fuzzy Inference System: LDA-ANFIS in 2009. They used the PIMA Indian Diabetes Data set and obtained an accuracy of 84.61%, specificity of 85.18% and sensitivity of 83.33%. Kelam Polat , Salih Gunes and Ahmet Arslan [3] proposed Generalized Discriminant Analysis to classify between healthy and diabetic patient and used LS-SVM technique for classification and obtained an accuracy of 78.21% classification accuracy. The GDA-LS-SVM technique had an accuracy of 82.05% Mostafa Fathi and Mohammed Sainee Abadeh , [4] made use of Ant Colony Optimization for extraction of fuzzy rules for building a fuzzy classification system for diagnosis of Diabetes disease. A classification accuracy of 84.24% was obtained. In the year year 2008 Sean N. Ghazai and Thunshun W.Liao [5] adopted a fuzzy modeling technique using fuzzy K nearest neighbor algorithm and Adaptive Network based fuzzy inference system (ANFIS) for diagnosis of diabetes using Pima Indian Data set and obtained classification accuracy of 77.65% M. Durairaj, G. Kalaiselvi [6] conducted a survey on various techniques for classification on diabetes diagnosis followed by different researchers and concluded that the ANN technique was most effective. Rahul Kala et al. in the year 2010 [7] proposed an Evolutionary Radial Basis Function Network For Classificatory Problems and they tested their method using the pima Indian diabetics data and obtained an accuracy of 84.07% during training and 82.37% during testing. Nasib Singh Gill and Pooja Mittal [8] proposed a Novel Hybrid Model for Diabetic Prediction using Hybrid Hidden Markov Model, Fuzzy based Rule approach and Neural Network technique and used the Pima Indian Diabetic data set for training and testing. They obtained an accuracy of 92% Further a comparative analysis is performed with existing popular data mining approaches. The WEKA tool is used to apply different classification approaches on Pima data set. The approaches considered under WEKA are Bayesian Network, Neural Network Approach, SVM, KNN and Decision Tree approach. Devaraj, D. and Ganeshkumar, P [9] in 2010 used the Mixed Genetic Algorithm for the classification of data sets extracted form UCI Machine Learning Data repository They built the fuzzy classifier using mixed genetic algorithm and performed the classification on the ten bench mark datasets of various applications successfully. Ishibuchi, H., Yamamoto, T. and Nakashima, T. [10] proposed a Hybridization model of fuzzy GBML approaches for pattern classification problems and used the datasets form UCI machine learning data repository including Pima Indian Diabetic dataset for implementation. Dombi, J., & Gera, Z. [11] performed the Genetic Algorithm-Gradient Approach (GAGA) for classification problems in the year 2005. Karamath Ateeq and Dr. Gopinath Ganapathy [12] in 2017 proposed the novel hybrid Modified . Particle Swarm Optimization – Neural Network (MPSO-NN) Algorithm for classifying th Diabetes disease. They used MLPN and RBFN networks and obtained the accuracy of 68.84% & 67.48% respectively. Ebenezer Obaloluwa Olaniyi, Khashman Adnan[13] in 2014 proposed the Onset Diabetes Diagnosis Using Artificial Neural Network with Back propagation algorithm and obtained an accuracy of 82%. They performed classification using KNN, C4.5, BSS and EM algorithms. Amit kumar Dewangan, Pragati Agrawal [14] performed Classification of Diabetes Mellitus Using Machine Learning Techniques in 2015. They obtained an accuracy of 81.89%. Mehmet Recep et al [15] performed diabetic diagnosis using several machine learning techniques including LVQ, PNN, FFN,CFN, DTDN, TDN, GINI and AIS techniques and presented the accuracy , sensitivity and specificity. Kayaer and Yildirim [16] used the LM algorithm for the neural networks on a Pima Indian dataset and achieved an accuracy of 77.08%. Temurtas et al. [17] trained the neural network optimally with a probabilistic neural network (PNN) along with a LM algorithm and obtained an 82.37% accuracy with this approach. Mohana sundaram. N and Sivanadam.S.N [18] proposed a novel intelligent classifier model is designed employing ELMAN neural network architecture hybridized with biogeography based optimization technique. The proposed hybrid ELMAN – BBO classifier model is tested and validated by implementing it for various test benchmark datasets from UCI machine learning repository. Harikumar & Sukanesh [19] analyzed classification of epilepsy risk levels from EEG (Electroencephalogram) signals using Elman neural network and Multilayer Perceptron (MLP) Feed forward neural network. The result confirms that the Elman neural network superior with 97.87 % of PI and 23.31 QV compared to fuzzy classifier, MLP neural network A Cuckoo Search Levenberg Marquardt Elman Network (CSLMEN) was designed in order to eliminate local minima problem and improve the convergence rate for data classification [20] by Nawi et.al in the year 2014. Based on the above literature review it is proposed to build an efficient and improved classifier to diagnose the diabetes using bench mark dataset in this paper.

III. DATA SET

The Pima Indian Diabetes data set has 768 tuples with 8 attributes and 2 classes.

The attributes are listed below:

1. Number of times pregnant
2. Plasma glucose concentration a 2 hours in an oral glucose tolerance test
3. Diastolic blood pressure (mm Hg)
4. Triceps skin fold thickness (mm)
5. 2-Hour serum insulin (mu U/ml)
6. Body mass index (weight in kg/(height in m)^2)
7. Diabetes pedigree function
8. Age (years)

The class variable is denoted as 0 and 1 for Normal people and diabetic patients. There were 500 samples for normal people and 268 samples for diabetic patients. The data set is obtained from UCI machine learning Repository [21] which is from National Institute of Diabetes and Digestive and Kidney Diseases.

IV. IMPLEMENTATION

The Elman neural network is simulated in MATLAB platform. The architecture

Input Neurons: 8 (1 for each attribute)
Hidden layer : 1
Hidden neurons: 45

There is no hard and fast rule for fixing the number of Hidden layers and the number of Hidden layer neurons. In this experiment different approach with 9, 18,27,30,45 and 60 hidden neurons in one layer and two layers are tried and the most effective one was with 45 neurons in single hidden layer. Then the training algorithm selected was Scaled Conjugate Gradient (TRAINSCG) Back propagation algorithm. The experiment was conducted using different algorithms like Levenberg-Marquardt algorithm, TRAINOSS, TRAINSCG, TRAINGDA and TRAINLM and the optimum was obtained with Scaled Conjugate Gradient (TRAINSCG) algorithm. The Softmax activation function is used instead of sigmoid activation function The metrics considered are Accuracy, Sensitivity and specificity. Sensitivity is the probability that a diagnostic test is positive, given that the specified sample belongs to the category.

$$\text{Sensitivity} = TP / (TP+FN) \quad (1)$$

Specificity is the probability that a diagnostic test is negative, given that the specified sample does not belongs to the category.

$$\text{Specificity} = TN/ (TN+FP) \quad (2)$$

Classification Accuracy is defined as the probability that a diagnostic test is correctly performed.

$$\text{Classification Accuracy} = (TP+TN)/ (TP+FP+TN+FN) \quad (3)$$

where,

True Positives (TP) -Correctly classified positive cases
True Negative (TN) -Correctly classified negative cases
False Negative (FN) - Incorrectly classified positive cases.
False Positives (FP) - Incorrectly classified negative cases

V. RESULTS AND DISCUSSIONS

The experiment is conducted by simulating the Elman network with softmax activation function. The Data are divided as 60% for training, 20% for validation and 20% for testing. The resulting classification accuracy is obtained as 95.7%, Sensitivity as 92.5% and Specificity as 90.1%. The experiment is conducted with different number of hidden layer neurons like 9,15,18,20,27,37,45 and 60. The best results were obtained with 45 neurons. Similarly several training algorithms were tried and the Scaled Conjugate Gradient gave the best results. The proposed method showed better performance because of the Soft max activation function and the better adaptability and learning capability of Elman networks. The Comparison of results with other methods in the literature is presented in Table 1.

Table.1. Comparison of results with other methods

S.No	Approach	Performance Metrics		
		Classification Accuracy %	Sensitivity (%)	Specificity (%)
1	LDA- ANFIS [2]	84.61	85.18	83.33
2.	LS-SVM [3] GDA-LS-SVM [3]	78.21 82.05		
3.	Ant Colony Optimization fuzzy classification system [4]	84.24		
4.	ANFIS [5]	77.65		
5.	Evolutionary Radial Basis Function Network [7]	82.37		
6.	Hybrid Hidden Markov Model, Fuzzy based Rule approach and Neural Network [8]	92%		
7.	Mixed Genetic Algorithm (MGA) [9]	90.2	90.5	87.3
8.	Hybrid Genetic Based Machine Learning (HGBML) [10]	84.2	88.7	84.1
9.	Genetic Algorithm-Gradient Approach (GAGA) [11]	89.4	90.3	86.9
10.	MPSO-NN MLPN MPSO-NN RBFN [12]	68.84% 67.48%		
11.	BPNN [13]	82		
12	BSS KNN [13]	67.1 72		
13	C4.5 [13]	71.1		
14.	PNN [15]	72	63.33	76.88
15	LVQ [15]	73.6	54.44	84.38
16	DTDN [15]	76	53.33	88.75
17	AIS [15]	68.80	52.22	78.13
18	ANN with LM algorithm [16]	77.08		
19	PNN with LM algorithm [17]	82.37		
20	The hybrid ELMAN – BBO [18]	91.6	91.7	88.9
21	**Proposed Elman – Softmax neural network**	**95.7**	**92.5**	**90.1**

The figure 2 shows the Classification accuracy in percentage(%) for different methods

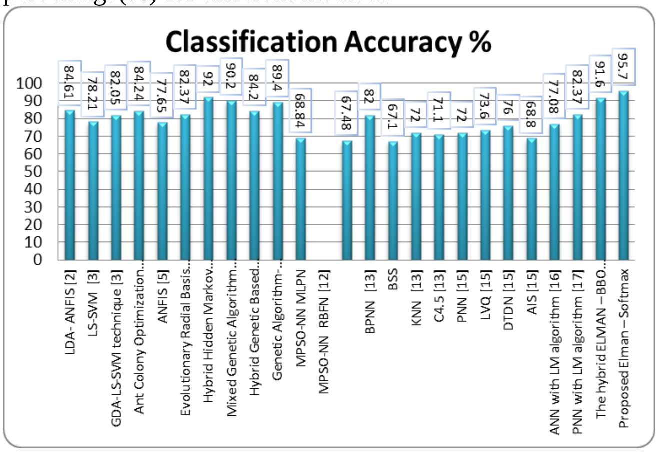

Figure.2. The Classification accuracy in percentage (%) for different methods

The figures 3 and 4 show the %sensitivity and % specificity for different methods.

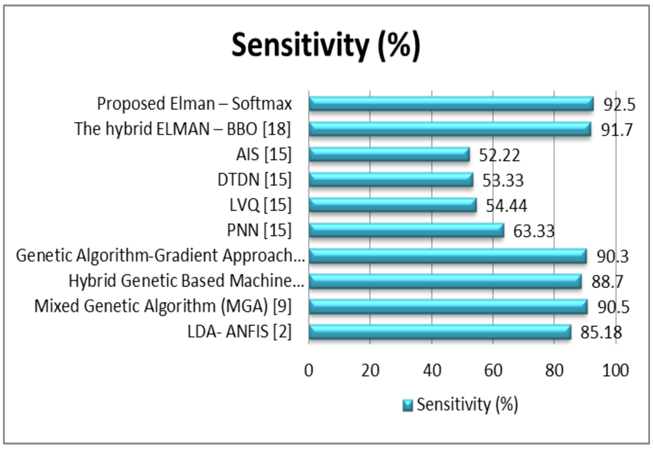

Figure.3. Sensitivity for various methods

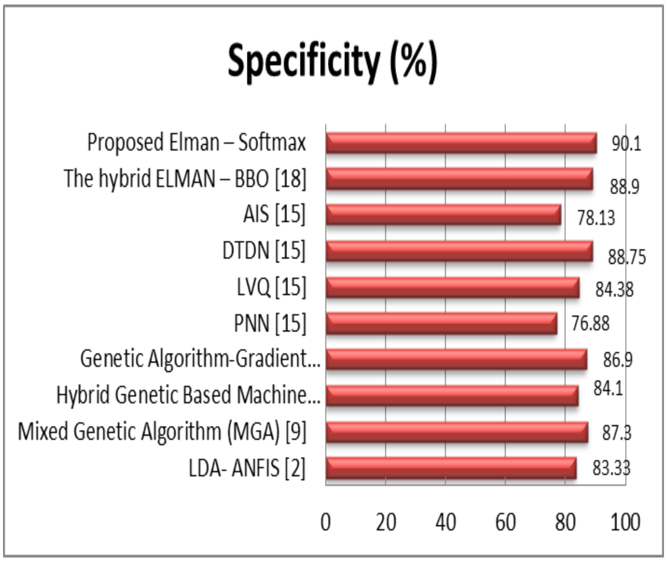

Figure.4. Specificity for various methods

VI. CONCLUSION

In this research paper, the proposed Elman softmax classifier is implemented and its results are presented and discussed. Usage of Softmax activation function instead of sigmoid activation function or linear activation function improves the performance. The performance of the proposed ELMAN Softmax model was better than the performance of the other available methods reported in the literature. The results prove that the proposed model achieves better classification accuracy.

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