Design and Implementation of Fuzzy Expert System for Real Estate Recommendation

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ABSTRACT

Expert systems are computer programs that make the knowledge of experts available when a human expert is not withineasy reach. The systems are to simulate the thinking and inference pattern of human being. The ultimate goal of expert system is to be analogous to human as much as possible. Utilizing the intelligent system in commerce is indispensable for establishing a better connection with customers in businesses. Use of fuzzy expert system that initiates some special activity could be noteworthy as a suitable solution in customer servicing.Nevertheless, fuzzy set theory presents a new approach for modeling in uncertainty situation in order toremove the vagueness of retrieval customers' information and system rules in terms of mathematical calculation, system design, and applied intelligence in this research. The designed fuzzy expert system has been analyzed and tested for real estate as an environment comprising enormous vagueness in stock portfolio recommendation. In this research,the researchers have introduced and designed an expert system to help applicants' property purchase shell and to pave the way for the accessibility of the required knowledge to contribute applicants' property purchase stored in knowledge base in rule format.

Keywords

Expert System, Fuzzy Set Theory, Knowledge Engineering, Knowledge Management, Real Estate.

1. INTRODUCTION

Real Estate recommendation is a collection of investment suggested to an institution or private individual. Selection of the assets and their proportion is a key problem in real estate recommendation. It is difficult to decide which real estate should be selected because of the existence of uncertainty on their returns; hence, it is necessary to balance between the maximizing expected return and minimizing the risk of the selected portfolio for better recommendation [1]. To smooth real estate recommendation, computerized and intelligent decision support has been used since past decades [4].

Various analytical approaches existin decision making in real estate, which are categorized in terms of two groups of technical analysis and fundamental analysis [4]. Technical analysts believe that the real estate prediction is possible through studying real estate prices in the past [4].

Real Estate recommendation is a complex multiple attribute problem. Combination of both scientific methodology and personal experience in the field of real estate recommendation is of paramount importance. Thus, the entire advanced tools are utilized to ensure the integration of the of professionals' knowhow in the field of real estate management to foster an anticipated return defined in terms of the undertaken risk.

Siskosand Despotis (2003) use multiple objectives interactive linear programming method to achieve a portfolio composition[18]. Accordingly,Siskos, Spyridakos, and Yannacopoulos (2005) ranked the stocks with Minora method of preference analysis[19]. A proactive system for expressing and implementing high-level stock trading strategies was developed by Garcia, Gollapally, Tarau, and Simari in 2000 which was suitable for implementing a deliberative multi-agent system in portfolio recommendation with technical and fundamental approaches. Luo, Liu, and Davis (2002) have designed a decision support system for buy or sell decisions based on fundamental analysis principles and technical indicators [5][10].

The most important elements of multiple criteria expert systems, as an important category of expert system, are developed by Matsatsinis, Samaras, Siskos, and Zopounidis (2002) for stock evaluation and portfolio management[17][22]. Therefore, Matsatsinis et al. (2002) have taken into considerationvarious important criteria deriving from fundamental and technical analysis, as well as

the investor's profile that revealstheir goals, preferences and policies besides the two basic criteria of return and risk in portfolio management with an MCDM approach[11]. In addition, Samaras and Matsatsinis (2003) use a multiple criteria expert system with the contribution of MCDM methods in order to rank the ASE stocks based on fundamental, technical and stock exchange analysis[17]. Besides, Vranes, Stanojevic, Stevanovic, and Lucin (2008) suggest that an investment program combining five different techniques such as heuristics, expert system, fuzzy logic, investor risk model, and PROM- ETHEEII (a MCDM method), as an intelligent multiple criteria expert systems,and at least one artificial intelligent technology should be utilized. The Fineva system [22] and Intelligent Investor Samaras and Matsatsinis (2003) in the ASE are the other examples of intelligent multiple criteria expert systems[11][17].

The outline of the paper is as follows: First, fuzzy expert system for real estate recommendation has been described. Afterwards, the architecture of fuzzy expert system has been introduced and design of the proposed system for portfolio recommendation at real estate is presented; then the designed system for portfolio recommendation at real estate is explained. Subsequently, the designed system is evaluated and the obtained results are described. Finally, in the conclusion the researcher pinpointthe benefits of proposed system.

2. FUZZY EXPERT SYSTEM

Problem solving mechanism is only a small part of intelligent computer system [20]. Thus, the necessity of expert system, a computing system capable of representing and reasoning about some knowledge-rich domain with a view to solving problems and giving advice [7], is accentuated.

The usage of expert systems or knowledge-based system has extensively increased during the last decade. The main difference of these systems with other software is that they process knowledge rather than data or information [2]. Expert systems provide powerful means for solving different problems, impossible to be solved by conventional methods. Expert system is also one of the successful branches of artificial intelligence from commercial aspect[13].

From another point of view, fuzzy set theory provides a framework for handling the uncertainties. Zadeh (1965) initiated the fuzzy set theory. Bellman and Zadeh (1970) presented some applications of fuzzy theories to the various decision-making processes in a fuzzy environment. In a non-fuzzy set, every object is either a member of the set or it is not a member of the set, but in fuzzy sets, every object is to some extent a member of a set ora member of another set. Thus;unlike the crisp sets, membership is a continuous concept in fuzzy sets. Fuzzy is used in cases there are linguistic variables. Fuzzy theory is widely applicable to information gathering, modeling, analysis, optimization, control, decision making and supervision .

Fuzzy expert decision support system is such an expert system that uses fuzzy logic instead of Boolean logic. It can be seen as a special rule-based system that uses fuzzy logic and derives conclusions from user's inputs and fuzzy inference process [8], whereas fuzzy rules and the membership functions make up the knowledge-base of the system. In other words a ''fuzzy if–then" rule is an ''if–then" rule in which some of the terms are given with continuous functions [21].

It is obvious that it lacks a system that can combine the advantages of the aforementioned systems. Thus, itis of great importance to develop a decision support system which can support the procedure of stock portfolio recommendation considering the investors parameters, stock market situation and the stored knowledge of the last recommendations.

3. ARCHITECTURE OF FUZZY EXPERT SYSEM

A fuzzy expert system is comprised of four components: fuzzification unit, knowledge base, decision making logic, and defuzzification unit which should be embedded in the architecture detail for fuzzy expert system construction. The big picture of system architecture is composed of three main blocks as shown in Figure 1.

3.1. Fuzzy Inference Engine

It is a program, which analyzes the rules and knowledge in the database leading to a logical result. There are different selections for the fuzzy inference engine depending on the aggregation, implication and operators used for s-norm and t-norms [21].

3.2. User Interface

Users of this system are organizational decision makers that enter the real number of all linguistic variables via user interface. Also, user interface shows the result scoring of all real estate; therefore, MATLAB user interface is used to materializeaim in the designed system.

3.3. Rule-Based Fuzzy

Experts' experience is used to build up the fuzzy rules. These rules are conditional statements and in general can be represented as

IF x is X and y is Y and … THEN o is O;

Where x and y are linguistic input variables. X and Y are possible linguistic values for x and y; respectively. They are modeled as fuzzy sets based on reference sets containing x and y: Similarly the output or decision variable, o is a linguistic variable with a possible value, O modeled as a fuzzy set. The clause x is X and y is Y can be interpreted as fuzzy propositions delivering partial set membership or partial truth. Consequently the partial truth of the rule premise can be evaluated, modifying the fuzzy set parameters of the output fuzzy sets [12].

4. DESIGN THE FUZZY EXPERT SYSTEM FOR PORTFOLIO RECOMMENDATION

The proposed fuzzy expert system aims at evaluating real estate to make the portfolio and recommend it to the target customers at real estate according to theirpay off preferences. For stock portfolio recommendation, the proposed system ranks the stocks by starting with the best one towards the worst. Ranking criteria are fundamental analysis ratios and qualitative criteria from the real estate. The undertaken risk is also incorporated in the ranking process. Thus, the portfolio recommendation is adapted to the investor's preferences. The

eligible real estate included in the portfolio arepicked out from the top of every ranking list.
The basic goals of developing the system are:

- The support of the decision-investor to the procedures of ill- structured decision making problems
- High level of interaction between the decision maker and the system
- The completed formulation of the preferences of the decision maker and the absolute specialization of his preference profile
- The incorporation of a huge volume of ‘‘active information” to make the system constantly updated and to support valuable decisions.
- Architecture of the possible incorporation of any environment at work

The fuzzy expert system is intended to provide support for investment decisions regarding real estate. However, it is fully parameterized and can be used in other cases, provided it is equipped with the respective databases.

The intention of this section is to describe the development of methodology in fuzzy expert system,indicating effectiveness and efficient recommendation in real estate. The overview of the framework is shown in Figure 2. There are sevenfundamental steps in the development of a fuzzy system consisting of the fuzzy inference process.

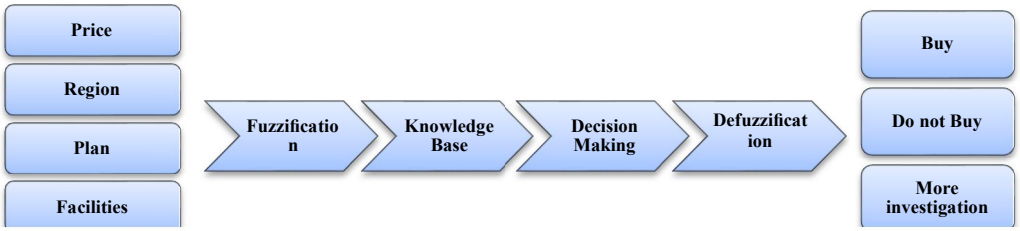

Figure1.Fuzzy Systems.

The detailed description of these steps is as follows:

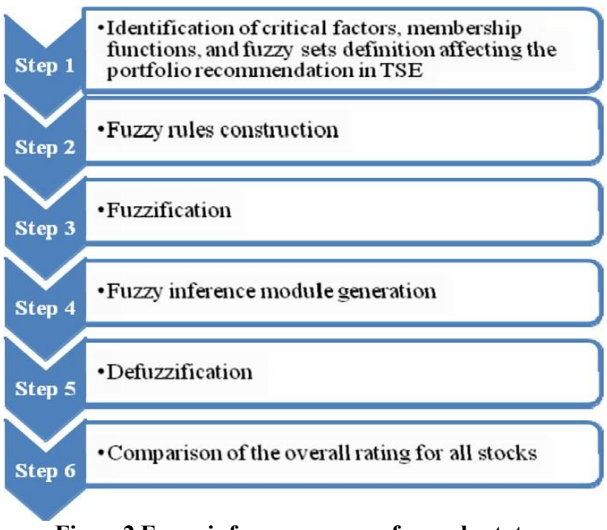

Figure2.Fuzzy inference process for real estate recommendation.

4.1. Identification of CriticalFactors

In Iran’s real estate, there are several important factors, which can be used by experts to evaluate and to make a portfolio of estate. Hence, to recognize the most important factors from tacit knowledge of experts, a questionnaire was distributed among expert in housing agency. The questionnaire had been distributed among 20 selected experts with the presented in which 18 of these experts completed the questionnaire.

Factors, which were more important for stock portfolio recommendation at real estate, have been chosen by experts:

1- Price,2- Region,3- Plan,4- Facilities.

It was assumed that decision makers could assign ratings to different estate under different selection criteria using common linguistic terms, for example, ‘‘low”, ‘‘medium” and ‘‘high”. Each linguistic term is defined by a membership function, which helps us take crisp input values and map them into degrees of membership in fuzzy data space. The most commonly used membership function has three types: bell-shaped, triangle-shaped and trapezoid-shaped [14]. Due to our experience in the present study, we assume the input and output fuzzy numbers are triangle-shaped forms and these forms approximate human thought processes. Triangle membership functions, hence, have been used to define the fuzzy sets for the linguistic values describing factors.

In the first round of Fuzzy Delphi Method of 4 factors, the most important factors for decision-making in real estate were scored. Following defuzzification,the mean value of scoresis obtained for each proposed factors.

In the second round of Delphi approach, the final results of the first one were sent for the 18 experts contributed in the first round. All of them answered the questionnaire. The results of this step have been collect, after deffuzzification of the aggregated fuzzy numbers for each of the 4 factors.

Finally, in the third round, the results of the second one were sent to the 18 experts who answered in the last round. Thus, this step was the final step and the Delphi rounds were cut.

4.2. Fuzzy Rules Construction

Fuzzy system makes decisions and generates output values based on knowledge provided by the designer in the form of IF THEN rules. The rule base specifies qualitatively how the output parameter of the estate ranking is determined for various instances of the input factors: Price, Region, Plan,

Facilities. The degrees were formulated in term of their linguistic variables: Low, Medium, and High. For instance, ‘‘If price is medium, region is high, plan is medium and Facilities is low, the estate ranking is low”.

To develop a knowledge-based system, it is toodifficult to elicit and integrate knowledge from multiple experts [6], especially the application domains in which various time scales of elements need to be taken into account. To deal with this problem, Fuzzy Delphi Method is proposed in this section, which takes time scales into consideration while eliciting expertise from multiple experts and model the vague expert’s opinion. There were potentially $3^4 = 81$ rules because each rule consist of four inputs, and input parameters are evaluated with three linguistic variables: Low, Medium, and High.

In the first round,20 experts of real estate are requested to determine the importance of all of the 81 rules with a triangle-shaped numbers. It is not necessary to increase the number of rules in rule base of fuzzy expert system. The rules with high degree of importance should be selected for the speed and accuracy of the fuzzy expert system, which is not increased with the number of rules necessarily.

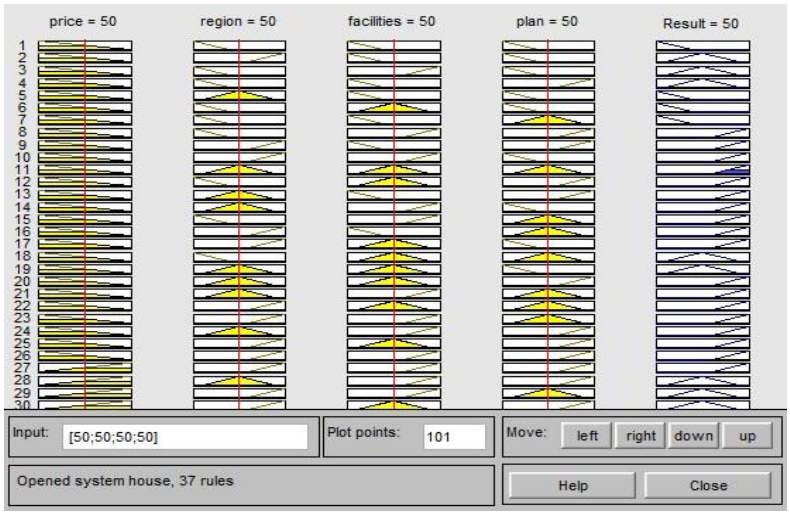

Figure 3.Fuzzy rule base view ofthe fuzzy expert systemfor real estate recommendation.

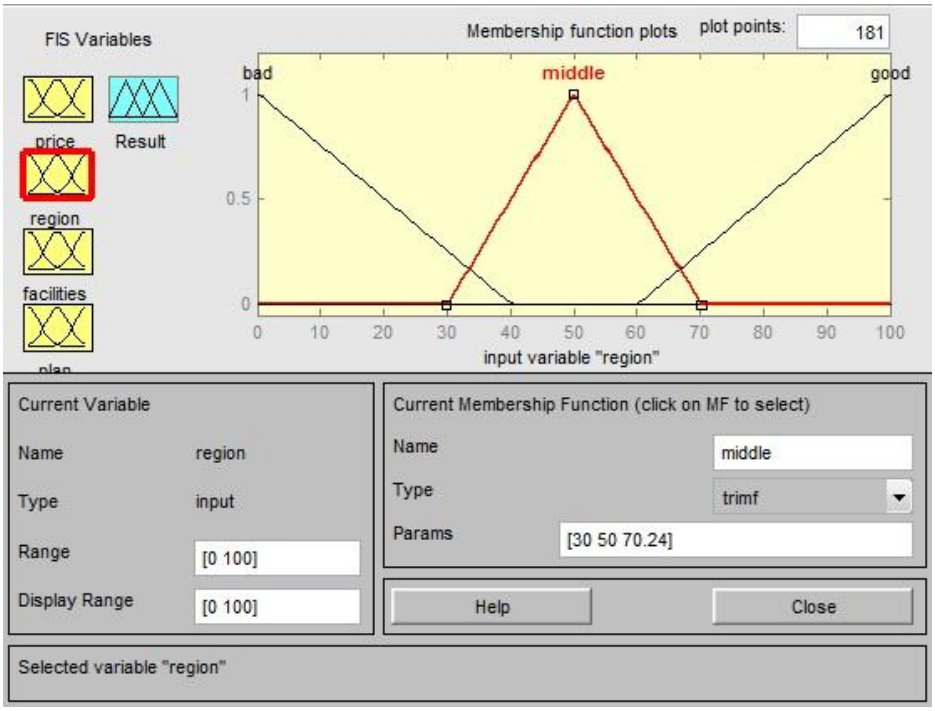

Figure4.Market of stock input variable in fuzzy expert system for real estate recommendation

Table1.Membership functions for linguistic values of estate portfolio recommendation factors

Plan		Facilities		Region		Price	
Fuzzy number	Linguistic variable	Fuzzy number	Linguistic variable	Fuzzy number	Linguistic variable	Fuzzy number	Linguistic variable
(0 0 0.5)	bad	(0 0 0.5)	low	(0 0 0.5)	bad	(0 0 0.5)	unsuitable
(0 0.5 1)	middle	(0 0.5 1)	medium	(0 0.5 1)	middle	(0.5 1 1)	suitable
(0.5 1 1)	good	(0.5 1 1)	high	(0.5 1 1)	good		

At the first step in Fuzzy Delphi Method, the first round of Fuzzy Delphi Method runs smoothly; furthermore, the average of the results has been computed according to step 2 of Fuzzy Delphi Method. Then in step 3, the output of the last step has been dispatched to the experts. The new scores of the 81 rules have been collected. Likewise, the Fuzzy Delphi Method has been run for three rounds.In the third round, from the total 81 rules, 37 ones were selected since the experts believed that the rules with high degree are higher than 7.5.The threshold point for rule selectionin terms of its importance should be considered in rule base of fuzzy expert system for estate recommendation. The rule base of designed fuzzy expert system for estate recommendation in real estate is illustrated in Figure 3.The sensitive analysis can be done in the rule base to extract the relationship among the effective parameters in estate recommendation at real estate.

4.3. Fuzzification

Fuzzification simply refers to the process of taking a crisp input value and transforming it into the degree required by the terms. Given the uncertainty arises; because of imprecision, ambiguity, or vagueness, the variable is probably fuzzy and can be represented by a membership function. If the inputs generally originate from a piece of hardware, or drive from sensor measurement, then these crisp numerical inputs could be fuzzified in order to be used in a fuzzy inference system [16]. Since inputs data are handled manually, singleton fuzzification method has been used to take benefit from its simplicity and speed of calculations in fuzzy expert system.

Defined linguistic variables of factors have been illustrated in Table 1, in which fuzzification inputs are in trapezoidal fuzzy numbers rangesfrom 0 to100. Region input variable in fuzzy expert system is illustrated in Figure4.

4.4. Fuzzy Inference Engine

Fuzzy inference is guided by the fuzzy rules. The standard max– min inference algorithm was used in the fuzzy inference process, as it is a commonly used fuzzy inference strategy [14]. The max–min composition applied to two association a(h, l)andb(l, b) defined in terms of Cartesian products H×L and L×Wyields a new association c defined in terms of the product space H×W. The new association, which is also a fuzzy set, is expressed by:

$c = \bigcup_{H\times w} v_1\,[\mu_a(h,l) \wedge \mu_b(l,w)]/(h,w),\ h \in H, l \in L, w \in W,$(1)

Symbols ∨ and ∧ denote min and max operators, respectively.It should be noted that singleton in Eq. (1) indicates the membership function of the new association produced by max-min composition.

$\mu_c(h,w) = v_1[\mu_a(h,l) \wedge \mu_b(l,w)],\ h \in H, l \in L, w \in W,$ (2)

In the max–min composition, the min operator is used for the ANDconjunction (set intersection) and the max operator is used for theOR disjunction (set union) in order to evaluate the grade of

membership in the antecedent clause of each rule. Mamdani inferenceis used as Eq. (3):

$\mu_B = \max_{i=1}[\sup \min(\mu_A(x), \mu_A(x_1)_{x\subset U}, \ldots, \mu_A(x_n), \mu_B(y)]$.(3)

4.5. Defuzzification

The process of computing a single number, which represents the best outcome of the fuzzy set evaluation, is called defuzzification[14]. There are several methods that can be used for defuzzification, including the methods of maximum orthe average height methods and others. The methods tend to jump erratically on widely non-contiguous and non-monotonic input values [3]. The researchers chose the centroid method, referred tothe center-of-gravity (COG) method, which isfrequently used to provide a consistent and well-balanced approach [9].

For each output using this defuzzification method illustrated in Eq. (4), the resultant fuzzy sets are merged into a final aggregate shape.Consequently, the centroid of the aggregate shape computed.

$$x' = \frac{\int \mu(x)xdx}{\int \mu(x)xdx} \qquad (4)$$

4.6. Comparison of the Overall Rating for all Estate

Due to the risk of each customer at real estate, a portfolio of estate has been constructed. Parameters of this assignment have been obtained through the questionnaires of critical factors determination.

5. IMPLEMENTATION AND EVALUATION OF THE SYSTEM

A prototype system is designed by use of MATLAB software. The procedure of building a prototype system has been widely used in software engineering research[15] because basic inherent problems emerge at an early stage can be addressed promptly. In addition, new concepts of user interface design can be evaluated assisting developersto gain insights into the application area and into the users' work tasks and the problems they face [14]. Once the prototype system is built, testing and evaluation of the prototype system can be performed. The designed system was tested for 10 estates in real estate and 10 customers. The mean and variance of the ranking outputs aredefuzzified through fuzzy expert system.

Comparison of outcome with the decision of agents shows that the system works properly and can be used instead of the expert of real estate who recommendcustomers estate. Evaluation is achieved through interviews with the experts

and users. We particularly asked the potential users about the effectiveness and the usability of the prototype system. Also, the researchersdemonstratedthe strength and weakness of the prototype system and feasibility of improvement. From 20 interviews, 18 agreed that the proposed expert system is seen to be a promising system for supporting the stock portfolio recommendation, which is based on the positive results of its evaluation, and three of them needed more time for more careful evaluations.

6. CONCLUSION

This paper described a new method for design of fuzzy expert system for Real Estate recommendation. Four critical parameters for Real Estate recommendation have been considered, which are obtained through distribution of questionnaires among experts of real estate concerningprice, region, plan, facilities. Comparing the system with the conventional one, the designed system in this article reveals that it is much less time consuming. Thus, the need to have different transaction committee meetings for decision making is omitted. The opinions of experts have been obtained through utilizing Fuzzy Delphi Method leading to congruent and consistent mindsetin the huge uncertainty. Performance evaluation has been done in a case study at real estate in Tehran. The results of the prototype evaluation are satisfactory and support the view that the system has performed its functions as expected. The feedback and comments collected from respondents have been used to make necessary adjustments to satisfy potential users' needs.

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