Using the Fuzzy Logic approach for the valuation of parcels

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Abstract

To offer instant solutions to the classical methods in real estate valuation, the existing methods are insufficient to create value maps. For this purpose, the usability of Fuzzy Logic methodologies supported by computer technology was investigated in the process of its application. In this study, the valuation process of the parcels was performed with Fuzzy Logic approaches using the data of 100 parcels existing within Selçuklu town of Konya, Turkey.

By means of applying the methodology, parcel criteria were established and the network structure was divided into four groups, which include the criteria of legal rights, the criteria created by the physical conditions, equipment criteria and locational score. The application of Fuzzy Logic is assessed through the four main criteria of structure themselves and these main criteria were re-modeled in their combination. The Matlab program has been used for modeling with Fuzzy Logic.
Keywords: real estate, Fuzzy Logic.

1   Introduction

Impartial, accurate and actual valuation of real estates of great significance to the economy of any country is among the issues that are studied most diligently today. The valuation of real estates is taken into account in a number of fields including

taxation, banking transactions, expropriation and buying and selling. The criteria and methods used in this field vary greatly.

Method of valuation can be defined as painstakingly appraising a value on a property through experience and the ability of judgment [1]. The method to be utilized for valuation is determined depending on the location of the property to be valued and on the dominating habits of the property market [2]. In the process of valuing real estates, the class of the real estate must first be determined, and then the suitable method must be established based on the criteria required by that class. The most commonly used methods in real estate valuation are those of comparison, cost and income.

The method of cost is generally used for valuation of the constructed real estates on which buildings are set up, such as hotels, factories, industrial sites, office blocks. The basis of the cost management is composed of the approach to the cost value of the real estate at the time of the valuation, that is, the approach to the exact value. This value is made up of the value of the structure, external facilities, special operational equipment and the land value. The land value is the value determined through the method of comparison of prices and the value of the structure is the total value of the structure, external facilities, special operational equipment determined through their values at the time of the valuation. This value is obtained after the value-decreasing elements, such as physical, operational and environmental ones, are excluded from the new value [3].

Although these methods are preferred in the general sense, they remain inadequate for practices, such as for taxation system, that require an extensive study. Because there are limited data in these methods and because there is a set of information unique to one single real estate, they cannot be used in regional or massive implementations.

In regional or massive real estate valuation processes, such developed methods as [4–5] multiple regression analysis from statistical methods, artificial neural networks) from artificial intelligence methods, location-based analysis [6] and Fuzzy Logic [7] are employed [8].

Fuzzy decision-making systems give a more realistic form to statements because of including intertwined ambiguous statements rather than clear-cut limited statements [9]. That the fuzzy approach is suitable in value estimates is because there are objective and subjective criteria in the concept of value. The value is best expressed numerically by the personal view through clustering in Fuzzy Logic (fuzzification), making rules and clarification. In total 10 criteria and a data set were established out of the 100 building plots in the area specified in this study. The criteria in the data set were divided into 4 main groups (Legal Right, Physical, Equipment criteria, Locational Score) and the fuzzy real estate valuation system was established.

2 Method

2.1 Fuzzy Logic approach

Fuzzy Logic was first put forward by Dr. Lotfi Zadeh of the University of California, Berkeley, in 1960 to model the obscurity in the native language [10].

Zadeh demands that the Fuzzy Logic theory should be handled as a methodology used to generalize the fuzzification method by changing any theory from crisp, discrete form into a continuous, fuzzy form rather than an independent and complete theory [10].
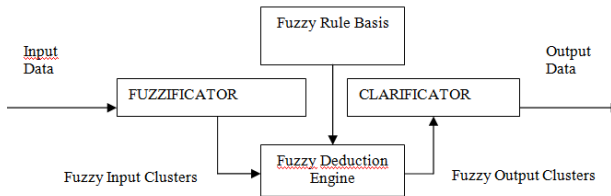

Figure 1: Fuzzy system with the fuzzification, clarification units.

In general, there is a structure consisting of three sets in the form of inputs, fuzzy deduction motor and outputs in Fuzzy Logic (Fig. 1). When the inputs are numerical, a fuzzification unit which serves to fuzzificate them by exposure to a process and a clarification unit that serves to digitize the outputs that are fuzzy are added. The outlines of the fuzzy system are:

- Fuzzyfication: In practice, the fuzzification of the shift intervals that usually appear in the form of a classical cluster is necessary for the processes of fuzzy cluster, logic and system. Therefore, instead of all the elements in an interval having a membership level equal to 1, they are considered to have distinct values between 0 and 1. The triangle, Gauss and trapez are the most commonly used of the fuzzification methods. Input value(s) is/are transformed into linguistic expressions in this section.
- Rule basis: It includes all fuzzy conditional sentences. The linguistic supervision rules appropriate to the purposes of supervision are found here, and given to the deduction unit from here.
- Clarification: First of all, each fuzzy output cluster made up of the membership values is identified within the output universal cluster for every rule. Then one of the clarification methods is used on the logical cluster composed by these clusters and the single output value is found, thus conducting the process of clarification.
- Fuzzy Logic deduction method: The heart of the Fuzzy Logic supervisor is the fuzzy deduction unit. The deduction unit is the main block in which the control algorithm of the deduction unit is conducted and the process of decision making takes place. The inputs of the deduction unit are the outputs of the fuzzification interface. They process the fuzzy rules they obtain by reaching the database and the linguistic variables coming from fuzzification interface. They decide on the control action at the end of this process. Before these fuzzy values are given to the system that will be controlled, they are scaled at the clarification interface and converted into actual numbers.

3 Application

The open spaces between the bus terminal and the university campus in Selçuklu town of Konya on Konya-Afyon intercity road were chosen as the area of the study. These areas had no structures on them and were building plots (Fig. 2).
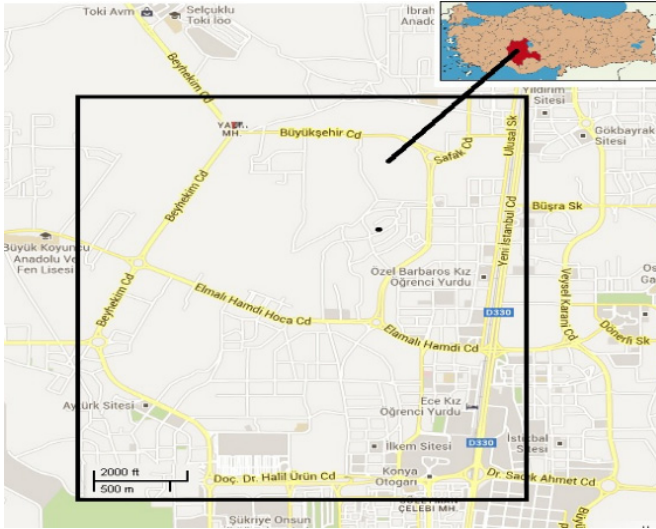

Figure 2: The general overview of the area of the study.

A set was formed with the criteria affecting 10 values (input) that are formed by the building plots with no structures in the study area and 100 data consisting of a market value (output). The general information regarding the 10 inputs and 1 output used in the data set is as follows; Building area, Number of floors, Plot area, Frontage, Location of the parcel, Width of Road, Green areas, Transportation Network, Commercial Areas, Location Score, Current Market Value.

The data set has been divided into 4 main groups made up of legal, physical, locational and social facilities as a result of the requirement to classify the criteria in practice, and thus a fuzzy system has been set forth (Fig. 3).

Subsequently, 4 stages were identified in the system. Separate fuzzy systems were formed for the first three stages, that is, Legal right, Physical and Equipment Criteria. While the sub-criteria in the three stages were blurred, the number of the membership function was set by 5. 125 rules were laid down in total and clarification process was carried out based on the Centroid Method. A new fuzzy system was brought out by adding locational score to the results of the 3rd stage.

While Legal rights, Physical, Equipment Criteria and Locational were fuzzified, the number of the membership function was set by 5. 625 rules were formed in total and clarification process was carried out based on the centroid method. Price values were attained at the end of this process.
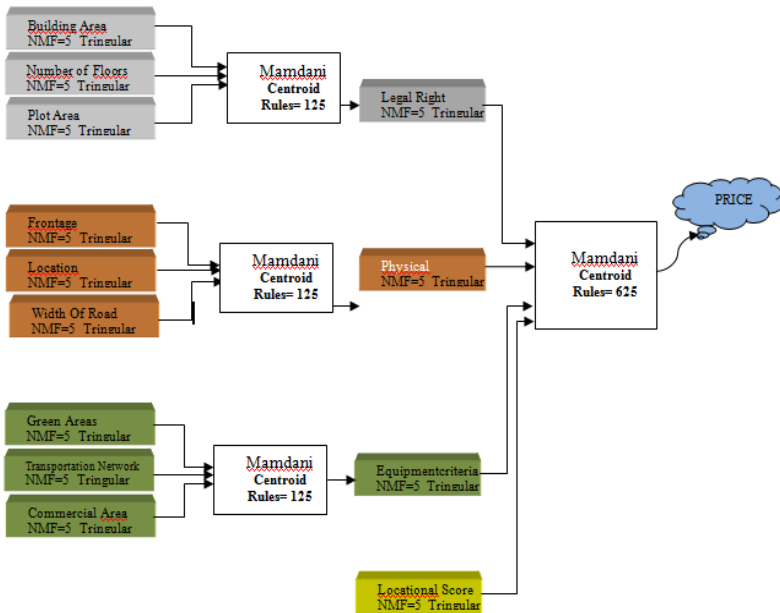
Figure 3: Fuzzy system flow chart for real estate valuation.

4   Result and discussion

It is seen in the distribution between market values and FIS values that FIS values are successful in estimating the market values in the system formed by using Fuzzy Logic approach in real estate valuation through criteria classification (Fig. 4a).

Since the target in the practice is to estimate the market price, a performance valuation is presented with a curve in Fig. 4b to show the extent to which FIS values estimate market prices. In $y = ax$ equation, the closer a and R^2 are to 1, the more accurate the model is. Based on Fig. 4b, now that $R^2 = 0.931$ and $y = 0.923*x$ are obtained, it is observed that FIS model yields a good result in estimating the value of plots.

The average closeness rate was obtained from Equation (1) and the success of the models and the standard deviation of AA% were examined.

$$AA\% = \frac{\sum_{i=1}^{n}\left(1 - \frac{|x_p - x_i|}{x_p}\right)}{n} * 100 \tag{1}$$

(x_p :Market value, x_i :Value of the model, i : {1,2,3….n}, n :Total number of the residential real-estates in the data set.)

In this study, AA% = %87 ± 12 was obtained. In a study by Yalpır in 2007 [11] entitled "The Development and Application of Real Estate Valuation Model with

Fuzzy Logic Methodology: Konya Case Study", the same data set was obtained as $AA\% = \%82 \pm 10.9 \ R^2 = 0.9005$ and $y = 0.8477*x$ as a result of the implementation without classifying the criteria in the Mamdani structure in Fuzzy Logic.
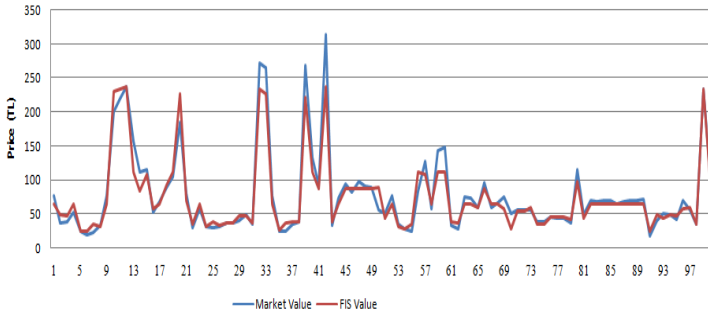
(a)
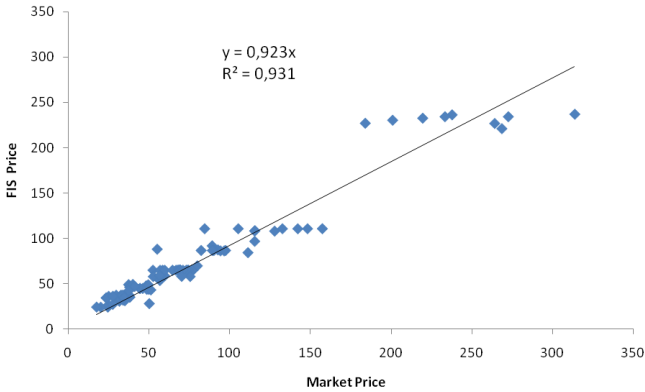
(b)

Figure 4:   Market values and the estimate of FIS values (a) and value distribution (b).

5   Conclusion

The criteria that affected the value of the real estate were divided into 4 stages in this study. While in every stage a triangular membership function by 5 was used in the fuzzification process, in the first 3rd stage 125 and in the 4th stage 625 rules were laid down and clarification was conducted through the centroid method. Thus FIS values were obtained. Given the success of the results obtained, this study is seen to be more successful than the study by Yalpır in 2007 [11]. Whilst the success rate of this study ranges from 75% to 99%, the results of Yalpır in 2007 was between 71% and 93%. Establishing the fuzzy system by grouping the criteria has yielded a better result in estimating the market values.

Acknowledgement

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