The Usage of Artificial Intelligence in Determining the Residential Real-Estate Prices in Urban Areas and the Comparison of Valuation Methods

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Keywords: Residential real-estate, Valuation, Fuzzy Logic, Artificial Neural Network

ABSTRACT

The determination of real-estate prices is today's one of the most popular labor branch. The factors like the difficulty in finding real-estate similar to the considered estate, having many factors affecting the price, variability due to local regions and preferences and the difficulty in defining the situation with common mathematical equations necessitate the new searches for the determination of values.

As a result of rapid improvement in computer technologies, the artificial intelligence techniques are now used in value estimations of real-estates. Artificial intelligence namely artificial neural network and fuzzy logic are observed to be the most appropriate approaches in determining the values of real-estates. The basis of the valuation was considered as learning and adaptability when artificial neural network was used and the database formation of oral expressions when fuzzy logic was considered.

In this study, the value of the residential real-estate was tried to be determined by applying the data obtained from Konya-Meram region to Fuzzy Logic approach and Artificial Neural Network (ANN) method. The results were given by using the MATLAB 6.0 computer program.

ÖZET

Taşınmaz değerinin belirlenmesi günümüzün en popüler çalışma alanlarından biridir. Değer tespitinde, benzer özellikli taşınmaz bulma zorluğu, değere etki eden faktörlerin çokluğu, yöresel bölgelere ve tercihlere göre değişkenlik göstermesi ve bilinen matematik denklemlerle ifade edilme zorluğu değer tespiti için yeni arayışları zorunlu kılmaktadır.

Bilgisayar teknolojilerini hızlı gelişiminin ile günümüzde yapay zeka teknikleri çoğu alanda olduğu gibi taşınmazın değer tespitinde de kullanılmaktadır. Yapay zeka olarak adlandırılan yapay sinir ağları ve bulanık mantık taşınmaz değerlerinin tespitinde kullanılabilecek en uygun yaklaşımlar olduğu gözlenmektedir. Yapay sinir ağları ile değer tespitinde öğrenme ve adapte olabilirliği temel alınırken, bulanık mantıkta sözel ifadelerle veri tabanının oluşturulması temel alınmıştır.

Bu çalışmada Konya-Meram bölgesinden elde edilen verilerle, bulanık mantık yaklaşımı ve Yapay Sinir Ağları (YSA) kullanılarak taşınmazın değeri belirlenmeye çalışılmıştır. Uygulamada MATLAB 6.0 programından faydalanılarak elde edilen sonuçlar verilmiştir.

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1. INTRODUCTION

Real-estate valuation; can be defined as the unit price determination process of related real-estates by considering the properties of them under the marketing conditions of countries.

There are various methods for the value determination of real-estates which is significant under today's conditions. These methods present instability due to life standards and positions of the countries. Being at the top of the important subjects of our country, there exists no definite arrangement for real-estate value determination. In order to make this arrangement that especially affects the country economy, the necessary infrastructure studies should be accelerated. In the study, the results obtained from Fuzzy Logic and Artificial Neural Network (ANN) methodologies were discussed by using information technologies to achieve the quick and exact solution in determining the value of the residential real-estate.

2. REAL-ESTATE VALUATION METHODS

It is difficult to talk about definite models in determining the values of residential real-estates. Each country has different culture and experience which will determine the methods adopted for any particular valuation. The majority of all methods will rely upon some form of comparison to assess market value. This may be done, in its simplest form, by direct capital comparison or may rely upon a range of observations that allow the value to determine a regression model. Any such method is referred to in this paper as "traditional".

Other model or methods try to analyze the market by directly mimicking the thought processes of the players in the market in an attempt to estimate the point of exchange. These models tend to be more quantitative in method and will be referred to as "advanced"

Residential real-estate valuation methods; are classified into two as traditional valuation methods and advanced valuation methods (Pagourtzi at all, 2003).

1) Traditional valuation methods
- Comparison method
- Income method
- Cost method
- Benefit method
- Multiple regression method
- Hedonic pricing method

2) Advanced Valuation Methods

- Artificial Neural Networks(ANN)
- Fuzzy Logic
- Spatial Analysis Methods
- Autoregressive Integrated Moving Average Method (ARIMA)

Due to factors like the difficulty in finding residential real-estate similar to the considered real-estate, having many factors affecting the price, variability due to local regions and preferences, and the difficulty in defining the situation with common mathematical equations which are encountered in value estimation with traditional valuation methods, the advanced valuation methods have been developed.

2.1. Advanced Valuation Methods

Today, the computer technologies are being used in many branches extending from professional applications to shopping. It becomes possible with computer technologies to reach the quick and exact solutions by making more detailed analyses with the help of more data.

The logic concept is a human characteristic that its application to computer technology is provided by artificial intelligence techniques. Artificial intelligence methods and application areas are divided into many different subsubjects. The Fuzzy Logic and ANN methods are observed to be the most preferred methods in residential real-estate valuations.

2.1.1. Fuzzy Logic

Oral and numerical variables are in question in residential real-estate valuation. Since Fuzzy Logic is an effective method in processing oral variables, the process of fuzzy operations can be provided by introducing this type of data to the computer. In other words, the variables expressed as true or false in classical logic can be graded between 0 and 1 in Fuzzy Logic.

The general features of Fuzzy Logic can be listed as in the following; (Şen, 2004)

1. In Fuzzy Logic, instead of thinking based on definite reasons, the thinking based on approximate values is used
2. Everything in Fuzzy Logic is presented between [0, 1] with a definite grade.
3. The information in Fuzzy Logic is in terms of oral expressions like “large”, “small” and “very small”.
4. Fuzzy inference process is performed with the rules described between oral expressions.
5. Every logical system can be expressed as fuzzy
6. The Fuzzy Logic is so appropriate for the systems whose mathematical model is very difficult to obtain

The fuzzy system used in the methodology of Fuzzy Logic is summarized in Figure1.

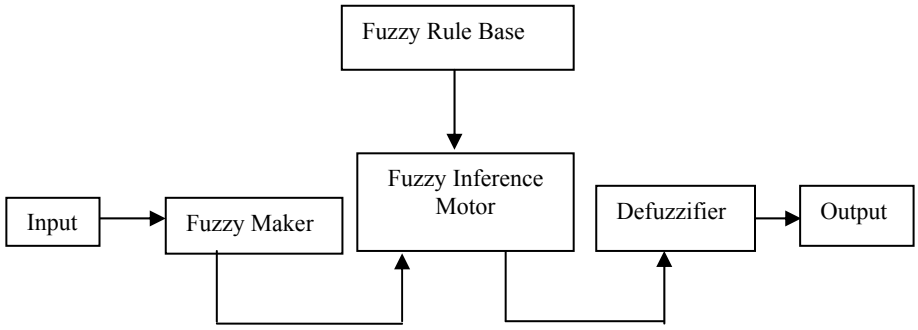


Figure 1. The diagram presenting the basic principles of Fuzzy Logic

General Information Base Unit; involves the input variables affecting the considered event and all the information related to these variables. The reason for saying "general" is due to the ability of information being numerical or/and oral. The fuzzy maker is a processor assigning the numerical input values to membership grades in orally characterized fuzzy sets. Fuzzy Rule Base Unit; contains all of the rules writeable in logical IF – THEN expression connecting input variables to output variables in the database. In writing these rules, all the possible intermediate connections (fuzzy set) between input data and outputs are taken into consideration. Fuzzy Inference Motor Unit; is a mechanism covering the group of processes providing the single output behavior of the system by gathering the separate relations built between the input and output fuzzy sets in the fuzzy rule base. This motor is used to determine what kind of an output will be obtained as a result of the input of the whole system by collecting all the rule inferences together. Defuzzifier; transforms the fuzzy inference solutions obtained as a result of fuzzy processes into definite numerical output values. The Output Unit; expresses the group of the output values obtained at the end of the interaction performed between information and fuzzy rule bases by the help of the fuzzy inference motor (Yilmaz and Arslan, 2005).

2.1.2. Artificial Neural Networks(ANN)

Artificial neural network model is a method that can make it possible to solve many problems encountered during the valuation of residential real-estates. Neural networks or with its known name artificial neural networks have been developed being inspired by biological neural networks. As in a biological neural system, there are neurons and neural networks connecting these neurons to each other, i.e. briefly it imitates the human brain. In a neural network, the data set is trained first and then the method (model) is used to estimate the newly updated values from the same market, and the nodes corresponding to neurons in the biological neural network are found and each node works connected to the other with a certain weighted coefficient. The weights are determined according to the given inputs and outputs. The neural network becomes trained when the appropriate weights were determined (Ölgen, 2003).

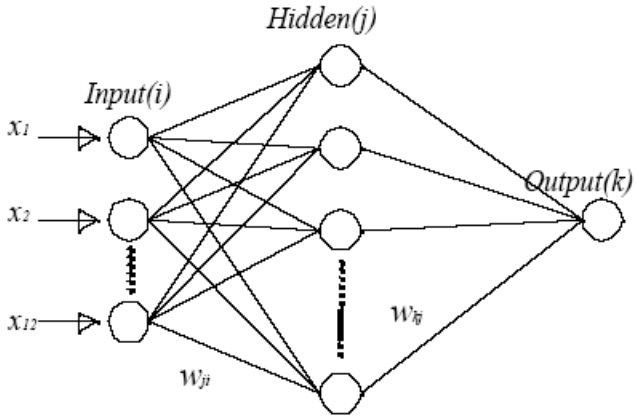


Figure 2. A typical three layer neural network model

The structure of a neural network is composed of three components. As shown in Figure 2 they are;

1. Input data layer
2. Hidden layer(s) is usually referred as black box, and
3. The output layer(s) is the layer at which the value or the values of the residential real-estate is calculated.

Hidden layer(s) is formed from two sections namely weights' cumulative function and transformation function. Both of these functions are the connections of the values between the input data (the properties of the residential real-estate; number of rooms, age of the building, area, etc.) and the output data (selling prices). The cumulative function of weights used as the neural network model in forward and backward feeding propagation is;

$$Y_j = \sum X_I W_{ij} \qquad (1)$$

In the above equation, Xi is the input values and W_i is the weights allocated to the input values in each of the hidden layer nodes. A transformation function depends on the values of output variable(s) or the cumulative value(s) of hidden layer(s) at Yi. This transformation function can be in terms of various types like linear functions, linear threshold functions, graded linear functions, sigmoid functions or Gaussian functions. Most of the software programs use regular sigmoid transformation function. For instance:

$$Y_T = \frac{1}{1+e^{-y}} \qquad (2)$$

This function is preferred due to its non-linearity, continuity, stability and characteristics presenting continuous variability (Trippi and Turban, 1993).

3. APPLICATION

In the application, there were made estimations with Fuzzy Logic and ANN method. The used data have been collected from the Melikşah region of Konya-Meram District. The collected data was belonging to 44 livable residential real-estates whose buying-selling values were known. The factors affecting the value of the residential real-estate are determined by poll results. They are;

- area of the residential real-estate,
- age,
- elevator condition,
- floor condition,
- architecture,
- facade,
- land portion,
- transportation condition (main, intermediate road etc.),
- price.

The area, age, elevator condition, floor condition, architecture, facade, land portioning, transportation condition were selected as input variables. The output variable was the value of the estate i.e. its cost. Since the floor condition, facade position, transportation condition and elevator condition were expressed orally, they were graded by the help of polls.

The models formed by 8 inputs and 1 output with Fuzzy Logic and ANN methodologies and the flow chart of the study are presented in Figure 3.

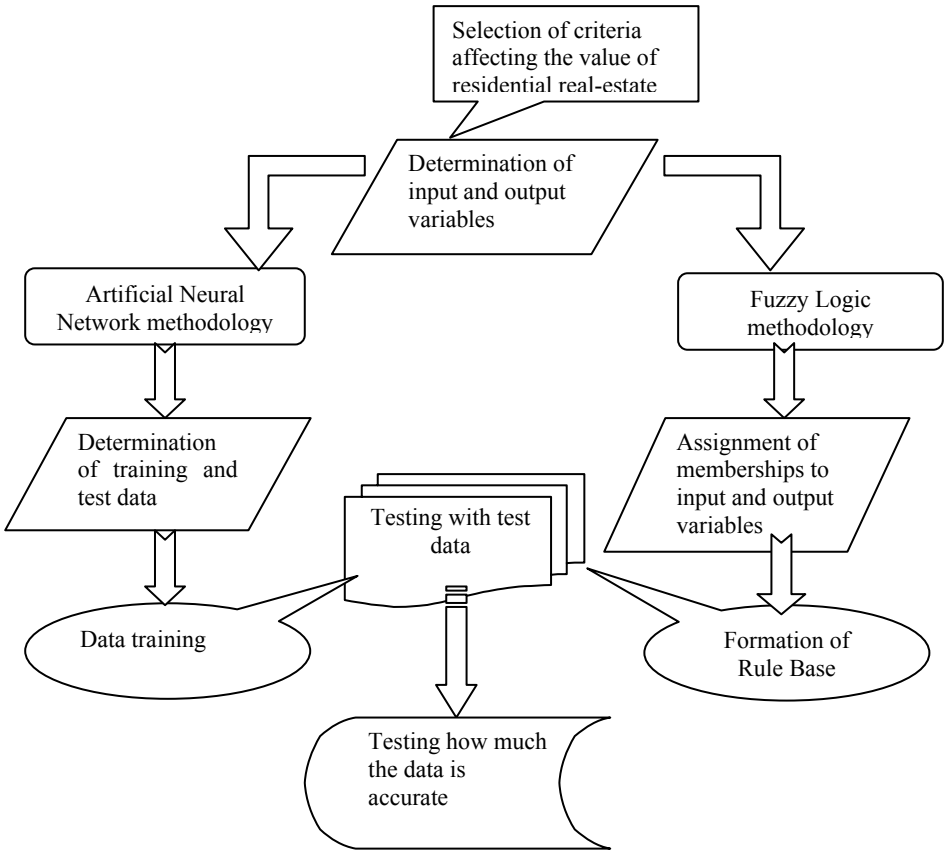
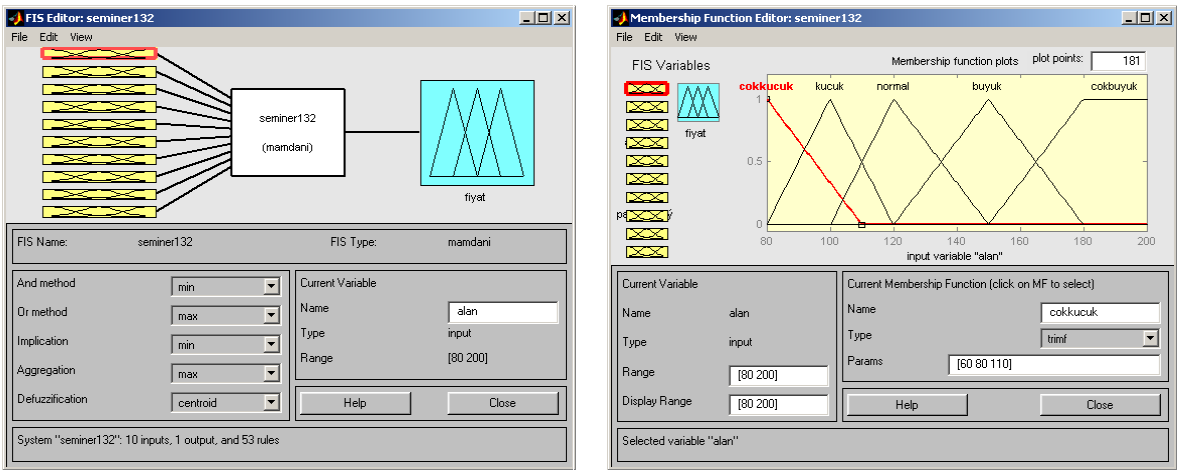


Figure 3. The flow chart of the application study performed with Fuzzy Logic and ANN methodologies

3.1. Fuzzy Logic Application in Residential Real-Estate Valuation

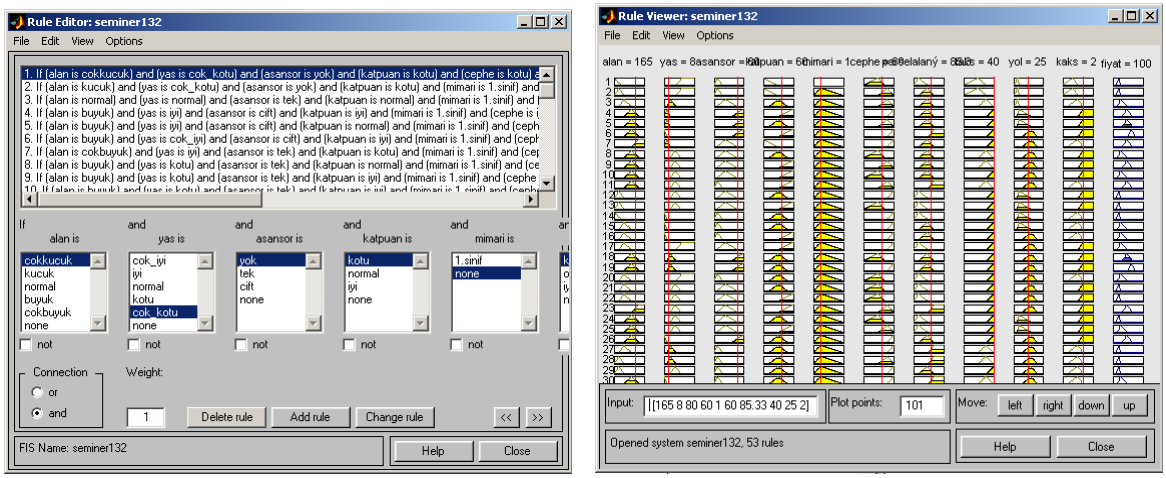
The input and output variables were selected in Figure 4 (a) by the help of FIS (Fuzzy Inference System) editor in the Fuzzy toolbox of the MATLAB program, and the membership assignment to these variables are shown in (b). Sets were formed by determining the variation intervals in the membership assignment. For instance; there were used criteria expressed as "very small", "small", "normal" or "large".



(a) (b)

Figure 4. (a) FIS structure (b) memberships of input and output variables

The formation of the rule base started after the assignment of the memberships. In the rule base, there were written 53 rules like "IF area GREATER AND age LESS AND …. THEN price is high". These rules were as presented in Figure 5. (a). The structure formed after these rules was tested in Figure 5. (b) by using the aforementioned data.



(a) *(b)*

Figure 5. (a) The section at which the rule base is formed (b) the section at which the data is tested

3.2. ANN Application in Residential Real-Estate Valuation

The data was standardized to quicken the value determination process of the residential real-estate with ANN, and the iteration was made with the training data. The number of iteration was 5000. There were used 20 nodes in the study. **.** Using 30 of 44 data in training and 14 data in testing, the training error and test error are determined as 0.68 and 11.33 respectively. The distribution after the iteration and the sufficiency of the number of iterations can be seen in Figure 6.

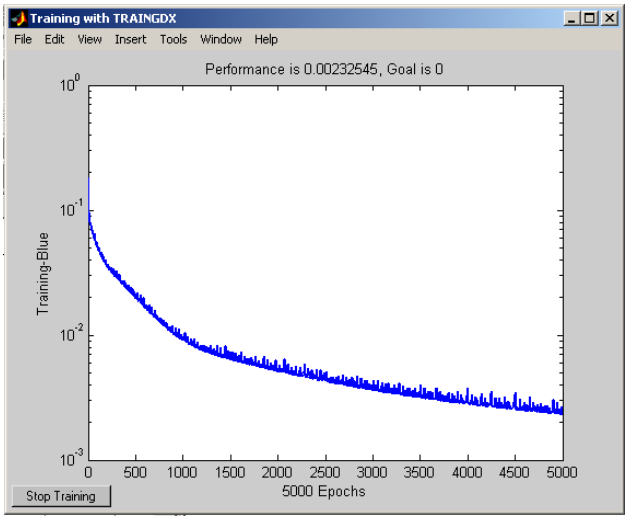


Figure 6. The iteration distribution of training data in ANN

3.3 The Comparison of Applications

A part of the results obtained by making the test data comparisons using the Fuzzy Logic Toolbox of MATLAB and ANN is presented in Figure 7. While testing all the data as a must of Fuzzy Logic methodology, in ANN some of the data is used for training and the rest of the data is left for testing. The comparison is relevant with the common data.

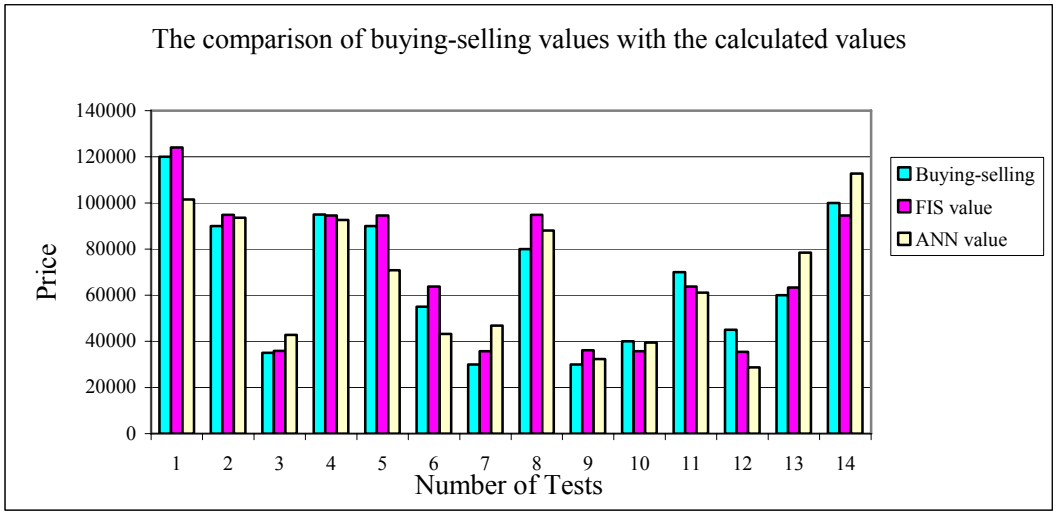
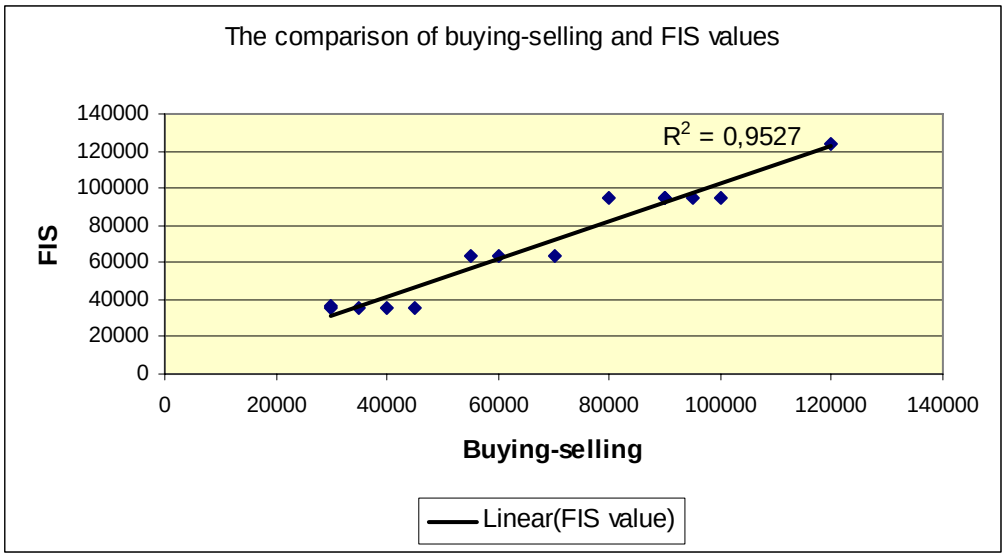
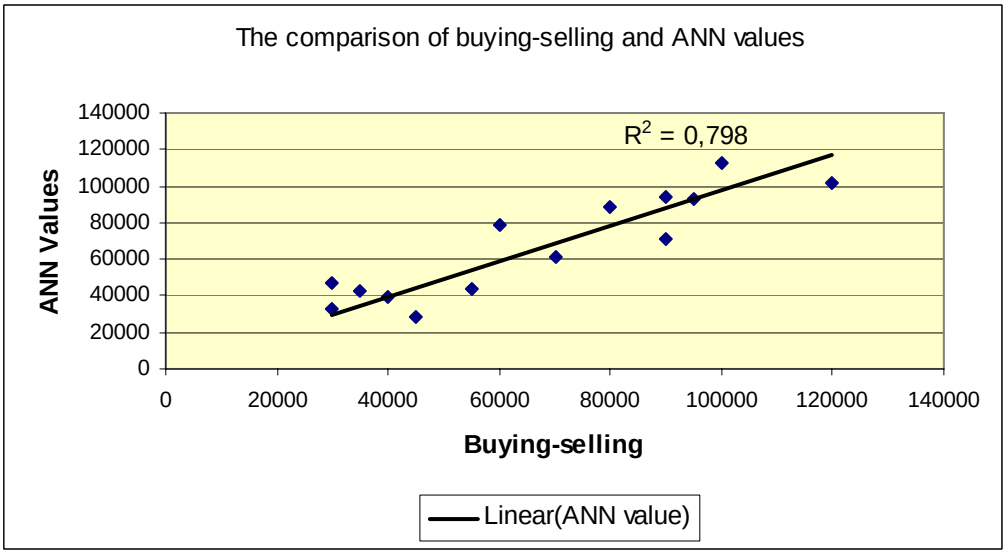


Figure 7. The comparison of buying-selling value with the values determined by Fuzzy Logic and ANN methodologies

The regression line is used to find the linearity between the buying-selling values and the FIS and ANN application results. The comparisons can be seen in Figure 8.



(a)



(b)

Figure 8. The regression lines between (a) buying-selling (market) values and FIS (b) buying-selling values and ANN values.

As seen in the above figure, the regression coefficient between market value and FIS value is closer to 1.

4. CONCLUSION

In the study, there were used fuzzy logic and artificial neural network methodologies to estimate the residential real-estate values. When the estimations were examined, it has been observed that the estimations made with FIS were more overlapping with the market values. The usage of various alternatives during the stages of selecting criterion affecting the value of residential real-estate, assigning memberships, formation and training of rule base becomes possible while estimating the values of residential real-estates with FIS. However, during the estimation performed by ANN, the proper algorithm is found and trained with data after the selection of criterions. Although the education with FIS requires a specialist person, ANN does not require any.

The appropriate method selection for the value estimation of residential real-estate can vary due to regional customs and market conditions. It is possible to obtain quicker and more accurate estimation results by considering various alternatives with advanced valuation methods. Fuzzy logic can be preferred to be used in estimating the values of residential real-estates due to its capability of numerical and oral data evaluation all together.

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BIOGRAPHICAL NOTES

Dr. Şükran Yalpır, born in 1974 and graduated in 1995 as Dipl. Eng. in Surveying from Selcuk University and completed doctorate degree in 2007 at the Natural Science of Institute. of Selcuk University. She worked as Surveying Engineer between 1995 and 1998 in public administration of Konya. She has been working in Selcuk University, Department of Geodesy and Fotogrametry Engineering

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