A New Land Reallocation Model for Land Consolidation

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Key words: Land consolidation, land reallocation, fuzzy logic, membership degree and function

SUMMARY

Events and systems are defined by using definite mathematical models in engineering and in other fields of science. By way of using these constructed models, it is attempted to estimate the future state or the behavior pattern of the event or the system. However, a great majority of the problems encountered in daily life either can not be accurately modeled, or these mentioned problems may not represent a certain state or condition for several reasons. Fuzzy logic approach can be implemented to investigate and solve such problems. Fuzzy logic theory has attracted increasing attention as the result of the fact that fuzzy control systems have provided successful results in a good number of industrial areas. The reason for this is that fuzzy controllers represent human thought and commands better than classical controllers with the help of fuzzy rules. Today, as in other areas of engineering, fuzzy logic is also used for the solution of a great deal of geodesic problems.

In the present study the fuzzy logic theory, which has been increasingly used day by day was investigated and the land reallocation phase of land consolidation, which does not have a definite mathematical model, was modeled by using the fuzzy logic method.

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1. INTRODUCTION

Land consolidation projects are conducted to consolidate fragmented agricultural properties, scattered parcels of the distinct farms, and thus to achieve improvements in the harvest and the living standards. It is carried out by means of projects neighbouring the rural area through a project management. Land consolidation may also include the improvement of the road and of the water management system, as well as of the landscape and the conditions of nature in project areas (Sonnenberg, 2002). It also includes the process of fragmented or scattered plots of farms. For this purpose, the land is divided into blocks by planning an optimal network for roads and channels and then the problem of reallocation is solved by answering to the question "how much land from which block is given to a farm?" In some of the land consolidation applicable country, the possible applications of operations research techniques are investigated. Klemper (1974), Kropff (1977), Riemer (1983) and Lemmen and Sonnenberg (1986) studied how to use different algorithms of the mathematical programming methods in reallocation of farm lands (Avcı, 1999). Different and complementary general-purpose software tools aid experts to solve particular aspects of only some tasks of the process. These tools use different data models and formats. Moreover, the high volume of consolidation information is spread among different institutions and there is a lack of coordination between the participants involved in the process: landowners, rural engineers, local and regional administrations, and consultants. Specific-purpose tools have also been designed to assist the development of consolidation plans, including those in The Netherlands (Rosman & Sonnenberg 1998), Hungary (Kovacs, 2001), and Morocco (Semlali, 2001), but they only cover partial aspects of the consolidation process(Tourıño et al. 2003). Necessary algorithms for standard software to be used for the applications of General Directorate of Rural Service and Agricultural Reform were developed and their capacities were then investigated in Cay and Iscan (2004;2006). However, land reallocation should be done by using modern methods, because of technological development and science. Fuzzy logic provides one of the most important modern methods that can be used for this purpose.

A number of geodesic problems can be successfully solved with the help of fuzzy models that are constructed by using adequate amount of data. Among these problems, the determination of outliers is presented in detail in Gökalp and Boz (2004), valuation of real estate and deformation analysis in Akyılmaz and Ayan (2003), Heine (2001), Akyılmaz (2005), prediction of earth rotation parameters and modeling the earth gravity field in Akyılmaz (2005), GPS integer ambiguity resolution in Akyılmaz (2005), Kutterer (2001b, 2002a, 2002b) and Leinen (2001), coordinate transformation in Akyılmaz et al. (2005), data analysis in geographic information systems in Akyılmaz and Ayan (2003) and Heine (2001) (Yilmaz and Arslan, 2005).

In the present study the fuzzy logic theory, which has been increasingly used day by day was investigated and the land reallocation phase of land consolidation, which does not have a definite mathematical model, was modeled by using the fuzzy logic method.

2. FUZZY LOGIC APPROACH

2.1. Fundamentals of Fuzzy Set Theory

The origin of the fuzzy logic approach dates back to 1965 since Lotfi Zadeh's introduction of the fuzzy set theory and its applications. Since then the fuzzy logic concept has found a very wide range of applications in various domains like estimation, prediction, control, approximate reasoning, pattern recognition, medical computing, robotics, optimization and industrial engineering, etc (Sen, 2004).

In 1965, L.A. Zadeh published his famous paper "Fuzzy sets" in Information and Control providing a new mathematical tool which enables us to describe and handle vague or ambiguous notions such as "a set of all real numbers which are much greater than 1", " a set of beautiful women," or "the of tall men." Since then, fuzzy set theory has been rapidly developed by Zadeh himself and numerous researches, and an increasing number of successful real applications of this theory in a wide variety of unexpected fields have been appearing. The main idea of fuzzy set theory is quite intuitive and natural: Instead of determining the exact boundaries as in an ordinary set, a fuzzy set allows no sharply defined boundaries because of generalization of a characteristic function to a membership function [Sakawa, 1993].

The framework of fuzzy logic is unique in its ability to represent subjective or linguistic knowledge in terms of a mathematical model. For this reason, fuzzy logic provides a natural method for constructing systems that emulate human decision making processes. Literature on the subject of fuzzy logic systems (FLS) is extensive and applications, particularly in the field of fuzzy control and fuzzy expert systems, are prevalent. Mendel (1995) and Klir and Yuan(1995) provide good introductory texts on FLSs, while some examples of applications of FLSs may be found in Sugeno and Park(1993), Maiers and Sherif (1985) and Kandel (1991) and Ramot, et.all. (2003).

Fuzzy logic is a recognized instrument for modeling in many scientific and technical fields. There are also a lot of problems where fuzzy methods can be used to reach better solutions than classical models can do. It concerns on the one hand questions, where uncertain parameters occur, which cannot be handled by classical methods in adequate way. On the other hand, there are problems where linguistic fuzzy rules can describe relations better than it can be done by crisp mathematical formulas.

Many of us, especially those in positions to develop models of physical process, understand that we lack complete information in solving problems. Some of the information we do have about a particular problem might be judgmental, perhaps a visceral reaction on the part of the modelers, rather than hard quantitative information. How then do we incorporate intuition into a problem? This paper will be example this question [Ross, 1995].

2.2. The Basic Elements of Fuzzy Systems

The basic elements of each fuzzy logic system are, as shown in Figure 1, rules, fuzzifier, inference engine, and defuzzifier.

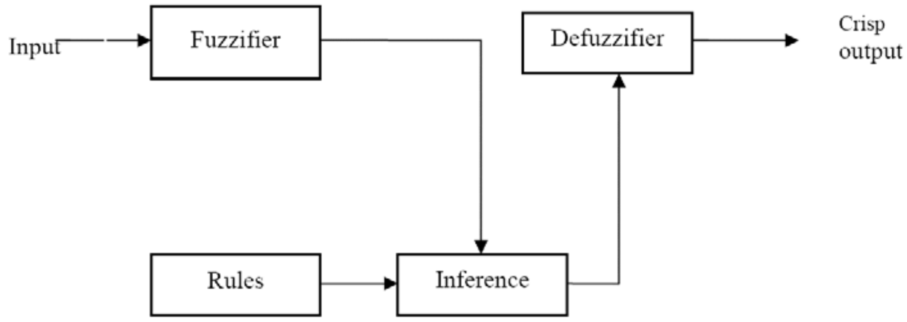

Figure 1. Basic elements of a fuzzy logic

I

nput data are most often crisp values. The task of the fuzzifier is to map crisp numbers into fuzzy sets (cases are also encountered where inputs are fuzzy variables described by fuzzy membership functions). Models based on fuzzy logic consist of “If-Then” rules. A typical “If-Then” rule would be:

If the ratio between the flow intensity and capacity of an arterial road is SMALL Then vehicle speed in the flow is BIG

The fact following “If” is called a premise or hypothesis or antecedent. Based on this fact we can infer another fact that is called a conclusion or consequent (the fact following “Then”). A set of a large number of rules of the type:

If premise Then conclusion is called a fuzzy rule base.

We would note that in classical expert systems, rules are derived exclusively from human experts. In fuzzy rule-based systems, the rule base is formed with the assistance of human experts; recently, numerical data has been used as well as through a combination of numerical data-human experts. An interesting case appears when a combination of numerical information obtained from measurements and linguistic information obtained from human experts is used to form the fuzzy rule base. In this case, rules are extracted from numerical data in the first step. In the next step this fuzzy rule base can (but need not) be supplemented with the rules collected from human experts. A fuzzy rule base obtained from numerical data can be used to solve the same type of problem solved by artificial neural networks. The inference engine of the fuzzy logic maps fuzzy sets onto fuzzy sets. A large number of different inferential procedures are found in the literature. In most papers and practical engineering applications, minimum inference or product inference is used. During defuzzification, one value is chosen for the output variable. The literature also contains a large number of different defuzzification procedures. The final value chosen is most often either the value corresponding to the highest grade of membership or the coordinate of the center of gravity [Teodorovic and Vukadinovic, 1998; Terzi et.al.,2003].

3. MODELLING OF LAND REALLOCATION BY USING FUZZY LOGIC METHOD IN LAND CONSOLIDATION

Land reallocation process is the most difficult and the most important step in land consolidation studies. For this reason, it has a highly complex structure. It is of great importance that farmers do not face unfair practices and policies and that they are given equivalent parcels when the land reallocation process is carried out. The satisfaction of farmers directly affects the success of land consolidation. For this reason, it is of great importance what the farmers pay attention to in land reallocation, because the input variables of the fuzzy logic model to be constructed should be determined according to the criteria of the farmers and the implementers. The points which the farmers and implementers pay attention to in land reallocation in previous studies can be listed as below,
-The place of the biggest parcel of land owned by the farmer,
-The place of the parcel density owned by the farmer,
-The place of the immovable facility owned by the farmer,
-The place of the second biggest parcel of land owned by the farmer,
These criteria constitute the input variables of the fuzzy logic system. However, as these criteria signify the location information, they should be represented in terms of angle and distance. That is, a criterion has to be represented as two different input variables. For this reason, there has to be 4*2=8 input variables. Similarly, as the output also has to represent a location, there has to be two outputs. However, in a system with eight inputs and two outputs, there may be thousands of rules depending on the number of membership functions. For this reason, it is possible to decrease the number of inputs in order to set up the system in an easy way. Therefore, the place of the biggest parcel can be taken as the first input variable, and the other three criteria can be taken as the second input variable, because the place of immovable facility, parcel density and the second biggest parcel of land owned by the farmer may not exist at the same time. Of these criteria, the one which exists can be taken as input. An input variable is also required in order to determine according to which criterion and from which block the land will be given. Therefore, it should be taken into consideration if the parcel areas are smaller or bigger than one another. By this way, a five-input and two-output fuzzy system can be formed. As the input and output variables will be entered as polar coordinate values, a starting point should be determined. The smallest coordinate values of the project area should be taken for the starting point. The biggest coordinate values should be taken as the endpoint in order to determine the borders of the project area. That is, the project area should be surrounded by a tetragon (Figure 2). The general structure of the fuzzy logic model is as shown in Figure 3.

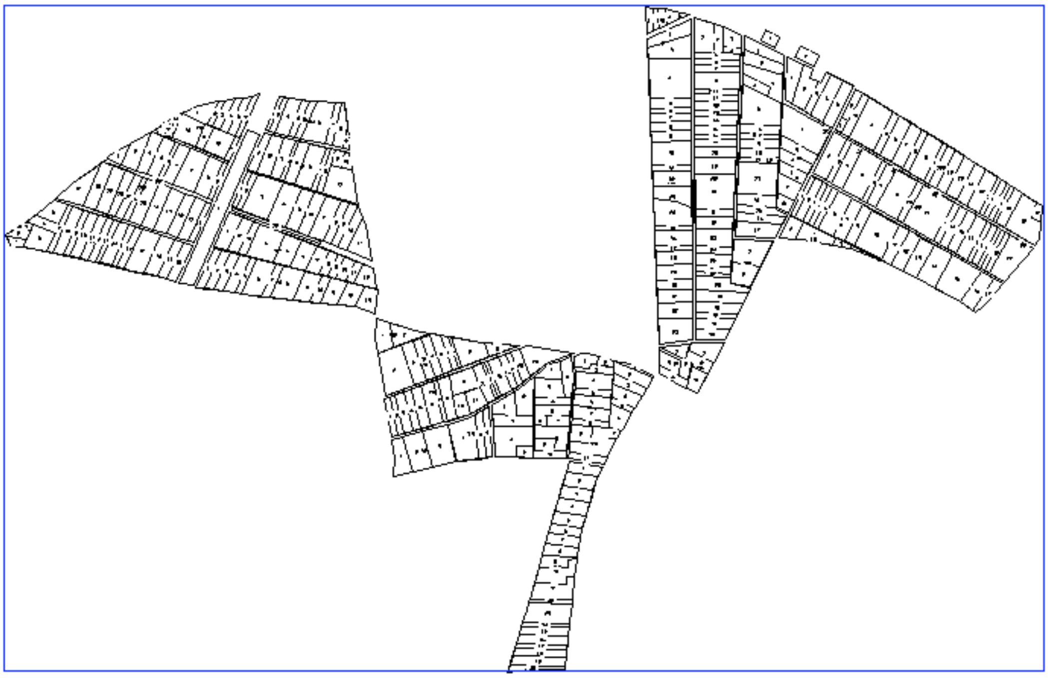

Figure 2. Project area

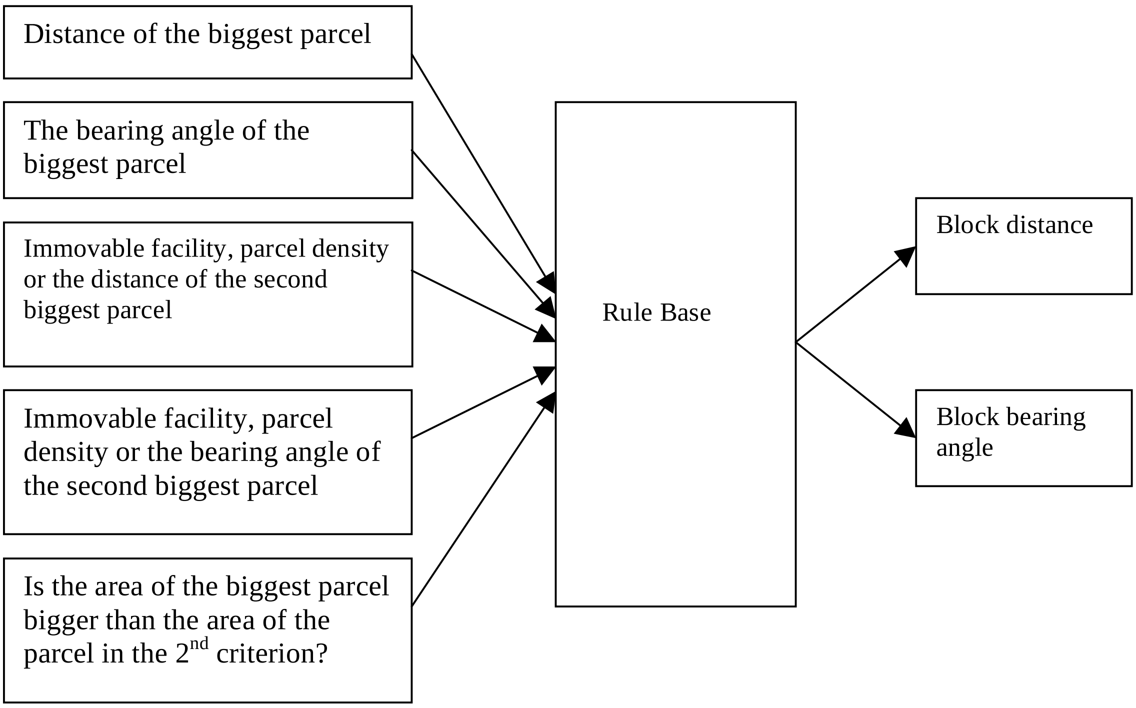

Figure 3. General Structure of Fuzzy Logic Model

The membership functions and the ranges of the input and output variables should be the same, except for the 5th input. The reason for this is that the distance and the bearing angle will be the same for the project area. The range for the distance inputs should be taken as the distance from the starting point to the end point (diagonal length). It should not exceed 100 grades for the bearing angle. This constitutes the first step of the system.

It is not possible to solve the problem of land reallocation in land consolidation in a single step. The correct result can only be achieved in a number of steps. For this reason, the project area is divided into 4 zones. In the first step of the fuzzy system, land reallocation to these four regions is first performed (Figure 4).

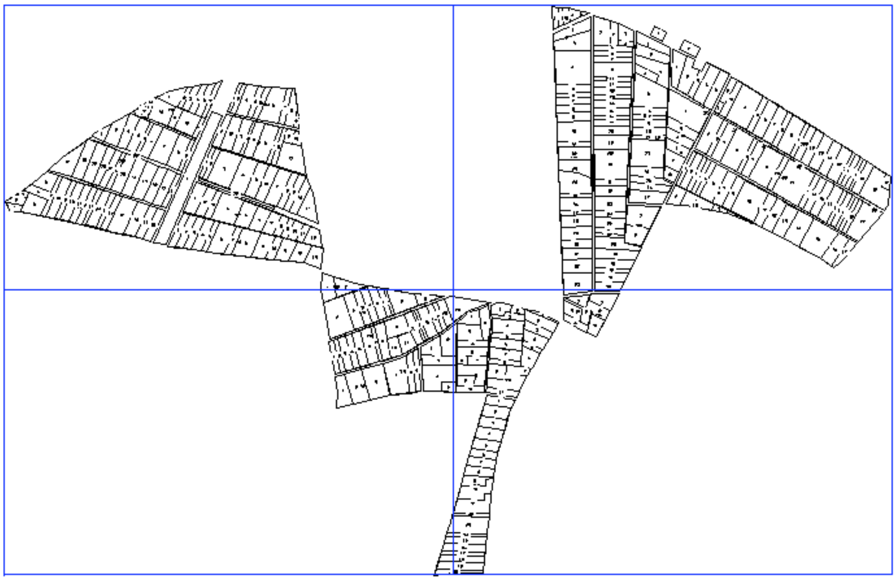

Figure 4. Project area divided into four zones

As the result of the first land reallocation, it is determined which region each enterprise is located in. After this, we proceed to the second system. In this system, each enterprise is processed in the region where it is located. That is, it does not have a relation with other zones. The model is the same also in the second system. That is, each area is divided again into four zones. However, only the ranges in the distance inputs will change. The range equals to the half of the preceding range. In this way, the project area is divided into regions until it is correctly determined which enterprise will be given to which block. In other words, the clustering process is carried out. Land reallocation is implemented in an easier way with the clustering process.

For the first system, a model is formed in the fuzzy logic toolbox of the Matlab software (Figure 5). The membership functions belonging to the model are shown in Figure 6, 7 and 8. While developing the fuzzy logic algorithm, the shape of the membership functions was selected as trapezoid. There are three selected membership functions for each linguistic variable.

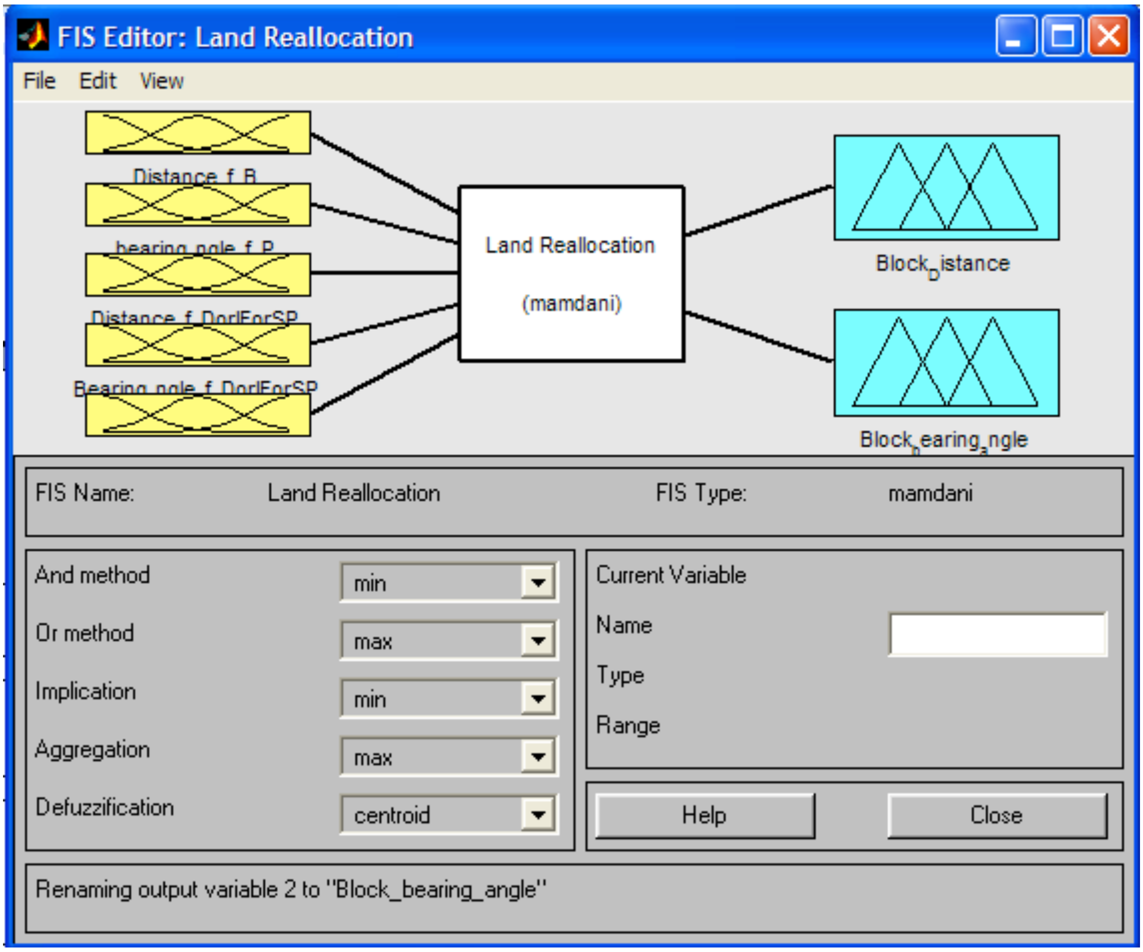

Figure 5. Mamdani-type fuzzy system model

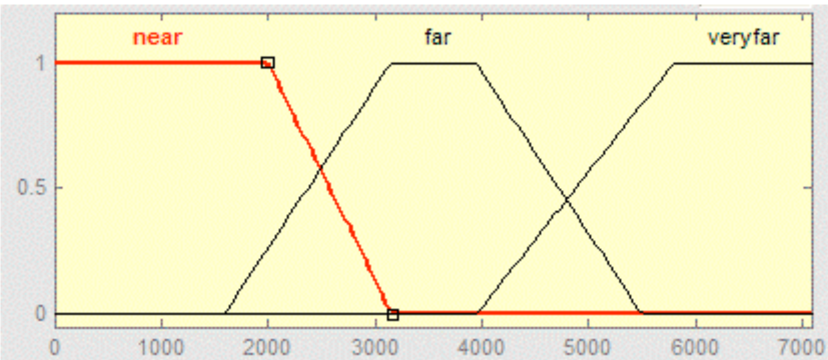

Figure 6. Membership function for distance

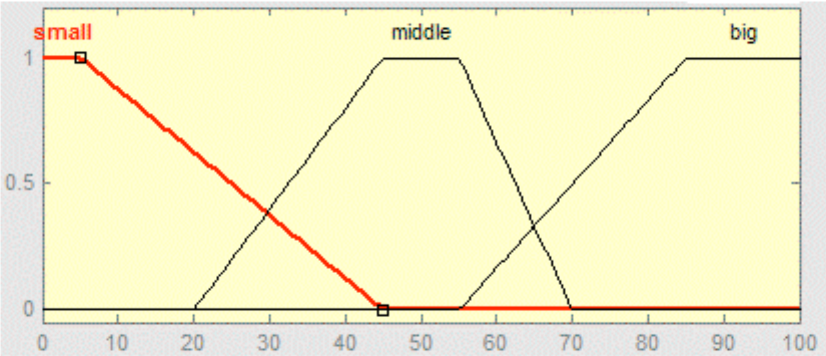

Figure 7. Membership function for the bearing angle

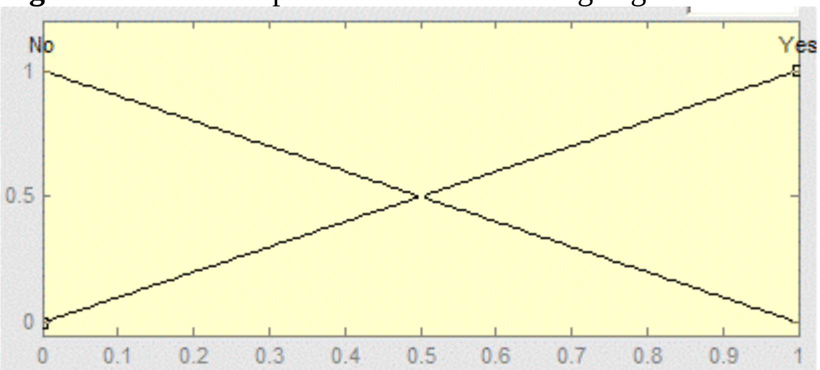

Figure 8. Membership function for area size

The membership functions of the output variable are the same as that of the input variables. After the membership functions were formed, 164 rules were written for the first system in accordance with expert opinions (Figure 9). The centroid method is used for defuzzification.

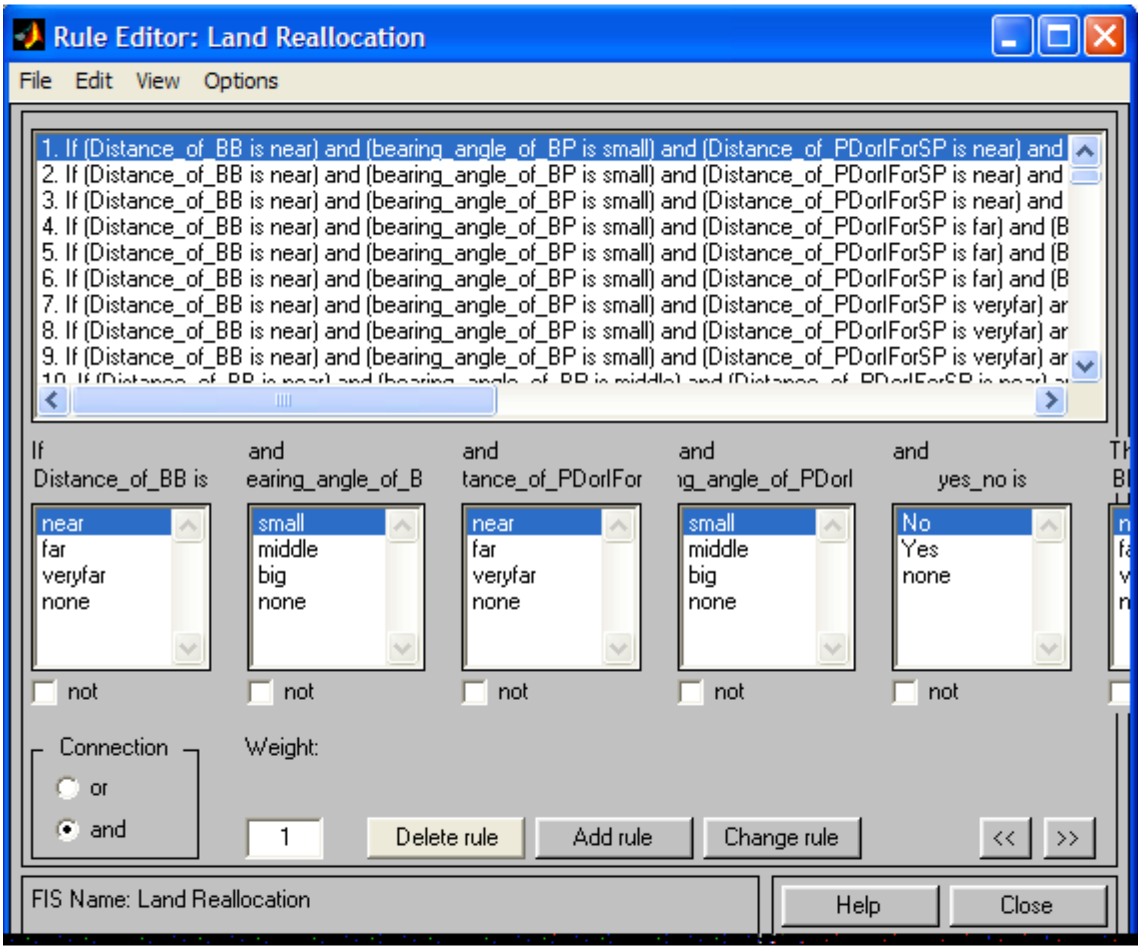

Figure 9. Rule base

After the rules are written, each enterprise is included into this system. The region to which each enterprise will belong to is determined (Figure 10). Afterwards, we proceed to the second system. In the second system, the enterprises divided to the zones are reevaluated in the model existing in that zone. These processes are carried out until it is determined to which block the enterprise will be given.

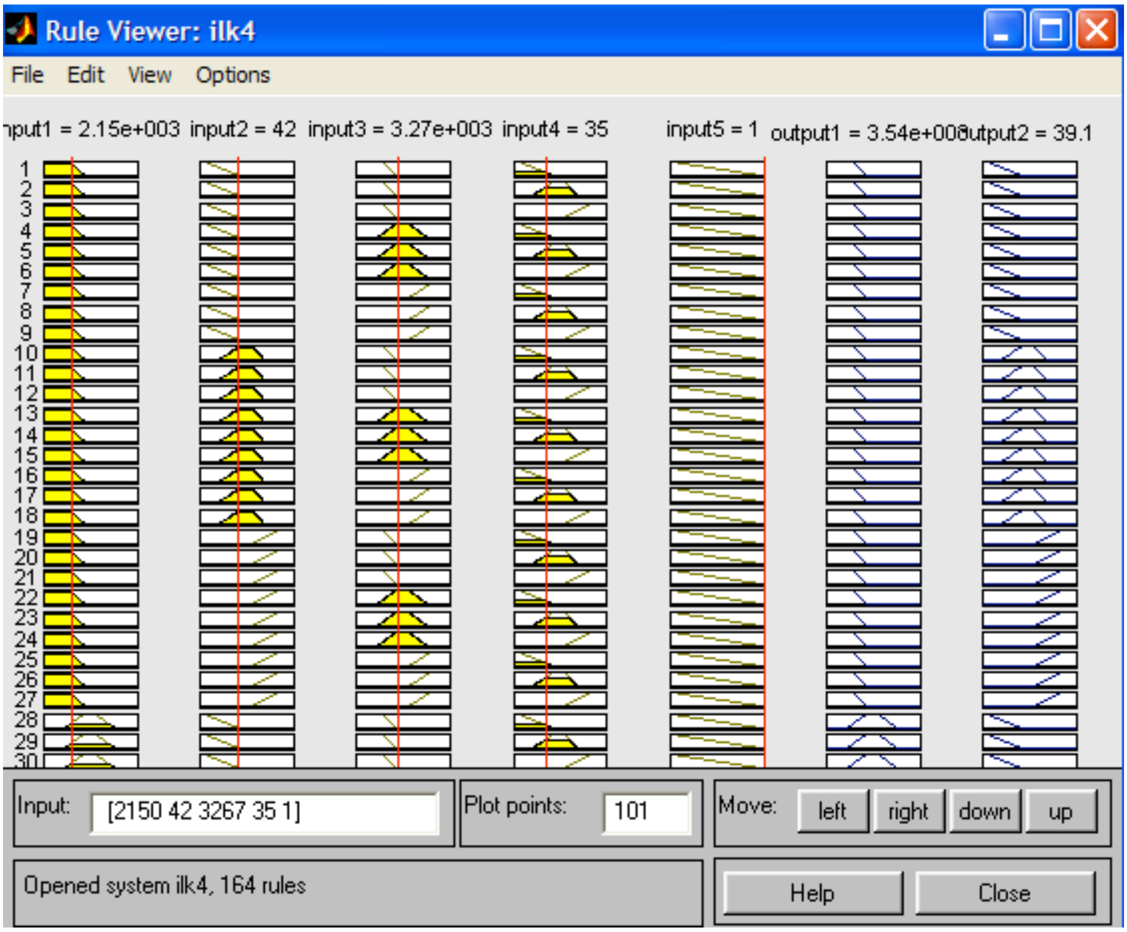

Figure 10. Evaluation of the Data

4. CONCLUSION

In this study, the fuzzy logic method is suggested for the land reallocation process of land consolidation operations. Fast, economic and effective results can be achieved through this method. As the input and output variables regarding the model are given, implementers can perform their projects according to these variables. A number of differences may occur in input variables for certain projects. These differences will not affect the land reallocation model in a significant manner.

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