THE EYESIGHT DIAGNOSIS BASED ON FUZZY LOGIC AND ARTIFICIAL NEURAL NETWORKS

Ibrahim Abdulrab Ahmed
Department of mathematics and computer science,
Faculty of Science, Ibb University, Yemen.
alqubati_ibr@yahoo.com

Rashad A. Al-Jawfi
Department of computer science,
Faculty of computer science and engineering, Hodeidah University, Yemen .
algofi@yemen.net.ye

ABSTRACT

This research provides new methods to diagnose eyesight state for people with problems in the vision and to define the problem (if it is found), is it Myopia (Short-Sightedness) or Hypermetropia (Long-Sightedness), by getting eyesight distance (SPH) and deviation (CYL) measurements ,wherever the measurements of SPH or CYL are in normal Range then there is no problem for physician, but when measurements of both SPH and Cyl are out of normal Range it is relatively difficult and take more time to take decision.

Because of the importance of eyesight we have the diagnosis using Neural Networks and Fuzzy Logic system to detect the performance of these used methods and to know the ability of each of them to confirm and assist specialist physician to take appropriate decision.

KEYWORDS : Fuzzy Logic, Neural networks, Diagnosis, Short-Sightedness, and Long-Sightedness.

1. INTRODUCTION

Artificial Intelligence elements like Artificial Neural Networks, Fuzzy logic, Expert Systems, Genetic Algorithms, etc. are tend to emulate the human brain. Fuzzy Logic system can be a very powerful tool for dealing quickly and efficiently with imprecision and nonlinearity [2]. Artificial Neural networks have been successfully applied to problems in pattern classification, pattern matching, function approximation, optimization and associative Memories [4, 5].

In this paper Fuzzy Logic and Neural Networks have been used. In Fuzzy Logic the process of formulating the mapping from input to an output is known as fuzzy inference. One of the main functions of fuzzy logic systems is to give us much precision and to display the ambiguous in the results of experimented application work, which can't be verified using another artificial intelligence fields. Fuzzy inference systems are two types, Mamdani and Sugeneo. Fuzzy inference system used in this research is type of Mamdani. Several tries have been done to get at last the appropriate parameters (member ship functions, logice operators, if then rules, and implication relation) with which we have got established system and desired results [10, 13].

In Neural Networks the input signals (entered parameters) and weights are coming to the summing node. The summed signal then flows to the output through a transfer function and threshold value. Transfer function is type of signum or linear, or nonlinear continuously varying type like sigmoid, inverse-tan, Gaussian etc., note that the nonlinearity of transfer function gives the network capability to emulate nonlinear mapping properties [6, 12].

The neural network can be classified as a feedback or feedforward type, depending on interconnection of the neurons. In this research a feedback net has been used.

2. EXPERIMENTS DESIGN

Matlab 7.0.1 package has been used for Fuzzy logic and Neural Networks methods. The datasets of the Eyesight test (L-SPH, L-CYL, R-SPH, R-CYL) used in this study were obtained from the archives of dr. Hafiz Sabry Optical Clinic and Ibn Al-haitham eyeglasses shop. Since sphere (SPH) measures a long-sighted and short-sighted and cylinder (CYL) measures the astigmatism.

L-SPH is the left eye's sightedness measurement.

L-CYL is the left eye's astigmatism measurement.

P-SPH is the right eye's sightedness measurement

R-CYL is the right eye's astigmatism measurement

SPH in the range of [-6 to 6] as the following:

[-6 to -0.5]it means Short-Sightedness, [-0.25 to 0.25] it means Normal Eyesight and [0.50 to 6] means Long-Sightedness.

CYL in the range of [-4 4] as the following :

[-4 to -.5]it means Short-Sightedness (Myopia), [-0.25 to 0.25] it means Normal Sight and [0.50 to 4] means Long-Sightedness(Hypermetropia) [1, 7].

We collected required amount of data (account is 90 of left eye and 90 of right) for diagnosis and divided it into two groups, learning and testing.

3. RESEARCH METHODS

3.1. ARTIFICIAL NEURAL NETWORKS

A neural networks have been used for classification and checking Sightedness. The designed neural Network has been trained by using Back propagation algorithm. Back propagation considers one of high ability algorithms which use in classification. In practices the back propagation neural network is one of popular methods which provides a powerful linear, capable of nonlinear mapping.

We have selected this algorithm because of the best results in classification using ANN [9] especially that the second comparison method is fuzzy logic which usually give precise results in classification. Designed network with Back propagation Algorithm for one hidden layer [3]and its parameters with which BP was in stability stage:

Input neuron 4
Hidden neuron 2
Output neuron 1
Initial weight in the rang [0,1]
Learning Rule: Standard Delta Rule
Learning rate: 0.2
Transfer Function: logsig
Iteration=12000
Performance :0.001

The basic BP architecture is shown in Fig.1

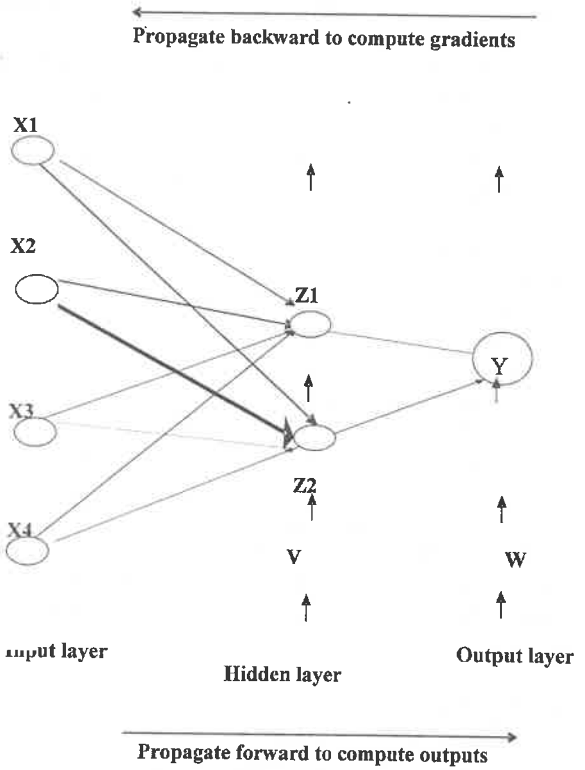

Fig.1 BP Structure

Tab.1 Some samples of the testing output using ANN

EYESIGHT STATE	TESTING RESULT	TARGET
Myopia	-0.7175 -0.8125 -0.9463 -0.9887 -1.0268	**-1**
Normal	-0.0201 0.0512 0.0117 -0.0168 0.0140	**0**
Hypermetropia	0.9862 0.9853 0.6332 1.0068 1.0288	**1**

3.2. FUZZY LOGIC

The input parameters are first fuzzified to obtain the membership values corresponding to the measured parameter values, and then the membership values are fed to a fuzzy rule base, the implication relation of these rules is modelled through Mamdani min implication operator to provide the output membership values. These output membership values are then defuzzified using the centroid defuzzification technique [8, 11], to obtain a crisp output value.

A. Fuzzy Rule base:

The membership value of each fuzzy set in the input function is calculated from the membership function definition and the conjunction in our paper based on AND fuzzy math. The fuzzy rule base converts the given input functions into outputs as we see in tab.2, since this table defines all possible corresponding actions of input fuzzy sets combinations.

Tab.2 Fuzzy Rule Base

SPH CYL	SMALLER THAN (-0.25)	NORMAL (BETWEEN [-0.25 0.25])	BIGGER THAN (+0.25)
Smaller than (-0.25)	Myopia	Myopia	___
Normal (Between[0 - 0.25])	Myopia	Normal	ypermetropia
Bigger than (+0.25)	___	Hypermetropia	Hypermetropia

B. Fuzzification with various membership functions:

In this Paper the membership functions for input variables (SPH, CYL) and output variable (determination precision of Eyesight State) are divided in to several fuzzy regions (Myopia , Normal and Hypermetropia).

The goal is to get the helpful and beneficial results through the comparative between memberships functions used in designed system. Here was applied the membership function with two parameters in input, so we execute and verify our data on sigmf, zmf, smf and gaussmf membership functions as follows:

The SIGMF membership function

- Sigmf membership function for inputs and output :

Tab.3 Some samples for sigmf membership function in Input And sigmf,zmf,smf,gaussmf membership functions in Output

EYESIGHT STATE	DATA FOR TESTING SPH CYL SIGMF		OUTPUT TARGET (DIAGNOSE AND PRECISION)[0 1]			
			Output for sigmf I	Output for zmf II	Output for smf III	Output for gaussmf IV
Normal	0.0	0.0	-0.00425	-0.419	0.5	0.5
Hypermetropia	1.5 3.75 2	1.5 0.0 2.5	1.43e-017 1.68e-017 7.57e-018	-0.351 -0.154 -0.303	0.5 0.499 0.499	0.253 0.477 0.309

The ZMF membership function

-Zmf membership function for inputs and output :

Tab.4 Some samples for zmf membership function in Input And zmf,sigmf,smf,gaussmf membership functions in Output

EYESIGHT STATE	DATA FOR TESTING SPH	CYL ZMF	OUTPUT TARGET (DIAGNOSE AND PRECISION)[0 1]			
			Output for zmf I	Output for sigmf II	Output for smf III	Output for gaussmf IV
Normal	0.0	0.0	-0.23	-0.00111	0.579	0.61
Hypermetropia	1.5	1.5	-0.206	-0.00871	0.717	0.964
	3.75	0.0	-0.132	0	0.654	0.953
	2	2.5	-0.138	8.53e-017	0.659	0.954

The SMF membership function :

Tab.5 Some samples for smf membership function in Input And smf,zmf,sigmf membership functions in Output

EYESIGHT STATE	DATA FOR TESTING SPH	CYL SMF	OUTPUT TARGET (DIAGNOSE AND PRECISION)[0 1]		
			Output for smf I	Output for zmf II	Output for sigmf III
Normal	0.0	0.0	0.5	-0.5	-0.00205
Hypermetropia	1.5	1.5	0.505	-0.398	-0.00425
	3.75	0.0	0.5	-0.16	-0.00111
	2	2.5	0.505	-0.265	-0.00331

Tab.6 Some samples for smf membership function in Input And gaussmf membership function in Output

EYESIGHT STATE	DATA FOR TESTING SPH	CYL SMF	OUTPUT TARGET(DIAGNOSE AND PRECISION)[01] GAUSSMF
Normal	0.0	0.0	0.025
Hypermetropia	1.5	1.5	0.254
	3.75	0.0	0.518
	2	2.5	0.473
	5	2	0.526
	5.5	3.7	0.529
	6	4	0.53

Results in Tab.3,Column I , tab.4,Column II , tab.5,Column III don't verify all hypothesis of eyesight testing , because the values approximate to zero.
Results in Tab.3,Column II , tab.4,Column I , tab.5,Column II don't verify all hypothesis of eyesight testing, because of the negative values with normal and hypermetropia states.
Results in Tab.3,Column III ,tab.3,Column IV ,tab.5,Column I don't verify all hypothesis of eyesight testing, because the values are centralize to 0.5.
Results in Tab.4,Column III , tab.4,Column IV don't verify all hypothesis of eyesight testing , because (for example) the output value for normal not in[-0.025 0.0 0.025] .
results (output) in Tab.6, where smf membership function in input and gaussmf in output verify hypothesis of eyesight testing , but with values equal to 0.53 only as a maximum value on output.
Results in next table(Tab.7) ,where membership functions for inputs and output are gaussmf verify all hypothesis of eyesight testing .

The GAUSSMF membership function
In Fig.2.1 the horizontal-axis represents the left SPH (L-SPH) input whereas the vertical-axis quantifies the partial membership values of a given L-SPH in each fuzzy region.
In Fig.2.2 the horizontal-axis represents the left deviation CYL (L-CYL) input whereas the vertical-axis quantifies the partial membership values of a given L-CYL in each three fuzzy region.
In Fig.2.3 the horizontal-axis represents the crisp output whereas the vertical-axis quantifies the partial membership values.

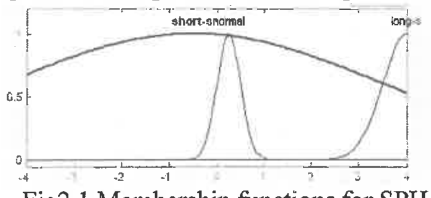

Fig2.1 Membership functions for SPH

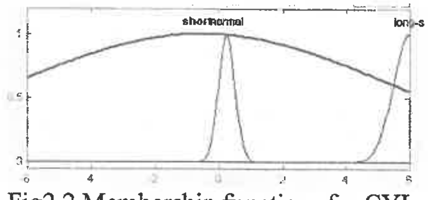

Fig2.2 Membership functions for CYL

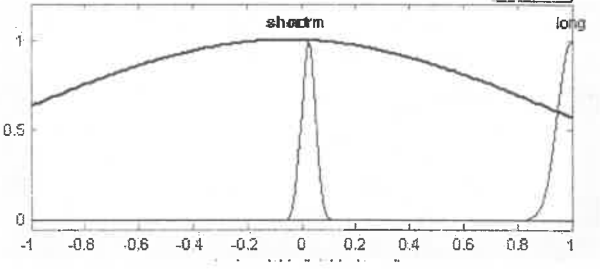

Fig2.3 Membership functions for output

Tab.7 Some samples for gaussmf membership functions in Input And Output

EYESIGHT STATE	DATA FOR TESTING SPH	CYL	**OUTPUT** TARGET(DIAGNOSE AND PRECISION)[0 1]
	GAUSSMF		**GAUSSMF**
Myopia	-1.5 0.0 -5.0 -3.0 -2.0	-1.5 -3.75 -2.0 -0.5 -2.5	**0.453** **0.96** **0.898** **0.849** **0.827**
Normal	0.0 0.25 0.25	0.0 0.0 0.25	**0.0** **0.0** **0.024**
Hypermetropia	2.0 4.0 0.75 3.75 1.5	2.5 1.75 4.0 0.0 1.5	**0.827** **0.887** **0.943** **0.887** **0.453**

In the last column of tab.7 the results (different from normal) shows that the diagnosis of output for each of SPH,CYL (together) has proved the existence of the Hypermetropia or Myopia depending on the signals of data for testing in the second column , and not only this, but showed also the degree or percentage of Myopia , Hypermetropia for each person separately, this function which can not done by neural networks ,so when the values approach from one ,it indicates a short-sighted (Myopia) or long–sighted (hypermetropia) in high degree or high percent and the contrary , the values of the approaching zero , it indicates a short-sighted (myopia)or long–sighted(hypermetropia) in a lesser degree or low percent.

4. RESULT

In this section, tested was both of designed Fuzzy Logic System and Artificial Neural Networks. The ability of fuzzy logic and neural networks to approximate and classify the hypermetropia (Long-Sightedness) , myopia(Short-Sightedness) ,and normal sightedness are presented in tab. 1 and tab. 7. The NNs have got 90% rightness classification (see table1) , but here all of hypermetropia and myopia are not determined in quantities , this is because of the function of NNs which can't determine the ambiguous state of myopia or hypermetropia precisely , so in this study the fuzzy logic system as addition step provides us with the ability to verify precisely the degree of hypermetropia or myopia (tab.7),during this deduced also on fuzzy system the following:Select a membership function in the fuzzifcation

depends on function parameters number, obtained originally from the reality of used data in the search. Through the application of all possibilities membership functions relevant on designed fuzzy logic system, appeared that data range defines the performance of membership function which in turn fuzzification and results in output will gets signs can be analysed
, interpreted and benefited.

Desired results and codified in tab.7 obtained with gaussmf membership function and this is perhaps because of data range, it appears that this function gives reasonable results with range of small values of data and others be useful with large values of any wider range.

All of this can help competent physician to take the appropriate decision.

In the same way the R-SPH and R-CYL are realized.

5. CONCLUSION:

This paper represents very important achievement of selecting and using some fields of AI like Fuzzy Logic and Neural network to diagnose the Eyesight state, especially Fuzzy Logic, because of its capability not only in classification but it's powerful to make ambiguous things realized precisely.

The fuzzy logic based system designed in this study offers powerful tool for Short sightedness (Myopia), normal and Long sightedness (Hypermetropia) diagnosis.

REFERENCES

[1] D. Raughan ., T. Asbury ., General Ophthalmology, USA, 2002.

[2] George F. Luger , Artificial Intelligence : Structures and Strategies for Complex Problems Solving, Delhi India,2002.

[3] Hirose,Y .,Back Propagation Algorithm which Varies the Number of HiddenUnits, Neural Networks,Vol.4,pp.61-66,1991.

[4] J. Dayhoff, Neural-Network Architectures: A introduction, New York ,1990.

[5]K. Mehrotra, C.Mohan and S. Ranka, Elements of Artificial Neural Networks,Cambridge,1997.

[6] Lefteri H. Tsoukalas,Robert E. Uhrig,Fuzzy and Neural Approaches in Engineering, New York,1997.

[7] Morgan M. ,Duke Elder , Optics and Ophthalmic Lenses, USA,2002.

[8]Pedrycz W. and Gomide F., An Introduction to Fuzzy Sets Analysis and Design, Massachusetts Institute of Technology, USA 1998.

[9] R.Schalkoff ,Artificial Neural Networks, McGraw-Hill,1999.

[10]Suryanarayanan, S., Reddy, N.P., and Gupta, V., An Intelligent System with EMG-Based Joint Angle Estimation for Telemanipulation, in Medicine Meets Virtual Reality: Healthcare in the Information Age, Editors: Weghorst, S.J.,Sieburg,H.B. and Morgan,K.S.,IOP Press, Amsterdam ,pp.4546-4552,1996.

[11]Terano T. ,Asai K. and Sugeno M, Applied Fuzzy Systems, Academic Press ,Boston 1994.

[12] White .H, Artificial Neural Networks: Approximation and Learning Theory,Blackwell,1992.

[13] Yager R.R., Zadeh L.A., An Introduction to Fuzzy Logic Applications in Intelligent Systems,USA,1990.

ملخص البحث :

يقدم هذا البحث طرق جديدة لتشخيص حالة النظر عند الأشخاص الذين يعانون مشاكل في الرؤية وتحديد المشكلة (إن وجدت) هل هي طول نظر أم قصر نظر وذلك بأخذ قياسات النظر والانحراف فعندما تكون قياسات النظر أو الانحراف طبيعية فانه يسهل على الطبيب سرعة اتخاذ القرار ويصعب عليه ذلك عندما تكون القياسات لكل من النظر والانحراف غير طبيعية ولأهمية النظر فقد قمنا بالتشخيص باستخدام الشبكات العصبية الصناعية ونظام المنطق الضبابي لاكتشاف أداء هذه الطرق المستعملة ومعرفة قدرة كل واحدة منها لتأكيد ذلك ومساعدة الطبيب المختص لاتخاذ القرار المناسب .