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ESTIMATION OF DEPRESSION DISEASE BY NEURAL FUZZY INFERENCE METHOD

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ABSTRACT: In this study, an ANFIS model that analyzes the data set of depression disease was established and the degree of disease was estimated in this study which was performed for the detection of depression disease by neural fuzzy logic inference method (ANFIS). The data set was prepared according to Beck Depression Test results. The Neuro Fuzzy Designer included in Matlab R2016b was used to process the data set using ANFIS method and generate estimation values. In ANFIS, sugeno method was used and Trimf was selected as the activation function. The learning method is the backpropa method known as the back propagation method. At the end of 50 trainings, the training error value was determined as 0.018197. The training error value resulting from processing a total of 200 disease records is in good condition. The actual values and the estimated values produced by the system were analyzed with SPSS Statistics software and standard deviation and error values were determined. The system is aimed to classify the degree of disease correctly according to the symptoms.

Keywords: ANFIS, Fuzzy Logic, Depression, Disease, Artificial Neural Network

1. INTRODUCTION

Depression, which has a direct or indirect effect on a large part of the society, is a mood disorder with negative emotions such as a reluctance of individuals for a long time, inability to enjoy life, gradually decreasing self-confidence and hopelessness [1]. In severe forms of depression, such as clinical depression, failure to treat may cause significant problems. When left untreated, depression can cause life-threatening problems such as alcohol and drug addiction. By reducing the communication of individuals with their environment, it may cause problems in working life as well as cause greater harm [2]. Clinical depression, called major depression, is a serious disorder that affects the physical and mental state of individuals. It is not possible for people suffering from depression to get out of depression immediately. Clinical depression, such as the use of psychotherapy and the use of antidepressant medications, may persist for months or even years.

Haznedar and Kalınlı carried out a study on the relationship between genetic disorders and thrombophilia disease by using adaptive network based fuzzy logic inference system (ANFIS). In their study, they used Adaptive Network Based Fuzzy Logic Inference System (ANFIS) and compared their results with those of some commonly used classification algorithms. They found that the results obtained with ANFIS were more successful than the results obtained [3]. Arslan and Hazneadar used the Adaptive Network-Based Fuzzy Logic Inference System (ANFIS) to analyze the prostate cancer microarray gene expression problem. In their study, they compared the classification success of ANFIS model with the classification success of Artificial Neural Networks (ANN) and k-Nearest Neighbor (kNN) and J48 Decision Tree algorithms from traditional methods and as a result they found that ANFIS model was more successful than ANN and traditional algorithms [4]. In his master thesis, Kaya made important studies on the application of fuzzy logic methods for classification in the diagnosis of lung diseases. In this study, we designed a system using ANFIS (Adaptive Network Based Fuzzy Inference System) for the diagnosis of Mesothelioma disease known as membrane cancer. He concluded that the model he created with ANFIS showed a successful and satisfactory prediction performance and that the system was feasible [5]. Gökçe and Sonugür, used ANFIS method to carry the control of the production processes, recording, planning, stock management, the efficiency of natural stone blocks and estimating the production until the emergence of a stone-size raw slab that enters into a natural stone production enterprise as a block. In the study, they developed a system that can support business managers for planning and managing production with a relational database for the enterprise. Using the information in the database, they developed two different models using artificial neural networks and ANFIS, and with these models, they managed to estimate the efficiency and production times of the blocks. According to the efficiency estimation results, they found that sufficient success occurred in the artificial neural network model with the highest error rate of 4.9% [6].

In this study, a total of 200 disease data were used. Disease data set was formed according to Beck depression scale results applied to various patients. The Beck Depression Scale includes questions about physical and mental changes in the individual for at least one week and each question is answered by selecting one of the numbers 0, 1, 2 and 3. The severity of depression is determined by evaluating the sum of the numbers chosen for each question [7]. 150 records in the data set were used as training data. 50 records were used for test and control data. In the developed model, trimf membership function was used. At the end of the training, the error value was determined as 0,018197.

2. NEURAL FUZZY LOGIC INFERENCE SYSTEM (ANFIS)

The basis of ANFIS is Takagi-SugenoKang fuzzy inference system. Jang developed the ANFIS method in 1993 and used this new method to model nonlinear structures, control systems, detect nonlinear components and estimate chaotic time series [8].

In the first layer of the model in Figure 2, the values A_i and B_i are used to define characteristic expressions. The membership function assigns membership degrees to the values Ai and Bi and these values pass to the other layer. In the other layer, the input data is multiplied by each other and transmitted from a node. In the third layer, the activation values are proportional to the total activation values and normalization is performed. After the fourth layer, the Takagi-Sugeno-Kang model is activated. In Takagi-Sugeno-Kang Inference Method, the output variable is defined as a fixed number or variable-dependent function [9-10]. The outputs of the Takagi-Sugeno-Kang method are clear values away from turbidity. Therefore, no further clarification is required. As a result of the last layer, the total output value is obtained from the model.

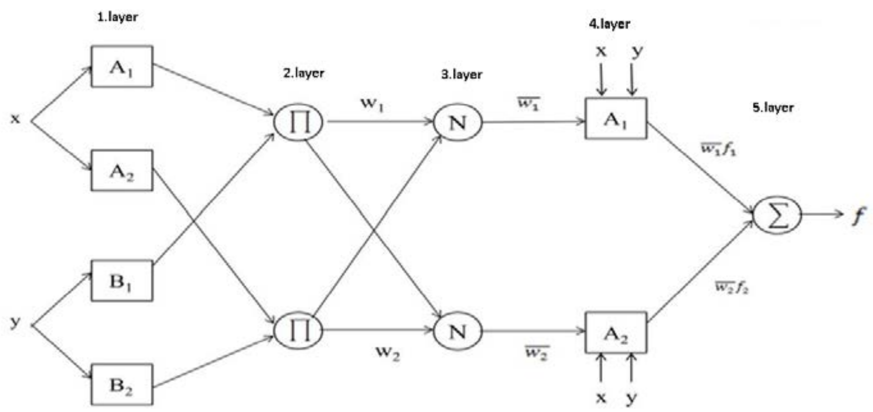

Figure 1. ANFIS Model [5]

To explain the process in mathematical expressions [11];

Set of rules: If, x A_i and y, B_i if $f_i=p_i. x+ q_i. y + r_i$

Layer 1: By selecting a membership function (μ (x)), membership degrees of character variables are determined.
$(\mu A_i(x).\mu B_i(y))$

Layer 2: $w_i= \mu A_i(x).\mu B_i(y)$

Layer 3: $\overline{w_l} = \frac{w_i}{\sum w_i}$

Layer 4: $\overline{w_l}$ = f_i is layer output.

Layer 5: $x_0 = \frac{\sum w_i \cdot f_i}{\sum w_i}$

3. MODEL

3. 1. Beck Depression Inventory

Diagnosis and treatment guidelines recommend the use of screening tests for depression in primary care. Beck Depression Inventory for Primary Care is an internationally recognized scale used for this purpose [12]. Beck depression test aims to find and classify the severity of depression. The questions found in the test are listed Table 5. The degree of depression is grouped according to the scores obtained from the inventory as shown in Table 2.

Table 1. Depression rating scale.

Degree of Depression	Total
Minimal depression	0-9
Mild depression	10-16
Moderate depression	17-29
Severe depression	30-63

Correlation (1) was used to calculate the severity of depression according to the test.

$$Depression\,Severity\,Value = \frac{Test\,Total}{Maximum\,Value}\,x\,4 \quad (1)$$

3.2. Structure of The Data Set

The data set used in the study was obtained from the study for Beck Depression Inventory [13]. The following table shows some of the data set we used in this study. The data set has three input sequences containing subtotals from a total of 21 questions in the test and an output sequence containing the severity of depression. The data set contains approximately 1000 records. In this study, 200 of 1000 records were used as training, test and control data.

Table 2. Sample values from the data set used as system input.

1-7 Subtotal	8-14 Subtotal	15-21 Subtotal	Depression Severity
14,00	12,00	4,00	1,90476
13,00	18,00	20,00	3,23810
7,00	12,00	7,00	1,65079
18,00	14,00	11,00	2,73016
11,00	7,00	17,00	2,22222
8,00	15,00	7,00	1,90476
4,00	7,00	11,00	1,39683
15,00	18,00	6,00	2,47619
3,00	7,00	17,00	1,71429

3.3. Model Evolution

In the study, Matlab software was preferred for the formation of data matrices, development of fuzzy logic inference system and analysis in the system. Before the data to be processed in Matlab program was transferred to the workspace, some operations were performed on the data. The data to be used were normalized in Microsoft Excel software, and then training, test and control data groups were created and input variables of the model were created. The data were normalized by linear conversion to [0,1].

For this, the Equation 2 was used [14].

$$X_n = \frac{x_0 - x_{min}}{x_{max} - x_{min}} \quad (2)$$

Training, test and control dataset was formed from data set consisting of approximately 1000 records. Simple random separation method was used to create these clusters. In this method, 150 records in the data set are divided into training sets. A test set of 50 records was defined to test the accuracy of the system, and a control data set of 50 records was also identified to check the system. The square root (RMSE) (Equation 3) of the mean of the error squares was used to evaluate the accuracy of the output generated by the system [15].

$$RMSE = \sqrt{\frac{(p_1 - a_1)^2 + \cdots + (p_n - a_n)^2}{n}} \quad (3)$$

Triangle membership function (trimf) is selected as membership function. Because the minimum error value appears in the trimf function. The fault tolerance value of the system is set to 0. The backpropagation technique was optimized and the training was repeated 50 times. Figure 2 shows the comparison of training results with actual values.

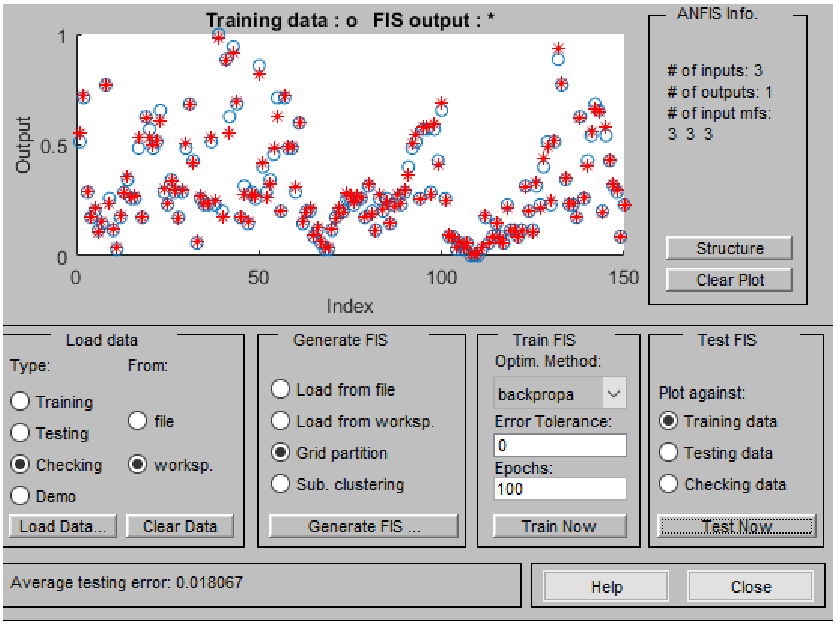

Figure 2. Comparison of actual and prediction results.

Since the accuracy of the developed system is desired to be measured with the test data, the estimation results of the system are compared with the actual values. The values represented by "*' in Figure 3 are the values estimated by the ANFIS system using test data. The values symbolized by "+ are actual values. The actual values and prediction values of the ANFIS system coincide to a great extent. The RMSE value was 0.013701.

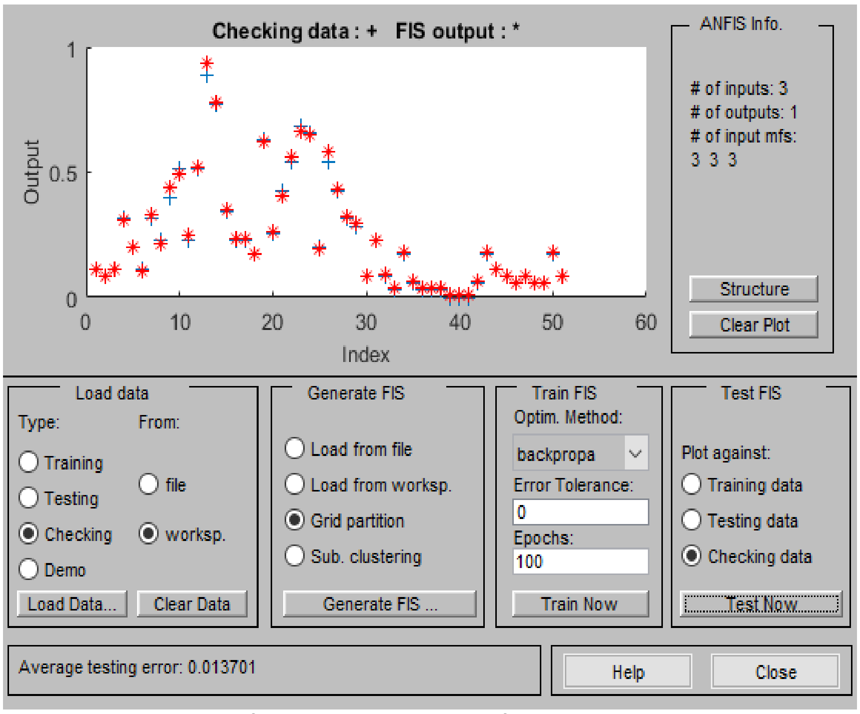

Figure 3. Comparison of the estimated values of the system with the actual values.

The developed ANFIS model has three inputs, one output and 27 rules. The network structure of the developed system is shown in Figure 4.

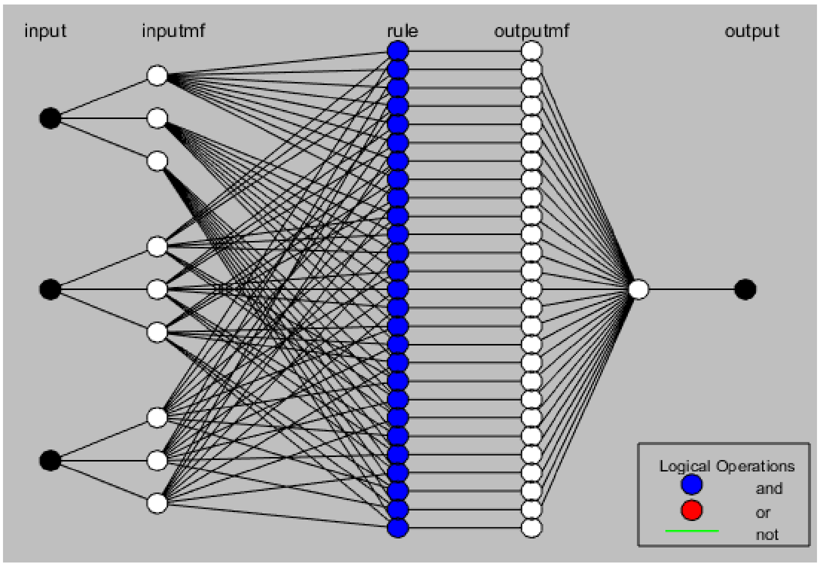

Figure 4. Network structure of the model created.

The membership functions and rules created for the input values of the developed ANFIS model are shown in Figure 5.

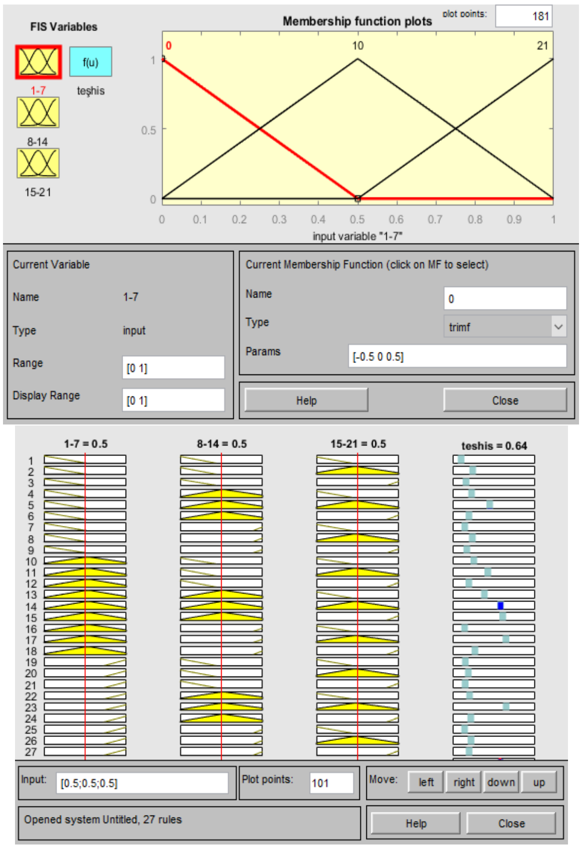

Figure 5. Membership functions of the model and rule table of developed model.

The variation of the error value according to the number of repeated training is shown in Figure 7.

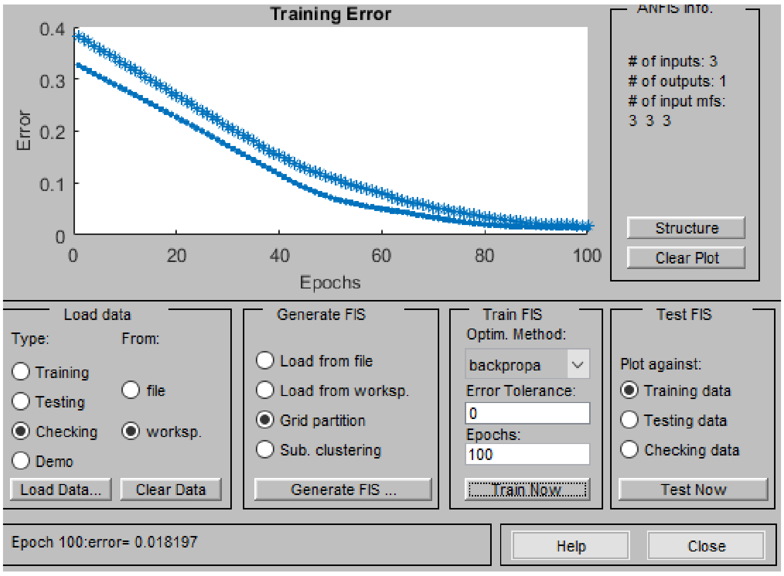

Figure 7. Error change during training.

Figure 8 shows the surface graphs showing the graphical distribution of the system created by the weights and effects of the inputs on each other after training.

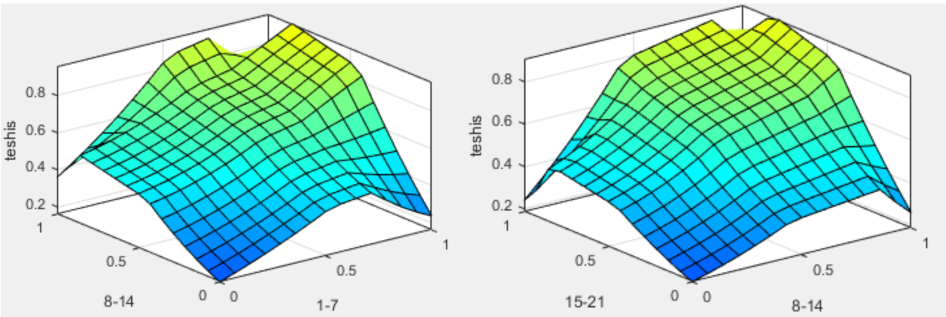

Figure 8. Model surface graphics.

In the Matlab program, the output of the system was created with the evalfish command and the related T test was performed in the SPSS analysis program to determine the similarity ratio between the estimated data and the actual values obtained. The results of the comparison in the SPSS program are shown in Table 3.

Table 3. Comparison of actual results and ANFIS results.

	Average	N	Standard. Deflection	R	p
Actual Results	,3135	150	,22097	,997	,000
ANFIS Results	,3158	150	,21967		

There is a significant similarity between the actual results and the system output ($p < 0.05$). The R value was 0.997 at the end of the test. This value means that the similarity between data is high and positive.

As can be seen from Table 4, the average of the differences is less than 0.05. This means that there is no difference between the output values. The system created according to these values is very successful in the diagnosis and classification of the disease.

Table 4. Comparison of actual results and system output.

	Differences Average	Standard. Deflection
Real Results - ANFIS Results	,00226	,01798

4. CONCLUSIONS

In this study, adaptive network based fuzzy logic inference system (ANFIS) was applied in MATLAB software to diagnose depression. In this study, a data set consisting of a large number of disease data was used. In the data set, 3 separate data series are defined as input variables. The expected result from the system is the accurate diagnosis of the degree of disease based on the data in the input sequences. Of the 1000 data lines in the data set, 150 were allocated as training data, 50 as test data, and 50 as control data. 50 learning were performed in the system.

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APPENDIX

Table 5. Beck depression inventory.

1	0. I don't feel sad and distressed.
	1. I feel sad and distressed.
	2. I am always sad and distressed. I can't get away with this.
	3. I am so sad and distressed that I can't stand it anymore.
2	0. I am unhappy and pessimistic about the future.
	1. I am pessimistic about the future.
	2. I have nothing to expect from the future.
	3. I'm desperate about my future and it feels like nothing's going to be right.
3	0. I don't see myself as a failed person.
	1. I feel like I have more failures than most people around me.
	2. When I look back, I see that it is full of failures.
	3. I consider myself a completely unsuccessful person.
4	0. I enjoy many things as much as I used to.
	1. I don't like everything like before.
	2. Nothing gives me full pleasure anymore.
	3. I am bored of everything.
5	0. I don't feel guilty in any way.
	1. I feel guilty from time to time.
	2. I often feel guilty.
	3. I always feel guilty.
6	0. I feel punished.
	1. I feel I can be punished.
	2. Waiting to be punished.
	3. I feel punished
7	0. I am satisfied with myself.
	1. I am not very pleased with myself.
	2. I'm very angry with myself.
	3. I hate myself.
8	0. I don't think I'm worse than others.
	1. I criticize myself for weaknesses or mistakes.
	2. Because of my mistakes I always find myself guilty.
	3. I find myself wrong in every mishap.
9	0. I have no thoughts of killing myself. But I'm not.
	1. From time to time I would consider killing myself.
	2. I would love to kill myself.
	3. I would kill myself if I had the chance.
10	0. I can't cry more than ever.
	1. From time to time comes the cry.
	2. I cry most of the time.
	3. I could cry now, but now I can't.
11	0. Now I'm not more nervous than I have always been.
	1. I get angry or angry more easily than before.
	2. Now I'm always angry.
	3. The things that once made me angry now do not.
12	0. I have not lost my will to talk to others.
	1. I want to talk with others, to less than before.
	2. I have not lost my desire to talk and talk with others.

	3. I do not want to talk to anyone and see anyone.
13	0. I can decide as easily as before.
	1. I can't decide as easily as I used to.
	2. I have much difficulty in making decisions compared to the past.
	3. I can't make any decisions anymore.
14	0. When I look at myself in the mirror, I see no change.
	1. I feel older and ugly.
	2. I feel that my appearance has changed a lot and I'm ugly.
	3. I find myself very ugly.
15	0. I can work as well as I used to.
	1. I need to make an effort to do something.
	2. I have to push myself to do anything.
	3. I can't do anything.
16	0. I can sleep well as usual.
	1. I can't sleep as well as I used to.
	2. I wake up 1-2 hours earlier than usual and cannot sleep again.
	3. I wake up much earlier than usual and can't sleep again.
17	0. I'm not tired more quickly than usual.
	1. I get tired faster than ever.
	2. Everything I do tires me.
	3. I feel too tired to do just about anything.
18	0. My appetite is as usual.
	1. My appetite is not as good as usual.
	2. My appetite decreased.
	3. I have no appetite anymore.
19	0. I haven't lost weight recently.
	1. I lost more than two pounds.
	2. I lost more than four kilos.
	3. I am trying to lose more than six kilos.
20	0. My health does not worry me much.
	1. Pain, Ache, stomach disorders or constipation, such as discomfort, do not worry me.
	2. My health worries me, so it's hard to think about other things.
	3. I am so worried about my health that I can't think of anything else.
21	0. I haven't noticed a change in my interest in sexual issues lately.
	1. I am less interested in sexual issues than before.
	2. I am much less interested in sexual issues now.
	3. I have completely lost interest in sexual issues.