ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM (ANFIS) APPROACH FOR MODELLING THE EFFECT OF ACHIEVEMENT IN STATISTICS TO STUDENTS' ATTITUDES TOWARD STATISTICS

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Abstract

This study investigates the effect of achievement in statistics to students' attitude toward statistics using the Adaptive Neuro-Fuzzy Inference System (ANFIS).Attitude toward statistics is obtained by means of a statistics attitude scale, and achievement in statistics is assessed by the midterm exam grades of the students. For fuzzy clustering membership function is selected to be triangular and subtractive clustering is used. As a result of clustering, three fuzzy clusters are obtained for statistical achievement, which are named unsuccessful/ moderate/successful. The model established from ANFIS showed that the attitude of students receiving low achievement grades in statistics is negative and that attitude is more positive as the achievement increases. This study also showed that fuzzy methods are used successfully in social sciences.

Keywords: *Attitudes towards Statistics; Achievement in Statistics; Fuzzy Neural Network; ANFIS*

İSTATİSTİK BAŞARISININ ÖĞRENCİLERİN İSTATİSTİĞE KARŞI TUTUMUNA ETKİSİNİN UYARLAMALI AĞ-BULANIK ÇIKARIM SİSTEMİ (ANFIS) YAKLAŞIMI İLEMODELLENMESİ

Özet

Bu çalışma bulanık çıkarım sistemine dayanan uyarlamalı ağ yaklaşımı (ANFIS) ile öğrencilerin istatistik başarılarının, istatistiğe karşı olan tutumlarına etkisini araştırmaktadır. İstatistiğe karşı tutum, bir istatistik tutum ölçeği ile elde edilmiş, istatistik başarısı ise öğrencilerin ara sınav notlarıyla değerlendirilmiştir. Bulanık kümeleme için üyelik fonksiyonu olarak üçgensel fonksiyonu seçilmiş ve eksiltici kümeleme yöntemi kullanılmıştır. Kümeleme sonucunda istatistiksel başarı için başarısız/orta/başarılı olarak

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adlandırılan üç bulanık küme elde edilmiştir. ANFIS ile kurulan model başarı notları düşük olan öğrencilerin istatistiğe karşı tutumlarının olumsuz olduğunu ve başarı arttıkça tutumun daha olumlu olduğunu göstermiştir. Bu çalışmada, bulanık yöntemlerin sosyal bilimler alanında başarılı bir şekilde kullanıldığı da gösterilmiştir.

Anahtar Kelimeler:İstatistiğe karşı tutum, İstatistik başarısı, bulanık sinir ağları, ANFIS

1.INTRODUCTION

Statistics can be easily defined scientifically. However, it would be quite difficult to define statistics as perceived by students in the social sciences. From their viewpoint, statistics is a difficult required course full of numbers, tables, formulas and calculations. Most of these students are unaware of the significance of statistics, and they question why they are taking the statistics course, which they think will not serve them throughout their lives. Statistics is a methodological discipline that provides coherent ideas and instruments to cope with data from studies in other fields (Coetzee and Merwe, 2010). It provides means for dealing with data that take into account the omnipresence of variability (Cobb and Moore, 1997). Florence Nightingale remarked on statistics as follows (Ridgway, Nicholson and Sean Mc Cusker, 2007):

"Statistics ... the most important science in the whole world: for upon it depends the practical application of every other science and of every art; the one science essential to all political and social administration, all education ..."

Even though statistics is an important discipline, it is fairly difficult to teach and learn. The purpose of giving a statistics course to students is that they acquire the required skills to understand the value of statistics in their professional and personal lives (Coetzee and Merwe, 2010), and to recognize simple statistics symbols and to be literate in statistics (Garfield and Ben-Zvi, 2007). Students taking statistics courses should have the skills of reading and criticizing news and articles containing statistical information (Mvududu and Kanyongo, 2011). However, a great number of students receiving education in different disciplines, such as social science and health science, experience statistics anxiety. This situation has been proven by many studies (Gal and Ginsburg, 1994; Onwuegbuzie and Seaman, 1995; Onwuegbuzie and Daley, 1996;Zanakis and Valenzi, 1997; Kolar and McBride, 2003; Onwuegbuzie and Leech, 2003;Baloğlu, 2004; Mills, 2004; Onwuegbuzie, 2004; De Vaney, 2010, Ashaari*et al*, 2011, Judi *et al* 2011, Khavenson, 2012). In these studies, it is established that most of the students are afraid of statistics and think that this course is not important for them, and they see the course as an impediment to their graduation. This situation shows that attitudes toward the statistics course are generally negative. It is crucial to determine the factors affecting the attitude toward statistics to change this attitude from negative to positive.

To measure the attitudes toward statistics, many attitude scales are developed. The first scale aiming to determine the attitude toward statistics in the literature is the Statistics Attitude Survey (SATS) developed by Roberts and Bilderback (1980). This scale is adapted from an earlier scale suggested by Dutton (1954) to measure attitudes toward mathematics (Santillan*et. al*, 2012). Later, various scales are developed.

The previous studies related to statistics attitudes investigate many variables such as the level of the statistics course, grade-point average, gender, achievement in statistics, and anxiety (Mills, 2004; Coetzee and Merwe, 2010; Hilton *et. al*. 2011,Chew and Dillon, 2015; Ghulami*et. al.*,2015; Sesé*et. al.*, 2105; Santillan *et. al.*, 2016; Salim and Ayub, 2017). In this study, the achievement in statistics was taken into consideration.

There are many studies aiming to establish the relationship between the attitude towardany course and academic achievementin the literature. In these studies, achievement is generally established with classical clustering and evaluated in two clusters: successful/unsuccessful. Students below a predetermined critical grade are assigned to the unsuccessful cluster and students above this grade are assigned to the successful cluster. As a result, students who are one point below or above the critical grade are assigned to different clusters and this represents a problem. Itis believed that fuzzy logic could be used to overcome this problem.

If fuzzy clustering is used instead of classical clustering, a more appropriate clustering can be conducted taking into consideration the distribution of grades that all students received. According to fuzzy clustering theory, students can be evaluatedwith a membership degree of both successful and unsuccessful clusters. Furthermore, it is also possible to divide success into multiple clusters defined with certain borders instead of dividing it into precise clusters as successful/unsuccessful.

In the case that achievementis fuzzy, a fuzzy model is required to determine the effect of achievement on attitude. The purpose of this study isfuzzification of the students’ achievement and establishthe effect of statistical achievement on attitudes toward statistics by means of ANFIS.ANFIS is a fuzzy inference system that makes analysis on the basis of neural networks for the creation of fuzzy rules. Learning and calculating power of neural networks can be given to the fuzzy control system by means of ANFIS, and humanlike decision-making of the fuzzy control skill can be introduced to the neural networks. It will be possible to estimate the attitudes toward statistics with the aid of the model obtained from ANFIS.

2. ANFIS

2.1. Fuzzy Inference Systems

Fuzzy inference system is a computing system based on fuzzy set theory, fuzzy if-then rules and fuzzy logic (see in Figure1). The units of the system are described below (Zadeh, 1965; Jang, 1993):

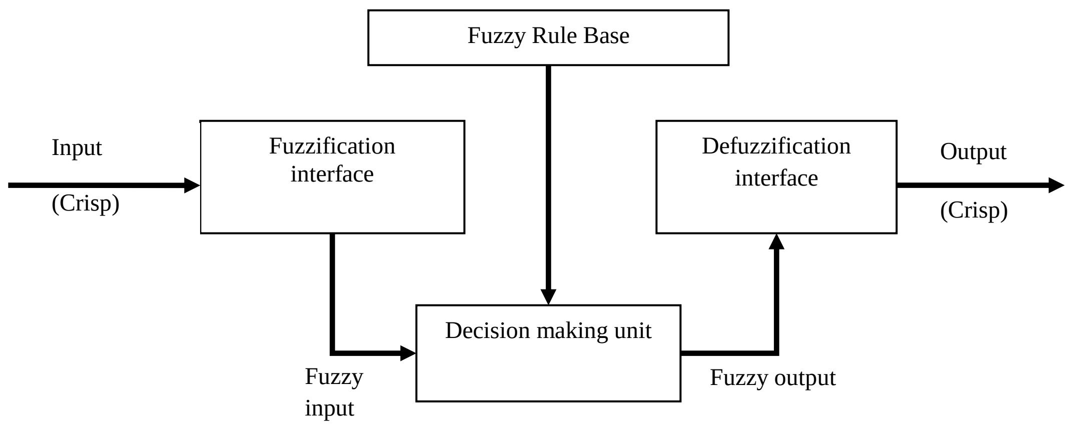


Figure 1. Fuzzy Inference System

- Input: contains crisp input values
- Fuzzification interface: transforms the crisp inputs into truth values
- Fuzzy rule base: defines fuzzy if-then rules and the membership functions
- Decision making unit: applies the inference operations on the rules
- Defuzzification interface: transforms the truth values into output
- Output: contains crisp output values

The fuzzy rule (or fuzzy if-then rule) form is as follows:

$$R:\ If\quad (x_1 = F_1\ and\ x_2 = F_2\ and\ ...\ and\ x_p = F_p)\quad then\quad Y = G \quad (1)$$

where $F_1, F_2, ..., F_p$ and G are linguistic terms which are defined by membership functions, $X_k = (x_{1k}, ..., x_{pk})^T$ are the input linguistic variables and Y are the output linguistic variables. The section between "if and then" statements shows the input information (premise) and the section following the then statement shows the output information (consequent) (Takagi and Sugeno, 1985; Klir and Yuan, 1992; Cheng and Lee, 1999). Several types of fuzzy if-then rules are used for fuzzy inference system. One of them is Takagi and Sugeno fuzzy if-then rules. In the Takagi-Sugeno fuzzy if-then rules, the output variables are a linear combination of input variables. Takagi-Sugeno fuzzy rules are of the following form:

$$\begin{aligned} R^l &: If(x_1 = F_1^l \; and \; x_2 = F_2^l \; and \ldots and \; x_p = F_p^l) \\ & then \quad (Y = Y^l = c_0^l + c_1^l x_1 + \ldots + c_p^l x_p) \end{aligned} \tag{2}$$

where F_i^l are fuzzy set associated with input x_i in the l^{th} rule, Y^l is the output of R^l rule and there are m rules, $l=1,2,\ldots,m$. The overall output of the system is a weighted average of the Y^l

2.2. The Model of ANFIS

ANFIS is a feed-forward network with five layers. Layers are connected to each other by direction links, parts of which consist of adaptive nodes (Jang, 1993). Adaptive nodes have certain parameters. Values of these parameters are defined by means of learning (Ishibuchi, H. and Tanaka, 1993; Jang, 1993). Figure 2 gives the ANFIS structure with two inputs and two rules(Jang 1993):

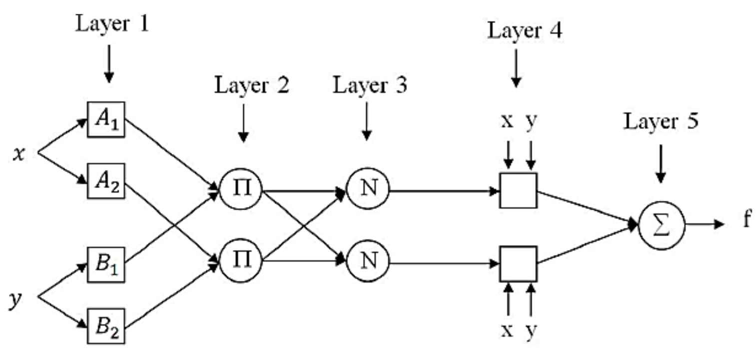


Figure2.Structure of ANFISwith two inputs and two rules (Jang, 1993)

First layer: Nodes located in this layer are adaptive. Fuzzy sets are shown by A_1, A_2, B_1 and B_2.

Second layer:Neurons located in this layer are fixed neurons. Each neuron has two input signals coming from Layer 1. Π is the defined as the multiples of these input signals.

Third layer: Neurons located in this layer are fixed nodes labeled N. Output value of this layer is the normalization of outputs of Layer 2.

Forth layer: Nodes located in this layer are adaptive neurons whose neural function is

$$f_{4,l} = \overline{w}^l . \hat{Y}^l \quad , \quad l = 1,\ldots,4 \tag{3}$$

where $\hat{Y}^l$ is the result section of fuzzy if-then rule and is defined as

$$\hat{Y}^l = c_0^l + c_1^l x_1 + c_2^l x_2 \tag{4}$$

c_i^l coefficients in the equation (4) are fuzzy numbers expressed as $c_i^l = (a_i^l, b_i^l)$ ($i = 0,1,2$; $l = 1,\ldots,4$), and they show consequent parameters.

Fifth layer: The single node located in this layer is the adaptive node that calculates the final output, and is computed as follows:

$$f_{5,1} = f_{output} = \hat{Y} = \sum_{l=1}^{4} \overline{w}^l . \hat{Y}^l = \frac{\sum_{l=1}^{4} w_l f_l}{\sum_{l=1}^{4} w_l} \tag{5}$$

The purpose of fuzzy adaptive network is to obtain the model of the relationship between the input-output data. This model is obtained by a learning algorithm. Back-propagation can be used for the training of premise parameters, and likelihood linear programming can be used for the training of consequent parameters(Jang, 1993; Jang and Sun, 1995; Cheng and Lee 2001). The difference between the output of the model obtained from the network and targeted output is defined as the error criterion. Errors for each observation are calculated and the amount of errors for the model is calculated in:

$$\hat{\varepsilon} = \frac{1}{N} \sum_{k=1}^{N} (y_k - \hat{y}_k)^2 \tag{6}$$

Provided ϕ is the amount of error prespecified by the decision maker, if $\hat{\varepsilon} < \phi$, training of the network is completed. The consequent parameter set obtained fromthe network is set as the parameter for the model to be established. If $\hat{\varepsilon} \geq \phi$, then the backpropagation error that is used in the updating of the premise parameter set is calculated and the premise parameter is updated. The updating formula iscomputed as follows:

$$\Delta\rho = -\eta \frac{\partial (y_k - \hat{y}_k)^2}{\partial \rho} \tag{7}$$

where ρ is a parameter of the l^{th} neuron at layer r and η is the learning rate.

3.METHOD

3.1. Sampling

The data in this study are obtained from students of the Faculty of Tourism, Gazi University. The statistics course is given in the first semester of the second year. A total of 323 studentswho registered for the lesson in the mentioned semester took part in the study.

3.2. Data Collection Methods

In this study, there are two variables: attitude scale toward statistic and achievement in statistics. The data is collected as follows:

Attitude scale toward statistics: In this study, cultural diversities are taken into consideration and used a scale developed by Diri (2007). Thescale has 40 items. Twenty of these items are affirmative and 20 of them are negative opinion sentences. The level of students approving these opinion sentences is measured by 5-point Likert scale (1 = strongly disagree, 3 = neither disagree nor agree, 5= strongly agree).

Validity and reliability studies of the scale have been realized. As a result of the confirmatory factor analysis is performed for validity, the scale is gathered in a single factor (KMO: 0.949; Bartlett's Test of Sphericityχ^2: 6881.623; p: 0.000; Total VarianceExplained: 60.283%). Reliability of the scale is calculated with Cronbach Alpha (α) coefficient and it is found to be α=0.95. Thus, the scale is fairly reliable.

*Achievement in statistics:*The data is the grade of the midterms.

3.3.Data Analysis

Data established in this study is analyzed by ANFIS to explore the effect of achievement in statistics to students' attitudes toward statistics.

4.FINDINGS

Fifty two % (168) of the students are female and 48% (155) male; 22.4% (72) of the students are receiving education in the Department of Recreation Management, 14.8% (48) in the Department of Travel Management and Tourism Guidance, 31% (100) in the Department of Tourism Management, 31.8% (103) in the Department of Gastronomy and Culinary Arts.

Midterm exam grades of the students are in the range of 1-100. Themean of midterm gradeis48.82, and the standard deviation is 24.33.This result showed that the students are not very successful.

Descriptive statistics of students' attitudes toward statistics is given in Table 1. According to this results, the mean ofattitudes toward statistics is 3.19 and it can be said that the students' attitudes are neither positive nor negative.

Table 1. Descriptive statistics of students'attitudes toward statistics

	n	Mean	Mode	Median	StandardDeviation
Students' attitudes toward statistics	323	3.19	2.85	3.17	0.76

Inthe application of ANFIS, first of all,data set are randomly divided into two groups. These are being training and test data which are used for creation of the fuzzy model and for testing the accuracy of the model created, respectively. Training set is used in the training of the network and test set is used to measure the performance of training.

Eighty % (258 data) of the data are included in the training set and 20% (65 data) in the test set. For the application, ANFIS editor under fuzzy logic module of MATLAB SOFTWARE is used.

Training data is loaded in MATLAB ANFIS Editor. Loaded training data is given in Figure 3.

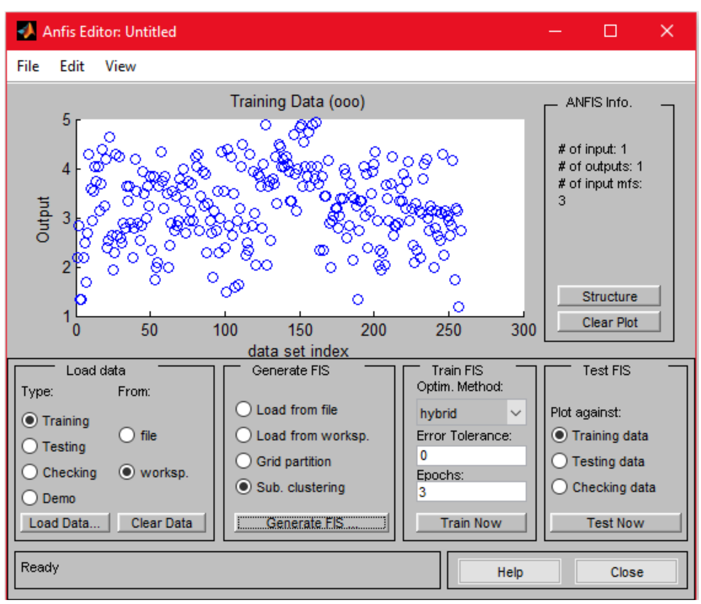


Figure3. Training Data

Cluster numbers for the independent variable are calculated by using subtractive clustering algorithm.Figure 4 shows the subtractive clustering window.

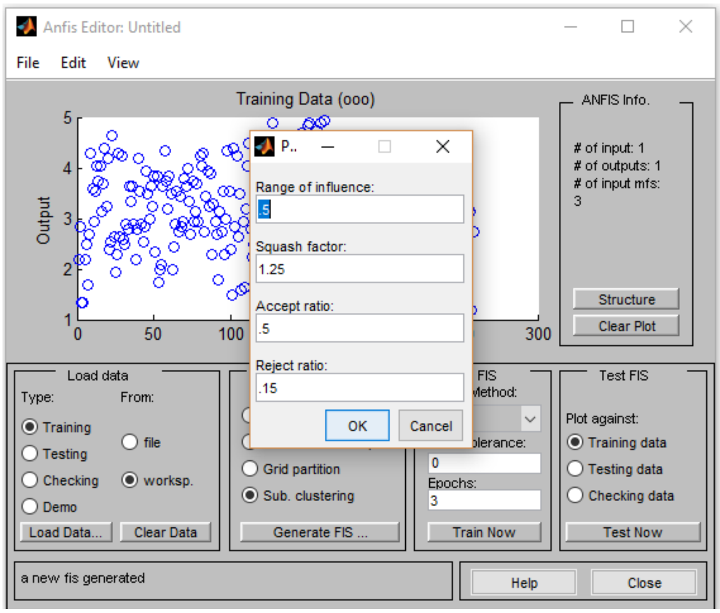


Figure4. Subtractive Clustering

As a result of the clustering algorithm, cluster number is found as three for term exam grades. Accordingly, the fuzzy rule number to be created shall be three. ANFIS model structure is shown in Figure 5. These classes can be linguistically expressed as “unsuccessful”, “moderate”, and “successful”.

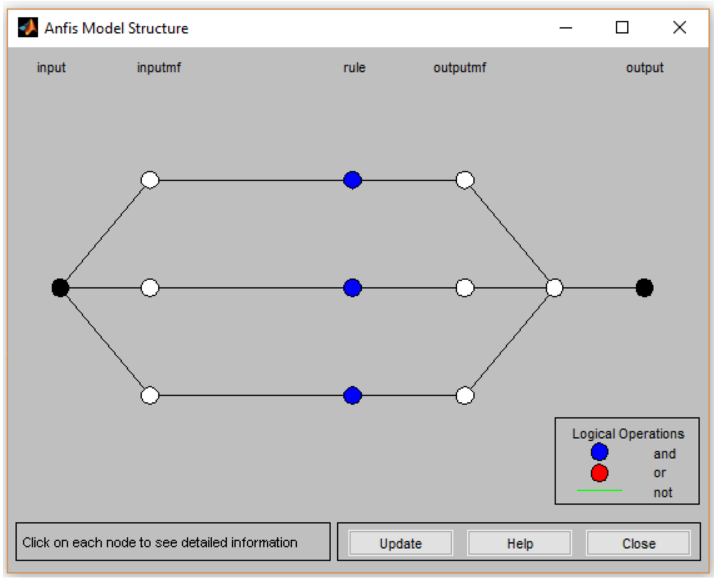


Figure5. ANFIS Structure

The membership function is selected as triangular function. A triangular fuzzy number can be defined by a lower limit a_1 , an upper limit a_3 and a value a_2 where $a_1 \le a_2 < a_3$. Membership function is in the following form (Kaufmann and Gupta, 1988):

$$\mu_A(x) = \begin{cases} 0, & x < a_1 \\ \dfrac{x-a_1}{a_2-a_1}, & a_1 \le x < a_2 \\ \dfrac{a_3-x}{a_3-a_2}, & a_2 \le x < a_3 \\ 0, & x \ge a_3 \end{cases} \quad (6)$$

Table 2 and Figure 6 give membership functions obtained as a result of clustering algorithm.

Table 2. Membership functions for three classes

	a_1	a_2	a_3
Cluster1: Unsuccessful	-21.21	20	61.21
Cluster2: Moderate	13.79	55	96.21
Cluster3: Successful	41.79	83	124.2

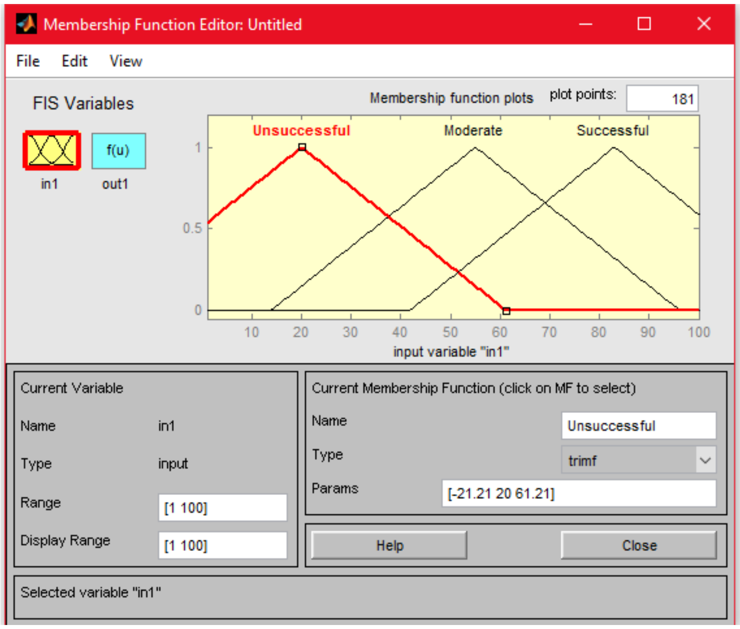


Figure6. Input membership functions plots obtained from subtractive clustering

Backpropagation algorithm is selected for the training of network. It is found suitable to perform 500 iterations for training as a result of preliminary tests realized.Tolerance value for errors is selected as 0.001. After these steps are realized, the program is operated and training of the network started (see in Figure 7). Table 3 gives three fuzzy rules.

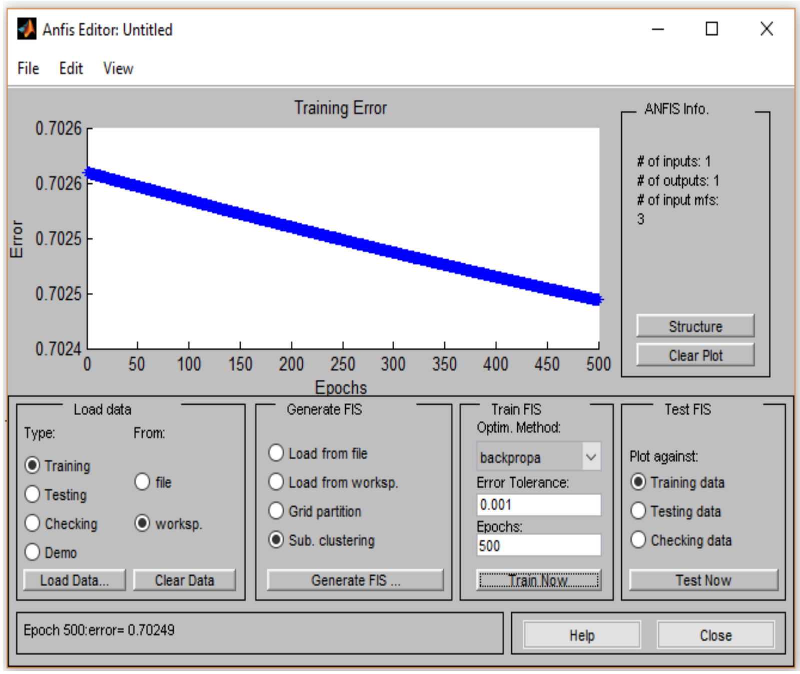


Figure7. Result of Training

Table 3. Fuzzy Rules

Rule	Model
Term exam grade is unsuccessful	Attitude= -1.214 + 0.085*(Grade)
Term exam grade is moderate	Attitude= 2.135 + 0.055*(Grade)
Term exam grade is successful	Attitude= 0.401 + 0.042*(Grade)

For the evaluation of the estimates obtained from the ANFIS, performance of the test set is considered. The RMSE value of the test set is calculated and is found to be as follow:

$$RMSE = \sqrt{\frac{\sum_{k=1}^{N}(y_k - \hat{y}_k)^2}{N}} = 0{,}67$$

Figure 8 gives the estimates obtained from the test set.

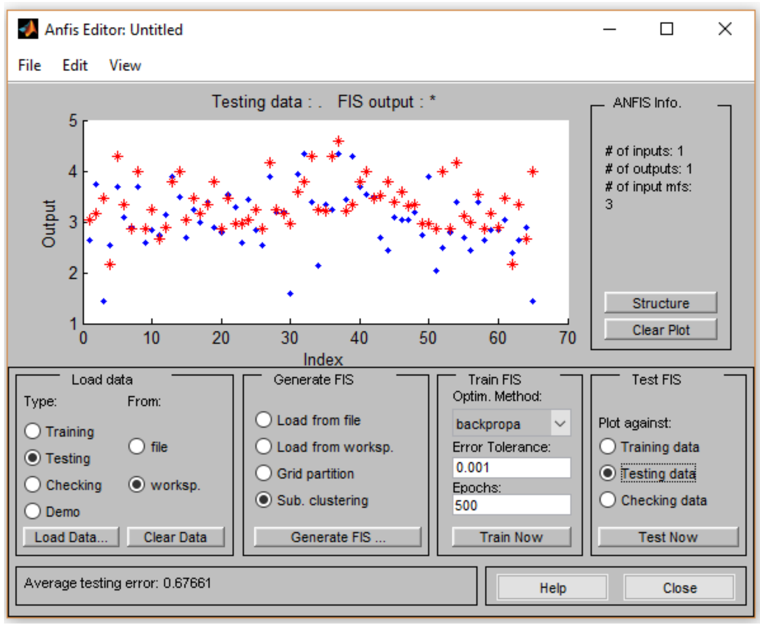
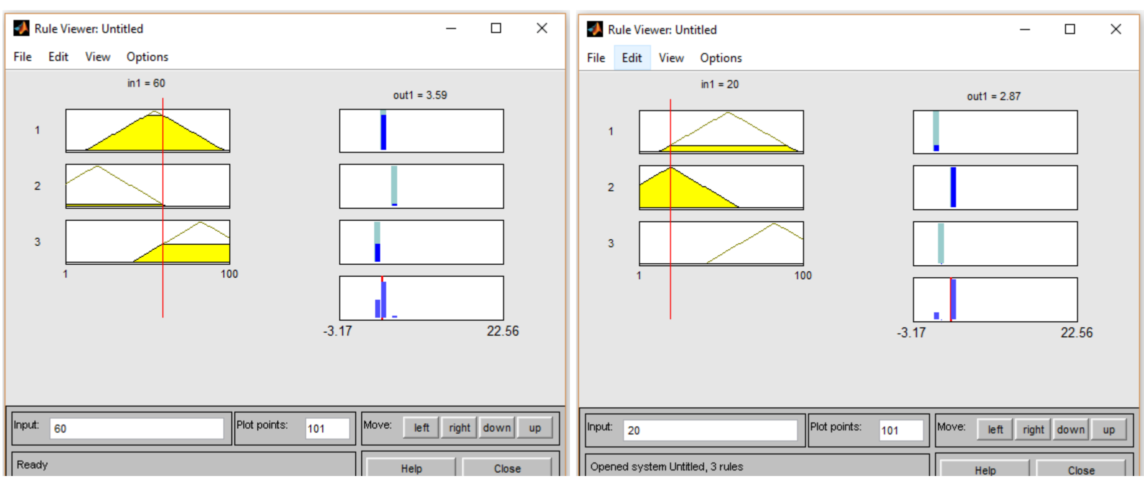


Figure 8. Values of test set and estimation values obtained from analysis (*: testing data/*: ANFIS output)

The rule viewer is given in Figure 9. As can be seen inFigure 9 (a) and 9 (b), when the midterm grade is 60, attitude toward statistics will be 3.59 and themidterm grade is 20, attitude toward statistics will be 2.87.



(a) (b)

Figure 9. The rule viewer

5.RESULTS

In this study, it was aimed to investigate the effect of achievement in statistics to students' attitude toward statistics.ANFIS approach was used for analysis. Fuzzy clustering assigns students to classes by fuzzificationof their midterm exam grades. ANFIS enables estimation of expected attitudes of students by modeling the relationship between achievement and attitude. As a result of the analysis, students are assigned to three classes according to their success. Table 2 shows restrictions of classes in the classification made by using triangular membership function. Three fuzzy rules established by modeling give the estimation of attitudes of the students in relation to their term exam grades as exact numbers. According to results, it can be said that students getting low grades have a negative attitude, and attitude is more positive as the success rate increases. This results is in line with the finding in previous studies by Mills (2004) and Diri (2007).

The statistics course given in all department of the Faculty of Tourism constitutes the work area of the research. On the other hand, students who are going to receive education on this subject are selected by their "Higher Education Exam" social score. Students with insufficient math knowledge are confronted with numbers in the statistics course.Thus, this situation causes fear of failure, and failure experienced in the exams adversely influences the attitude toward statistics. Lecturers believe that attitudes toward statistics are important. Negative attitudes can produce a disrupted environment in the class. In order for the attitude toward statistics course to be positive, the following suggestions are developed:

- Statistics lecturer should develop new education methods instead of using the classical statistics education, which is concentrated on formulas and calculations.
- Students who have negative attitudes toward statistics should be supported.
- Activities that will help students to know should be used.
- It is necessary to develop education methods that will improve success, provided that other variables affecting the attitude are taken into consideration.

This study isconducted only on the relationship between achievement and attitude. More comprehensive research can be conducted by taking into consideration other variables that influence the attitude and achievement in statistics.

Additionally, this study will bring innovation to the literature with the aspects of evaluating the achievement as a fuzzy variable and modelling the relationship with ANFIS. Fuzzy methods are used successfully in educational and social sciences as well as in science and engineering, especially when solving estimation problems.

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