International Review of Fuzzy Mathematics, Volume 13, No. 2, (December 2018)

Trupti A Thakre, Onkar K Chaudhari, Nita R Dhawade and Prashant Borkar

FITNESS PREDICTION MODELLING USING ADAPTIVE NEURO-FUZZY CLASSIFIER & ARTIFICIAL NEURAL NETWORK

Abstract: *Fitness of an individual plays very important role for better quality of life. It requires proper health caring system which can predict it properly as per the convenience of an individual. This increasing need has encouraged using more precise and transparent system. This paper aims to design artificial neural network (ANN) and adaptive neuro-fuzzy classifier (ANFC) for fitness prediction based on various input parameters. Twelve variables are used as input. Same training and testing data sets are used for comparing both models. Results of the adaptive neuro-fuzzy classifier and artificial neural network with their accuracy rate are compared and discussed for the conclusion.*

Keywords: Artificial neural network (ANN), Adaptive neuro-fuzzy classifier (ANFC), Fitness Prediction, health caring system.

MSC: *03B52, 68T05*

1. INTRODUCTION

Healthcare is an emerging area now days. Because of the changes in lifestyle and excessive work load, health is getting affected. Most of the people especially those who are working, hardly pay attention towards their fitness. This may be because of their busy schedule or money problem or scarcity of health services in their area or their ignorance to the fitness. Sometimes it is also difficult to visit doctor. But this may give rise to the development of severe disease in future. This requires emergence of a health care assistance system which will be convenient to use at home without actually going to the clinic, so that their time and money both are saved.

For overall health improvement, fitness becomes essential. A fit person is able to relish life with positive energy. So, a system can be helpful which will tell whether

the given person is fit or unfit. But it is difficult to tell on the basis of some factors about the fitness as it always involved some uncertainty or imprecise information. So a system use for the fitness prediction should be transparent and should minimize this uncertainty. Because of the advances in computer technology, computer based health care systems have become essential [16]. There are many portable devices available in the market for health check up at home such as sugar monitor, blood pressure monitor, thermometer, pulse oxymeter etc. which can predict various health related issues. In this paper, we tried to compare the results of two models for the fitness prediction namely artificial neural network and adaptive neuro fuzzy classifier which can minimize the uncertainty of the problem and can give reliable results. Comparisons of two models not have been done which is observed from the reviews of literature. These systems are useful for the patients as well as health care services providers.

This paper is organized into various sections as follows: Section 2 gives review of literature. Section 3 discusses about neural network for fitness prediction followed by section 4 describing adaptive neuro fuzzy classifier. Section 5 presents result and discussion of the work giving comparison of these two systems and section 6 gives conclusion of paper. Last section is devoted to recommendations for future research.

2. LITERATURE REVIEW

Various authors have proposed research works in this direction. Paper discussed on employing fuzzy logic in the diagnosis of clinical case describes that fuzzy logic can be successfully applied to the clinical diagnosis of the patient who suffers from different diseases bound by complex casual chain [7] in 2010. Neural network approach was presented in 2010 in artificial neural network applied to cancer detection in a breast screening program. Before going for mammography, the model can determine which woman is more likely to suffer from particular kind of tumor [6]. V. Sarasvathi and A. Santhakumaran in 2011, studied Artificial Neural Network for diagnosing thyroid problem with the help of back propagation algorithm giving result that whether the person is healthy or has thyroid problem [16]. Farman A. Moayed and Richard L. Shell developed artificial neural network (ANN) models in occupational safety and health utilizing ordinal variables in the year 2011 describing

that ANN model performs better than Logistic Regression (LR) models [3]. In 2013, Adaptive Neuro Fuzzy Inference system was proposed for health monitoring at home by [1]. They have developed ANFIS as health care system which will be useful for ill patients as well as pregnant women for their check up at home. In 2013, Dhifaf Azeez et al. did comparison of adaptive neuro-fuzzy inference system and artificial neural networks model to categorize patients in the emergency department. They explained that how these systems can capture vital signs and general appearance of the patients and can report the emergency status of the patient [2]. Fuzzy logic based health care system using wireless body area network is studied by Prakashgoud Patil and Samina Mohsin in 2013, demonstrating that the fuzzy logic can be applied to health monitoring system using wireless sensor network for deciding final observation of patient health status based on bio-signal reading [11]. For the classification of students' academic performance, the neuro fuzzy classifier is used by Quang Hung Do and Jeng-Fung Chen in 2013. They used previous exam results and other related factors as input and then labeled students based on their academic performance showing then that neuro fuzzy classifier performed better than well known classical algorithms [15].

Automatic heart disease diagnosis system based on artificial neural network and adaptive neuro fuzzy inference systems approaches is proposed by Mohammad A. M. Abushariah et al. in 2014 where it is proved that ANN system outperforms the neuro fuzzy system [9]. Francisca Nonyelum Ogwueleka et al. in 2014 proposed artificial neural network for the analysis and prediction of accident rates in a developing country which showed that ANN performed better than other statistical methods in use [10]. Furqan H. et al. described a fuzzy expert system in 2014 for fitness advisory which suggests suitable physical fitness by helping the user in tracking the calories taken per day and guiding for physical activities to burn back the calories [4]. The patient health care analysis is done based on ANFIS sugeno model in 2014 which described about adaptive neuro fuzzy interface system in order to analyze the risk factor values of human being [8]. Prashant Borkar et al. suggested model using linguistic hedges and feature selection approach for vehicular traffic density estimation in 2015 [14]. In 2016, Prashant Borkar et al. did performance comparison of multi-attribute decision making methods which used simple additive weighting, weighted product method, analytic hierarchy process method and TOPSIS

method showing that TOPSIS, weighted product method, analytic hierarchy process method provide similar results [12]. In the year 2016, the integration of artificial neural fuzzy inference system in health monitoring system is done to get the status of the patient in a real time patient monitoring system based on artificial neural fuzzy inference system (ANFIS) [5].

3. ARTIFICIAL NEURAL NETWORK (ANN) MODEL

The artificial neural network is collection of large number of connected processing units or nodes called as artificial neurons which are analogous to biological neurons in an animal brain. Following figure 1 represents typical artificial neural network.

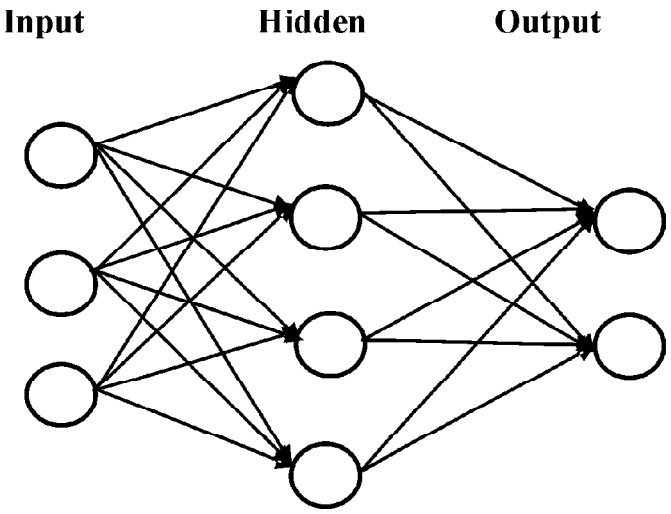

Figure 1: Typical Artificial Neural Network model

As shown in figure, it is cleared that artificial neural network consists of three layers namely input layer, hidden layer and output layer. The input layer takes number of inputs at a time which has number of nodes equal to number of input variables. These inputs are processed and output is generated with the help of some processing algorithms. It is based on graph topology in which neurons represent nodes and weights represent the edges in the network. Neurons are the processing units of the network represented by circles in figure 1 which uses some processing algorithms to produce output. The main advantage of artificial neural network is that it is used to

solve complex problem. In this paper, this model is used to find the accurate prediction of fitness on the basis of some inputs and because of its ability to support medical decision support system as it can learn the pattern of the data fed into it for the training.

3.1. The Flow chart

Flow chart for steps involved in the process of ANN is given as

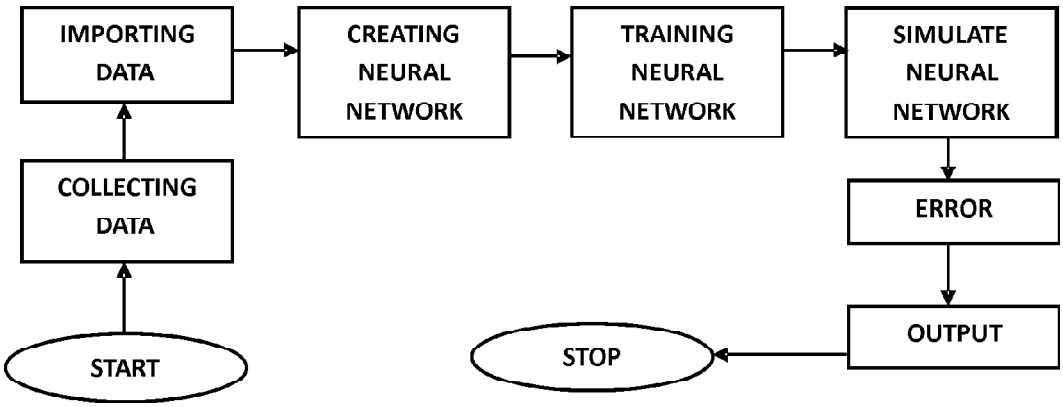

Figure 2: Flow chart for Artificial Neural Network Process

ANN model has to be trained, tested for the performance and validated. The model receives input then data is processed in the hidden layer by nodes and some activation function and then data is passed on to the output layer for giving results.

3.2. Application

The performance of the organization depends on employees working in it. So it is important that employee should be physically fit and healthy. Therefore there is need of a system which can predict the fitness and can help the employee as well as organization to take necessary action for improving the health of the workforce. This will also help the organization to develop health programs for employees. In this paper, data related to health parameters of employees working in one of the private company has been collected for their fitness prediction in future. These parameters are Age, Gender, Weight, Pulse, Blood pressure (upper and lower), Blood sugar (Fasting and Post meal), Red blood cells (RBC), and White blood cells (WBC),

Platelets, Hemoglobin (Hb) which are considered as input variables. The output here is fitness and unfitness.

3.2.1. Training the Network

The MATLAB R2013a software is used for implementing the network. The data collected has been fed into the network so that it can be trained. The above mentioned 12 input variables and fitness and unfitness as output variable are used as a training data set. The data is imported into the MATLAB which forms particular pattern that can be recognized by neural network. The pattern of the data set helps the network to learn and do prediction with more accuracy and less error. From recorded data, it is predicted that the person is fit or unfit. The multilayer new feed forward back propagation algorithm is used to train the network where we give size of hidden layers, number of neurons and tangent sigmoidal function is used as a activation function for transferring the data to the next layer. The network is trained by taking some iterations and calculating error every time and then it stops training once it finds the minimum error.

Figure 3 gives training state of the ANN

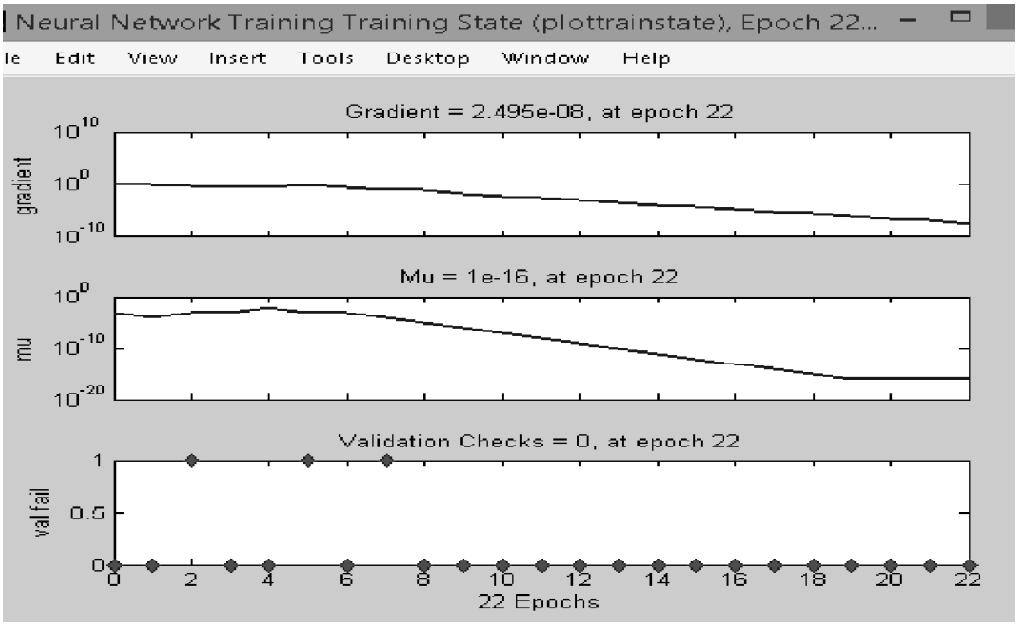

Figure 3: Training State of the Artificial Neural Network

3.2.2. Output of Artificial Neural Network

Artificial Neural Network is applied to predict the fitness for different combination of above mentioned input parameters.

Table 1 gives the accuracy of the artificial neural network.

Table 1
Accuracy of Artificial Neural Network

Overall Accuracy	84.62 %
Fit Accuracy	88.89 %
Unfit Accuracy	80%

Figure 4 represents the performance and error graph of the artificial neural network in present study which describes that best validation performance is 1.425e-07. It was found at 22 epochs.

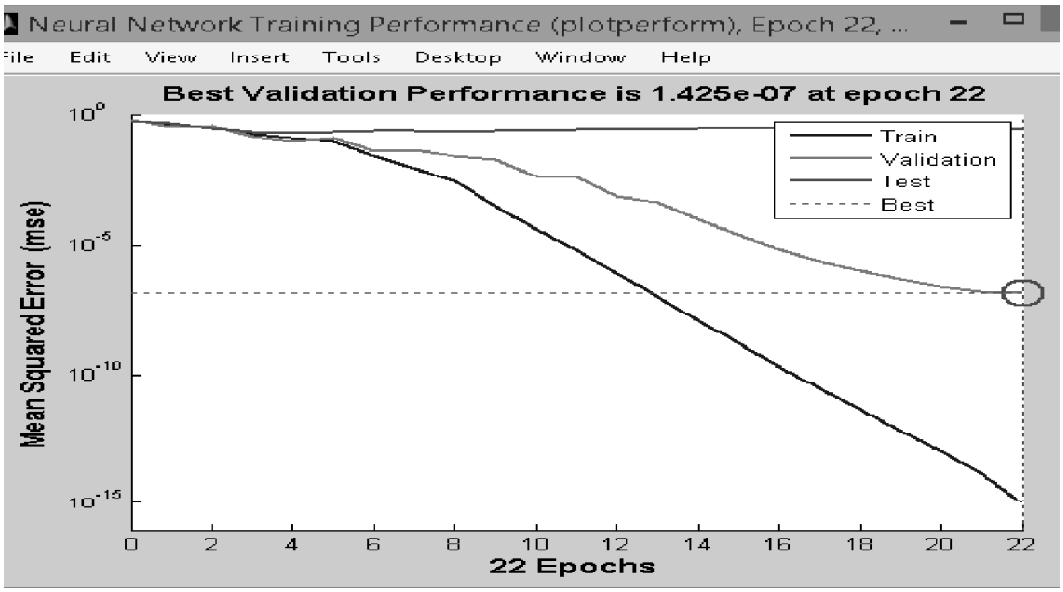

Figure 4: Performance of the Artificial Neural Network

4. ADAPTIVE NEURO-FUZZY CLASSIFIER(ANFC) APPROACH

The combination of fuzzy system and learning capabilities of neural network results in creation of neuro-fuzzy classifier. It is based on fuzzy system which is trained by

learning algorithm derived from neural network theory where parameters of fuzzy systems are determined by neural network or algorithm of neural network. The intention of using neuro-fuzzy approach is that it improves the fuzzy system by means of neural network. It is actually multilayer feed forward network where based on incoming input signal each node performs desire function [13]. It is useful to solve various classification problems [15] and it gives relationship between input and output. In this paper ANFC has been modeled to predict the fitness for different combinations of input parameters.

4.1. Architecture of Adaptive Neuro-Fuzzy Classifier

A typical adaptive neuro-fuzzy classifier contain input, membership, fuzzification, defuzzification, normalization and output layer [15]. It has multiple inputs and outputs. Following figure 5 depicts the architecture of Adaptive Neuro-Fuzzy Classifier.

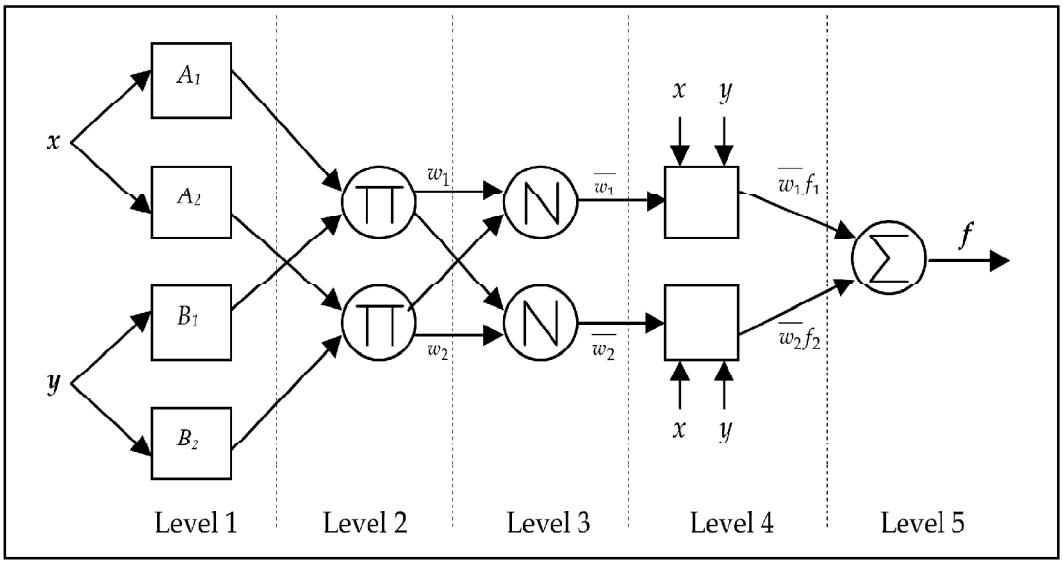

Figure 5: A Typical Architecture of Adaptive Neuro-Fuzzy Classifier

Layer 1: Every node in this layer is an adaptive node which adapts the function parameter. Here x and y represents input and output of each node is degree of membership $O_{1,i}$ given by fuzzy sets A_i and B_i which describes about the degree to

which *x* or *y* satisfies the quantifier. Here Gaussian Membership function is used since the function has fewer parameters which is given as

$$\mu_A(x) = e^{-\frac{1}{2}\left(\frac{x-c}{a}\right)^2} \tag{4.1.1}$$

$$O_{1,i} = \mu_{A_i}(x) \quad i = 1,2$$
$$O_{1,i} = \mu_{B_{i-2}}(y) \quad i = 3.4$$

Here (a,b,c) represents the parameters of membership function

Layer 2: Every node in this layer denoted by π is a fixed node which represents the firing strength of each rule. The output node here is obtained by multiplying all signals coming into the node and delivered to the next node.

$$O_{2,i} = W_i = \mu_{A_i}(x)^* \mu_{B_i}(y), \quad i = 1,2 \tag{4.1.2}$$

Layer 3: The result of this layer is called as normalized firing strength. Each node of this layer is labeled as *N* and it is fixed where ith node calculates the ratio between ith rules firing strength and sum of all rules' firing strength.

$$O_{3,i} = \bar{W}_i = \frac{W_i}{\sum_{i=1}^{2} W_i} \tag{4.1.3}$$

Layer 4: Every node in this layer is an adaptive node with node function. It is given by

$$O_{4,i} = \bar{W}_i f_i = \bar{W}_i (p_i x + q_i y + r_i) \tag{4.1.4}$$

Where $\bar{W}_i$ is normalized firing strength obtained from previous layer 3 and $\{p_i, q_i, r_i\}$ is the parameter set of this node. Parameters in this layer are referred as consequent parameters.

Layer 5: This layer contains single fixed node labeled by ", that computes overall output as a summation of all incoming signals from previous node and overall output is given by

$$O_{5,i} = \sum_i \bar{W}_i \, f_i = \frac{\sum_i W_i f_i}{\sum_i W_i} \tag{4.1.5}$$

4.2. Output of Adaptive Neuro-Fuzzy Classifier

In order to classify and predict the fitness as fit or unfit, the adaptive neuro-fuzzy classifier is applied. The physical fitness is predicted for varying combination of input variables namely, Age, Gender, Weight, Pulse, Blood pressure (upper and lower), Blood sugar (Fasting and Post meal), Red blood cells (RBC), White blood cells (WBC), Platelets, Hemoglobin (Hb). Number of iterations taken was 100.

Table 2 gives the accuracy of adaptive neuro-fuzzy classifier.

Table 2
Accuracy of Adaptive Neuro-Fuzzy Classifier

Overall Accuracy	88.46%
Fit Accuracy	92.59%
Unfit Accuracy	84%

Fuzzy rule representation and its corresponding evaluation of performance of the adaptive neuro-fuzzy classifier are given by following figure 6 and figure 7 respectively. From Figure 7 it clearly indicates that error goes on decreasing as number of iterations increases.

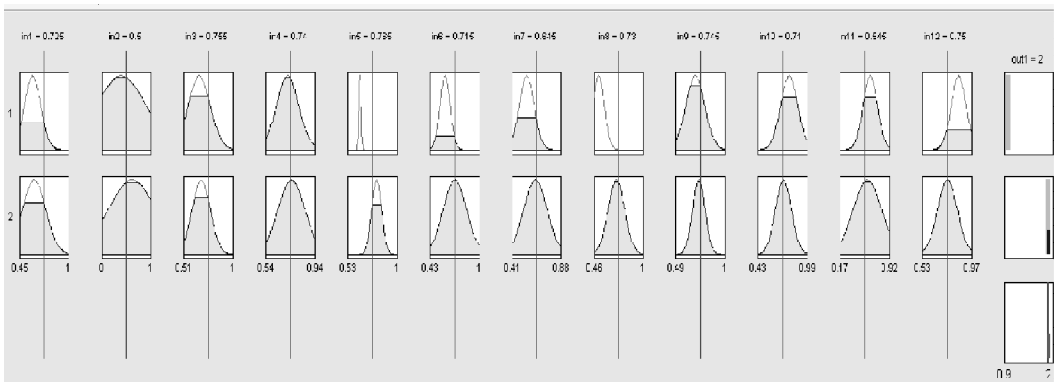

Figure 6: Fuzzy Rule Representation

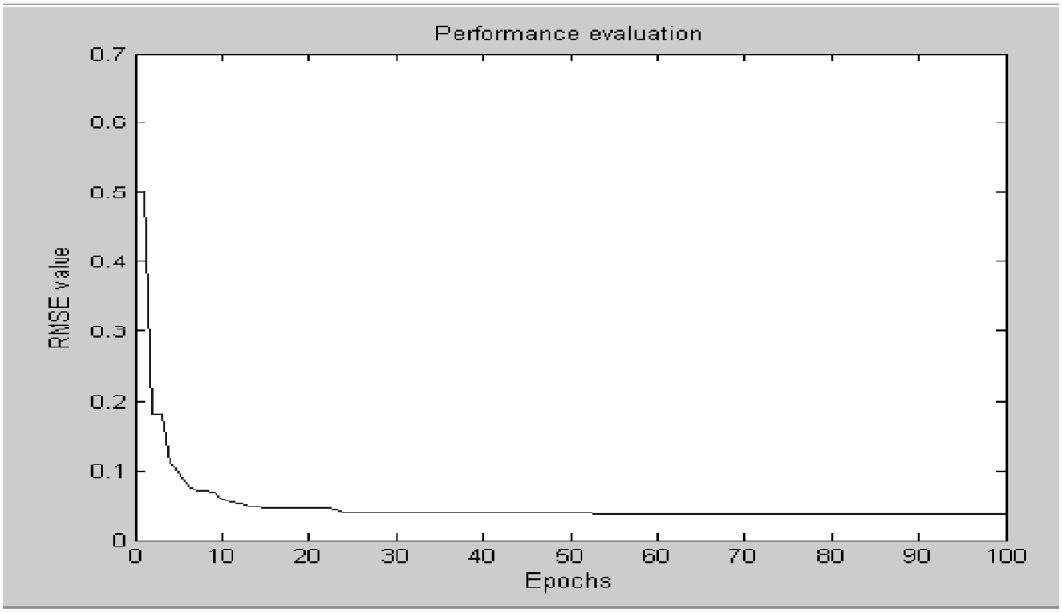

Figure 7: Performance Evaluation of Adaptive Neuro-Fuzzy Classifier

Figure 8 represents surface viewer showing relationship between input and output variables.

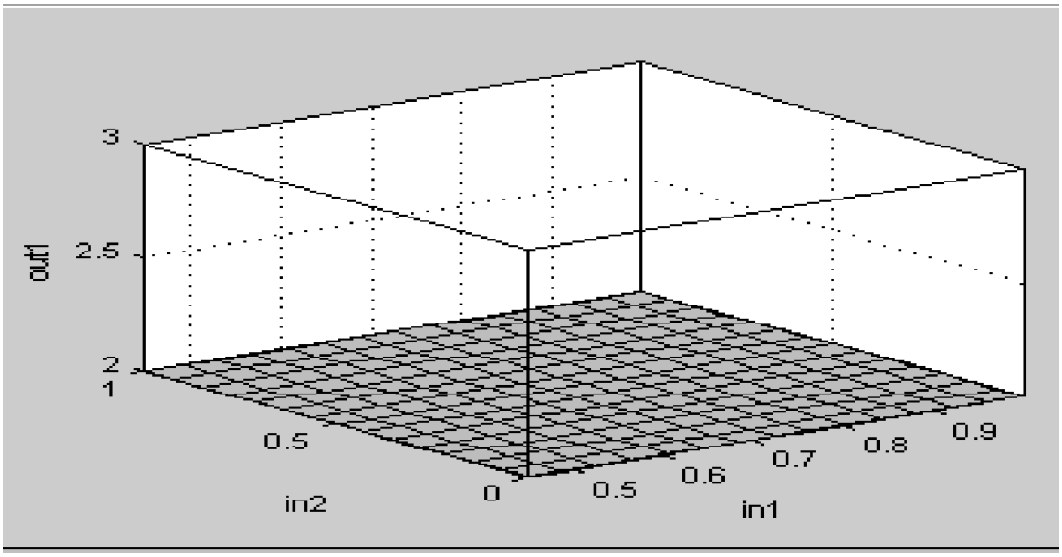

Figure 8: Surface Viewer

5. RESULT & DISCUSSIONS

The fuzzy system is not capable of learning itself. ANN is ambiguous to the user. ANFC is a hybrid intelligent system of fuzzy system and artificial neural network which makes the fuzzy system to learn itself. The result of ANFC is compared with the ANN on the basis of performance through accuracy. For modeling and training of the data, MATLAB is used for both artificial neural network and adaptive neuro-fuzzy classifier. The same training and testing data sets were used for the purpose of training and testing both models for making more reliable comparison. The predicted output that is physical fitness for tested data by both models is shown in the table 3 where 1 stands for fit and 0 stands for unfit.

Table 3
Predicted Physical Fitness Value by Artificial Neural Network & Adaptive Neuro-Fuzzy Classifier

Sr. No.	*Original Physical Fitness Value by Expert*	*Physical Fitness Value by ANN*	*Physical Fitness Value by ANFC*	*Sr. No.*	*Original Physical Fitness Value by Expert*	*Physical Fitness Value by ANN*	*Physical Fitness Value by ANFC*
1	1	**0**	**0**	**27**	1	1	1
2	1	1	1	**28**	0	**1**	**1**
3	1	1	1	**29**	0	0	0
4	1	**0**	**0**	**30**	0	0	0
5	1	1	1	**31**	0	0	**1**
6	1	1	1	**32**	0	0	0
7	1	1	1	**33**	0	0	0
8	1	1	1	**34**	0	0	0
9	1	**0**	1	**35**	0	0	0
10	1	1	1	**36**	0	**1**	0
11	1	1	1	**37**	0	0	0
12	1	1	1	**38**	0	0	0
13	1	1	1	**39**	0	**1**	**1**
14	1	1	1	**40**	0	0	0

contd. table 3

Sr. No.	*Original Physical Fitness Value by Expert*	*Physical Fitness Value by ANN*	*Physical Fitness Value by ANFC*	*Sr. No.*	*Original Physical Fitness Value by Expert*	*Physical Fitness Value by ANN*	*Physical Fitness Value by ANFC*
15	1	1	1	**41**	0	**1**	0
16	1	1	1	**42**	0	0	0
17	1	1	1	**43**	0	0	0
18	1	1	1	**44**	0	0	0
19	1	1	1	**45**	0	0	0
20	1	1	1	**46**	0	0	0
21	1	1	1	**47**	0	0	0
22	1	1	1	**48**	0	0	0
2s3	1	1	1	**49**	0	**1**	0
24	1	1	1	**50**	0	0	0
25	1	1	1	**51**	0	0	0
26	1	1	1	**52**	0	0	**1**

Table 4 gives comparison of both models in terms of accuracy as overall, fit and unfit.

Table 4
Comparison of ANN and ANFC

Approach	*Overall Accuracy*	*Fit Accuracy*	*Unfit Accuracy*
ANN	84.62 %	88.89 %	80%
ANFC	88.46 %	92.59 %	84%

6. CONCLUSION

The paper has designed artificial neural network and adaptive neuro-fuzzy classifier models for the prediction of the fitness of an individual. The results of both models are compared to make choice of better model on the basis of accuracy. It is clear from above results that the accuracy of fitness and the accuracy of unfitness by model adaptive neuro-fuzzy classifier are better than those of artificial neural network. The results presented in this paper are correct and more appropriate and based on the training and simulation through MATLAB R2013a.

7. RECOMMENDATIONS FOR FUTURE WORK

As research is never ending there is always a scope for new beginning. The artificial neural network and adaptive neuro-fuzzy classifier has recently gained the attention of researchers because of their reliable results. These models can be designed for disease recognition in the field of medical and in other organizations for real time applications. Multiple input factors and multiple output factors can be used for further exploration. The performance of the proposed work can be evaluated with different methods.

REFERENCES

[1] Anuradha T Agrawal, P. S. Ashtankar (2013). Adaptive Neuro-Fuzzy Inference System for Health Monitoring at Home. *International Journal of Advanced Science and Technology , 55*, 89-100.

[2] Dhifaf Azeez, M. A. Mohd Ali, Kok Beng Gan, Ismail Saiboon (2013). Comparison of adaptive neuro-fuzzy inference system and artificial neutral networks model to categorize patients in the emergency department. *SpringerPlus*.

[3] Farman A Moayed, R. L. Shell (2011). Application of Artificial Neural Network Models in Occupational Safety and Health Utilizing Ordinal Variables. *The annals of Occupational Hygiene , 55* (2), 132-142.

[4] Furqan H, Sofianita M, Shuzlina A-Rahman (2014). Fuzzy Expert System for Fitness Advisory. *Knowledge Management International Conference (KMICe)*, (pp. 879-884). Malaysia.

[5] Kajal Singh, Sharma D., Aggarwal S. (2016). A Real Time Patient Monitoring System based on Artificial Neural Fuzzy Inference System (ANFIS). *International Journal of Computer Applications , 146* (15), 22-28.

[6] L Álvarez Menéndez, F. J. de Cos Juez, F. Sánchez Lasheras, J.A. Álvarez Riesgo (2010). Artificial neural networks applied to cancer detection in a breast screening programme. *Mathematical and Computer Modelling* , 983-991.

[7] Licata, G. (2010). Employing fuzzy logic in the diagnosis of a clinical case. *Health , 2* (3), 211-224.

[8] Mayilvaganan M, Rajeswari K. (2014). Patient Health Care Analysis based on ANFIS Sugeno Model. *International Journal of Computer Trends and Technology , 17* (4), 200-204.

[9] Mohammad A M Abushariah, A. A. M. Alqudah, Omar Y. Adwan, Rana M. M. Yousef (2014). Automatic Heart Disease Diagnosis System Based on Artificial Neural Network (ANN) and Adaptive Neuro-Fuzzy Inference Systems (ANFIS) Approaches. *Journal of Software Engineering and Applications, 7*, 1055-1064.

[10] Ogwueleka, F. N., Misra S., Ogwueleka, T. C., Fernandez-Sanz, L. (2014). An Artificial Neural Network Model for Road Accident Prediction: A Case Study of a Developing Country. *Acta Polytechnica Hungarica, 11* (5), 177-197.

[11] Prakashgoud Patil, S. Mohsin (2013). Fuzzy Logic based Health Care System using Wireless Body Area Network. *International Journal of Computer Applications, 80* (12), 46-51.

[12] Prashant Borkar, M. V. Sarode, L G Malik (2016). Acoustic Signal based Optimal Route Selection Problem: Performance Comparison of Multi-Attribute Decision Making methods. *KSII Transactions on Internet and Information Systems, 10* (2), 647-669.

[13] Prashant Borkar, M. V. Sarode, L G Malik (2014). Acoustic Signal based Traffic Density State Estimation using Adaptive Neuro-Fuzzy Classifier. *WSEAS Transactions on Signal Processing, 10,* 51-64.

[14] Prashant Borkar, M. V. Sarode, L G Malik (2015). Modality of Adaptive Neuro-Fuzzy Classifier for Acoustic Signal-Based Traffic Density State Estimation Employing Linguistic Hedges for Feature Selection. *International Journal of Fuzzy Systems , 18* (3), 379-394.

[15] Quang Hung Do, J.-F. Chain (2013). A Neuro-Fuzzy Approach in the Classification of Students' Academic Performance. *Computational Intelligence and Neuroscience*, 1-7.

[16] V Sarasvathi, A. Santhakumaran (2011). Towards Artificial Neural Network Model to Diagnose Thyroid Problems. *Global Journal of Computer Science & Technology, 11* (5), 53-70.

Trupti A Thakre
Department of Mathematics,
R.T.M. Nagpur University, Nagpur, India
E-mail: trupti.arvind.thakre@gmail.com

Onkar K Chaudhari
G. H. Raisoni College of Engineering
Nagpur, India
E-mail: onkar.chaudhary@raisoni.net

Nita R Dhawade
Arts, Commerse & Science College,
Koradi, Nagpur, India
E-mail:dhawadenr.acs@gmail.com

Prashant Borkar
G. H. Raisoni College of Engineering,
Nagpur, India
E-mail: prashant.borkar@raisoni.net