A Comparison of Grading Models for Neighborhood Level of Family Hausing Units

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Abstract: More recently Turkey has witnessed fast housing development and real estate sector growth because of the mortgage preparations. With this development, property location quality has been considered important for selecting and paying them. This study uses a data set of new single family housing units in Kocaeli University Campus Area. By using 4 location quality criteria, 27 single family housing units are graded at the neighborhood level. It is aimed to examine the applications of grading property at the neighborhood level based on property location quality by testing with three methods. Traditional method and fuzzy logic method were discussed in our antecedent studies. In this study, an easy used numerical calculation method; Neural Networks (NN), is introduced. Its grading performance is compared with the previous methods. NN method is found to be more accurate and realistic than traditional grading approach where its designing stage is more practical and faster than fuzzy logic approach.

Keyword: *Neighborhood, property location quality, fuzzy logic, neural networks.*

1. Introduction

Following the financial crisis in 2001, the Turkish economy went through a recession period which lasted until the end of 2003. During this period, the residential demand suffered significantly, just like demand in many other sectors. The economy started to recover in 2004, accompanied by decreases in interest rates and a serious decrease in inflation. The economic recovery made a positive impact on real estate demand and the planned mortgage system, which is being organized by the government, will also provide many opportunities in the residential real estate market.

The major Marmara earthquake in 1999 had a number of effect on the characteristics of residential demand in Marmara Region. The urban residential demand was affected because the earthquake encouraged many of the residents of older buildings to search for newer building which comply with the earthquake safety regulations. The earthquake also had an important effect on suburban residential demand. Most of the suburban settlement models consist of 2-4 storey town house or villa type buildings, which are known to be more resistant to earthquake risks and which are a successful investment model with good construction quality and creative concepts located in technically and socially well developed areas. In 2004, the prices for new suburban villa and town house projects varied between large ranges.

There is evidence indicating that both internal physical and external environmental characteristics impact on real estate prices. Among the most common physical attributes are the number rooms, the number of bathrooms, the construction quality, the condition of the building and whether parking facilities are available. Environmental parameters refer to the quality of the neighborhood and the quality of the location within the neighborhood is commonly measured by ordinal variables (Din, A., Hoesli, M., Bender, A., 2001).

The aim of this paper is to test the applications of grading property at the neighborhood level based on the quality of the location within the neighborhood. One of the applications is the traditional method that most popular used in Turkey. And the other is fuzzy logic method that we suggested to use because of its way to understand system behavior by allowing us to interpolate approximately between observed input and output situations.

The research by Clarke & Gaydos, 1998 ; White & Engelen, 1993,1997 proposed urban development as a binary process of non-urban to urban conversion conducted under the paradigm of crisp set theory. Wu (1996, 1998a) developed models of urban development using fuzzy-logic-control for determining the urban transition rules, he determined the state of cells under the crisp set theory as non-urban or urban. Herbert & Thomas, 1997; Jakobson & Prakash, 1971 are resembled the process of urban development as a fuzzy process both spatially and temporally. Spatially, there is no sharp boundary between an urban built-up area, urban-rural fringe and non-urban rural land. Temporally, urban development is a continuous process, which follows the general trend of a logistic curve (Liu, Y., Phinn, S., R., 2003).

This paper provides understanding fuzzy logic grading approach at the neighborhood level base on property location quality that is more accurate and realistic than traditional method.

We wish to answer two basic questions:

1) Is there any sharp boundary between far and close, sufficient and insufficient, dominant and not dominant in property location quality criteria?

2) Are rational differences between traditional and fuzzy logic methods in application of grading property at the neighborhood level based on property location quality?

This paper is organized in the following way. Section 2 is mentioned definition of the traditional method that is widely used in Turkey and the fuzzy logic method. Section three describes the case area, database, the methodologies used and results. This section is followed by the conclusion.

2. Methods

2.1. Previous Methods: In the previous study, traditional and fuzzy logic methods had been used and compared to describe the quality of property location [1]. In the traditional way, extensive research has been conducted to substitute qualitative evaluation methods

by quantitative decision support systems. In such a framework, some qualitative variables may be replaced (Bordogna, G., Chiesa, S., Geneletti, D., 2006).
The traditional method is widely used in the grading of property location quality at the neighborhood level in Turkey. The traditional method offers a simple methodology for grading by classifying appropriate weighted environmental criteria.

On the other hand applications of fuzzy logic theory became a practical instrument in the solution of today's complex problems. Fuzzy logic has come a long way since it was first subjected to technical scrutiny in 1965, when Dr. Lotfi Zadeh published his seminal work "Fuzzy sets" in the journal *Information and Control*. Since that time, the subject has been the focus of many independent research investigations by mathematicians, scientists, and engineers from all around the world. Fuzzy systems can implement crisp inputs and outputs, and in this case produce a nonlinear functional mapping just as do algorithms. While fuzzy systems can focus on modeling problems characterized by imprecise or ambiguous information, the result found more realistic.

In the previous study [1] it has been observed that the traditional method has deficiency result in the abrupt changes in borderline cases. The change is because of having the same value for a wide range in traditional method. That rough evaluation possibly would cause misevaluation of location quality. Since fuzzy logic method take whole effects into consideration, in details, more sensitive, exact and realistic results are obtained. The study was a proof of the fuzzy methods performance.

Since fuzzy rules are depend on experiences and decision making of an expert, a perfect relation between the inputs values and the scores could not be determined unless a professional support is provided.

2.2. Neural Networks (NN) Method: Neural networks are another modeling method, which could establish a mapping through the numerical inputs and outputs. This will utilize to extract a similiar sensitive, exact and realistic relation from input-output data of the present traditional method. Neural networks can interpolate a realistic value from numerical input-output training data, without considering necessity of a linguistic input-output relation. If the NN supports the results of the Fuzzy Grading Model [1], it would serve as a more basically established, easy used, but realistic model.

3. Case Study

3.1. Definition of Case Area

Kocaeli City is located in Marmara Region. It is 97,345 km far from Istanbul and Ankara respectively. The city has a 1.206.085 Population (2000) and ranks first in industry in Marmara region. But, 60% of tax added value is diverted out of the city. Foreign and private capital establishments beginning with liberal economic implications diverted their attention to the region for location because of its proper infrastructure, the implications of government in national industrialization.
Despite industrial development inadequate service development, inequilibrium in sectors due to not supporting agricultural production brought about decrease in life standart and

city status. That is because lost in life and property is high in August 17th Kocaeli Earthquake. For the purpose of this study, a data set of new single-family housing units in Kocaeli University Campus Area is used.

Kocaeli University is established in 1992. Today, it has 10 faculties, 12 vocationals, 3 institutes, university hospital and various research and implication centers. Before the Earthquake of August 17th, Kocaeli University had approximately 20 000 students, 1150 staff and a campus of 650 000 sq per m. After 17th earthquake, most of the buildings of Kocaeli University destroyed and the rest were not suitable for use.

Kocaeli University needed to define a new and rapid physical reconstruction. Due to investigations, there is a trend to the north of the city in selection of new resident areas. Because of this Kocaeli University new campus area as named "Umuttepe Center Campus" was selected 5-7 kilometres north of present Kocaeli settlements. Today university hospital, administrative center, library, conference center, 7 faculty buildings, social buildings, dormitories and residences locate in campus area (Mert, Z., G, Mert, E., 2000).

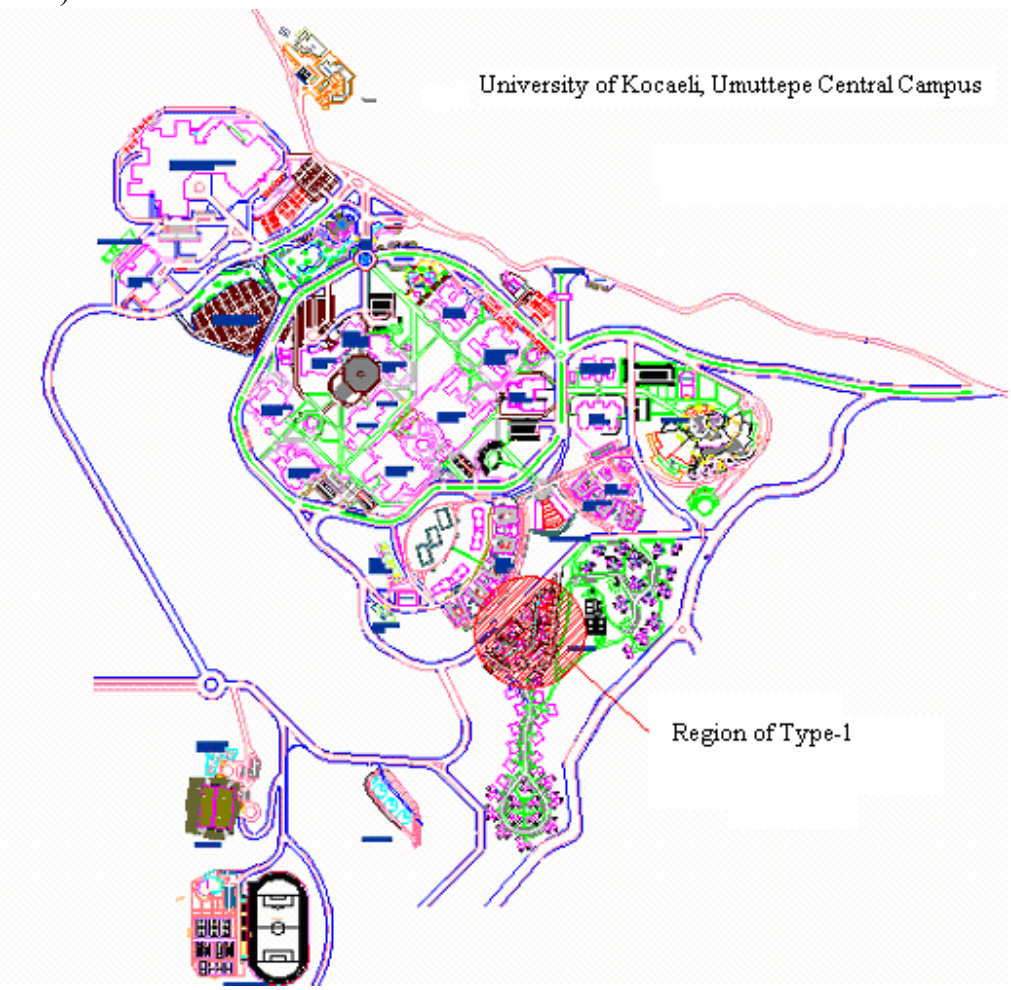


Figure 3.1. The Location Plan of Residence Area in Kocaeli University Umuttepe Center Campus

Residence area locates southeast of first stage location area of Kocaeli University Umuttepe Center Campus area (Figure 3.1.). There are 224 units by 5 different types in 80 000 sq per m. area. This study uses the data set of 27 new single-family housing units as named "Type 1". This type of building is 164 sq per m and dublex apartment. Their location area is 14 681 sq per m and surrounded by roads. There are recreations areas east and dominant view south of the location. Internal physical characteristics are similar but external environmental characteristics differ by location.
In this study, we use 4 quality criteria as listed in Table 3.1.

Table 3.1.Definitions of Criteria

Criteria	**Definitions**
Distance to recreation areas	Distance to sportive activities, children play area, open areas.
Size of around area	Size of using area around the house
Quality of view	General unobstructed view to surroundings
Distance to car road	Distance to stop for car

In this study, the weight of each criterion is found by expert experiences. The classification is done in terms of discrete categories, 3-5 for each criterion, which translate directly into quality notes for every location of property.
According to the environmental criteria are defined above, we examine the applications of grading property at the neighborhood level based on property location quality by testing traditional method and fuzzy logic method.

3.2. Applications

3.2.1. Traditional Grading Model: In the traditional grading model, the individual four values are not used directly as input parameters. The values lie in the interval defined for each criterion by expert experiences.
The scores for each criterion that defined in this study are seen as below (Table 3.2., 3.3., 3.4., 3.5.);

Table 3.2. Scores of the Distance to Recreation Areas by Intervals

Distance to Recreation Areas (DtRA)	
Distance(by step)	Score
0-100	20
101-200	16
201-300	12
301-400	8
401-500	4

Table 3.3. Scores of the Size of Around Area by Intervals

Size of Around Area (SoAA)	
Area(m^2)	Score
201 m^2 <	20
151 m^2 – 200 m^2	15
101 m^2 – 150 m^2	10
51 m^2 – 100 m^2	5

<50 m^2	0

Table 3.4. Scores of the Quality of View by Intervals

Quality of View (QoV)			
	Terrace	Bedroom s Terrace	Total Score
91%-100%	5	2	7
51%-90%	4	1	5
11%-50%	2	1	3
0%-10%	0	0	0

Table 3.5. Scores of the Distance to Car Road by Intervals

Distance to Car Road (DtCR)	
Distance(by step)	Score
0-30	3
31-60	2
61-100	1

Each property is measured and evaluated on location plan and/or on their place by the criteria that means above. Tables will be basis to creation of NN training set.

As shown in the scoring Tables 3.2 to 3.5, traditional method is a function that transfers and rounds an interval of definition set (input) to a unique scalar value (output). This means, two cases which have DtRA values of 0 step and 100 steps have the same scores. This is not equitable. This situation could be eliminate by a continuous and different score value assignment to each input value. This will provide us more realistic and special score assignment for each situations.

3.2.2. Fuzzy Grading Model: In the fuzzy grading model, individual four values are used as input parameters. A fuzzy inference system, called fuzzy grading system, FGS, processed the inputs and related score of the grading. The model is developed by an object oriented simulation program. Details are referred to antecedent study [1] to avoid duplications.

3.2.3. Neural Grading Model: In this study, NN is used as a input-output fitter which predicts the relation surface between iputs and output, by means of calculating the interpolation coefficients, called weights. These weights constitute a parameter matrix that maps an equation vector, say outputs to a state vector, and say inputs (Fig.A)

Type of the used network is feedforward. Back propagation algorithm, which uses the gradient descent method for updating the network parameters, is carried out the training process of the network (Bose&Liang, 1996). The network has 4 inputs called DtRA, SoAA, QoV, DtCR. Output of the network is Score.

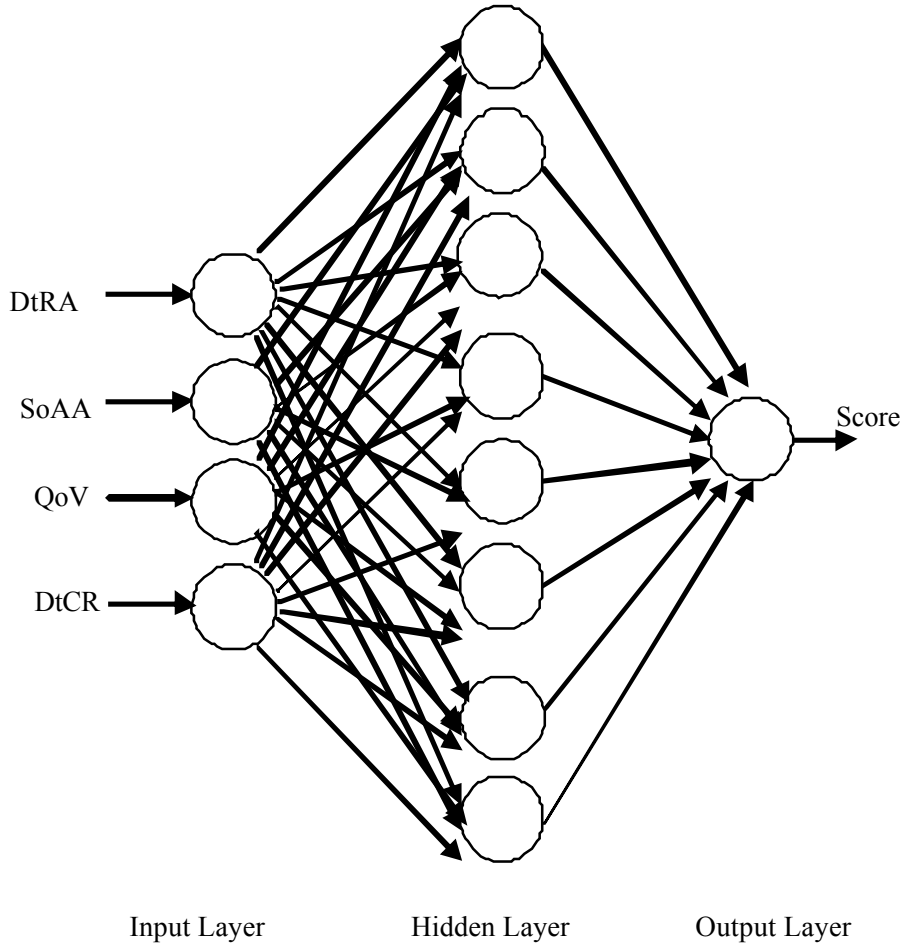


Fig.A. Structure of the Feedforward Neural Network used for Grading the Property Location Quality

The Input Layer Neurons transfer the inputs as a buffer, to their outputs without any change. Parameters of the network are given in Table.1.

Table.1. Structure of the NN Grading Model

Number of Hidden Layers	1
Number of Neurons in the 1st Hidden Layer (H.L)	8
Type of the Transfer Functions in the H.L. Number of Neurons in the Output Layer (O.L.)	Logaritmic sigmoid 1
Type of the Transfer Functions in the O.L.	Linear
Maximum Epochs	80 000 iterations
Goal of NN's Maximum RMS Error Tolerance	$1*10^{-6}$
Reached RMS Error Value After the Training	$1.30697*10^{-5}$

Input and output array of the training data is prepared from traditional data in this way: Inputs are consists of the midpoints of the traditional methods input data given in Tables 3.2 to 3.5 where output data is total score obtained from addition of corresponding scores to these midpoint inputs. A representative example for creation of the parameter DtRA is given in Table.2.

Table 3.2. Scores of the Distance to Recreation Areas by Intervals

Distance to Recreation Areas (DtRA)	
Distance(by step)	Score of DtrA which will be directly added to the Total Score
50 (midpoint of 0-100)	20
150 (midpoint of 101-200)	16
250 (midpoint of 201-300)	12
350 (midpoint of 301-400)	8
450 (midpoint of 401-500)	4

These scores will be directly added to the Total Score.

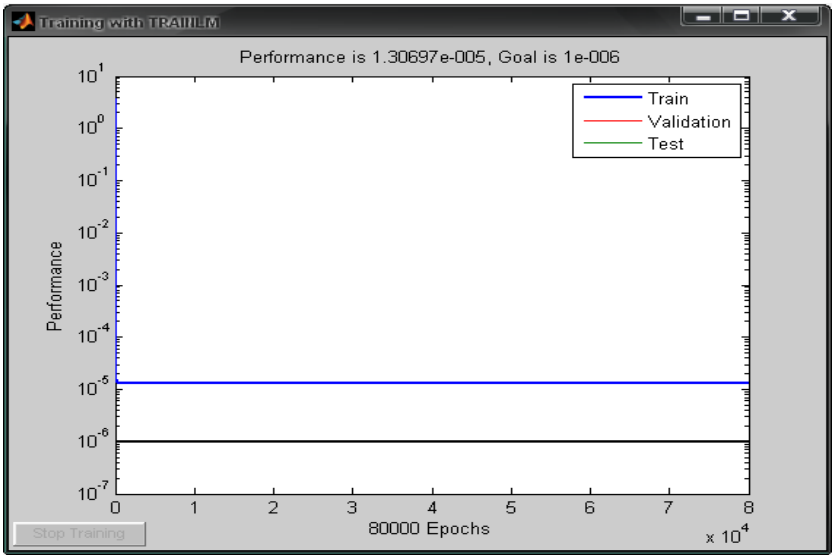
As an example, first 8 training inputs-output couples of the 420, are given in Table.X

Training Data

DtRA	50	50	50	50	50	50	50	50	…..	……
SoAA	500	500	500	500	500	500	500	500	…..	……
QoV	95	95	95	70	70	70	30	30	……	…….
DtCR	15	45	80	15	45	80	15	45	……	…….
Total Score	50	49	48	48	47	46	46	45	…….	……..

The data which will be tested are directly given in Table.3.10

Training performance of The Neural Network used in Grading
Performance of the Neural Network due to RMS Cost Function is given in Figure.



Program is written in Matlab programming language.

Relation Surfaces:
Changes of Score due to current DtRA and SoAA is shown in Fig.X

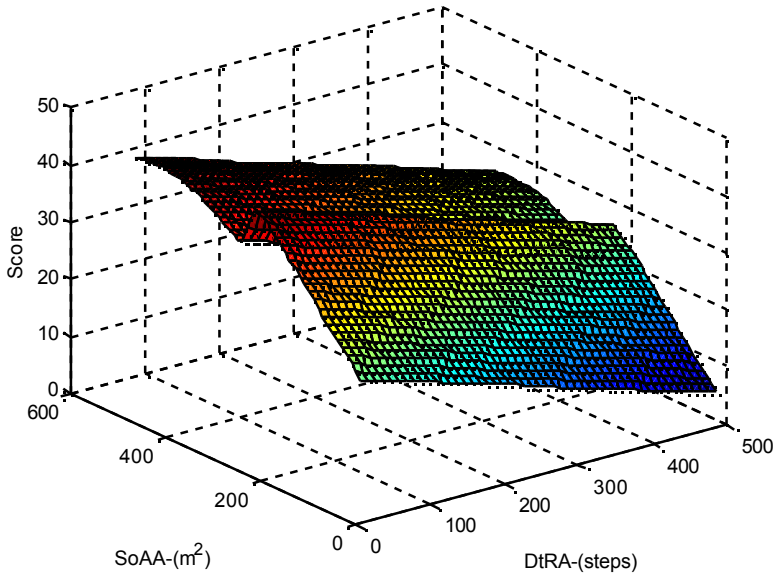


Figure. X. The relation surface of Score due to SoAA and DtRA

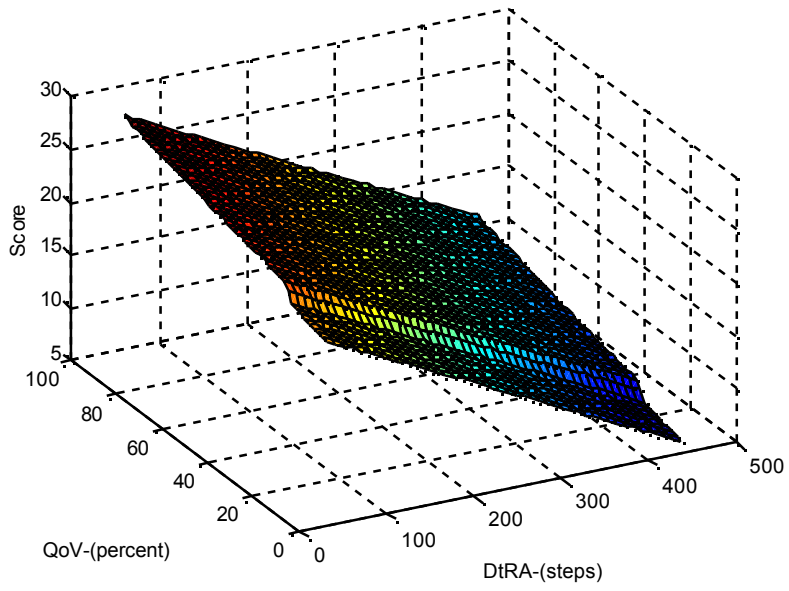


Figure.Y. The relation surface of Score due to QoV and DtRA

As seen from the Figure.Z, DtRA is zero. Thus, DtRA ≤ 50 m automatically creates 20p and score starts from a 20p offset, similarly where SoAA is zero ($\leq 25 m^2$) and so creates zero point.

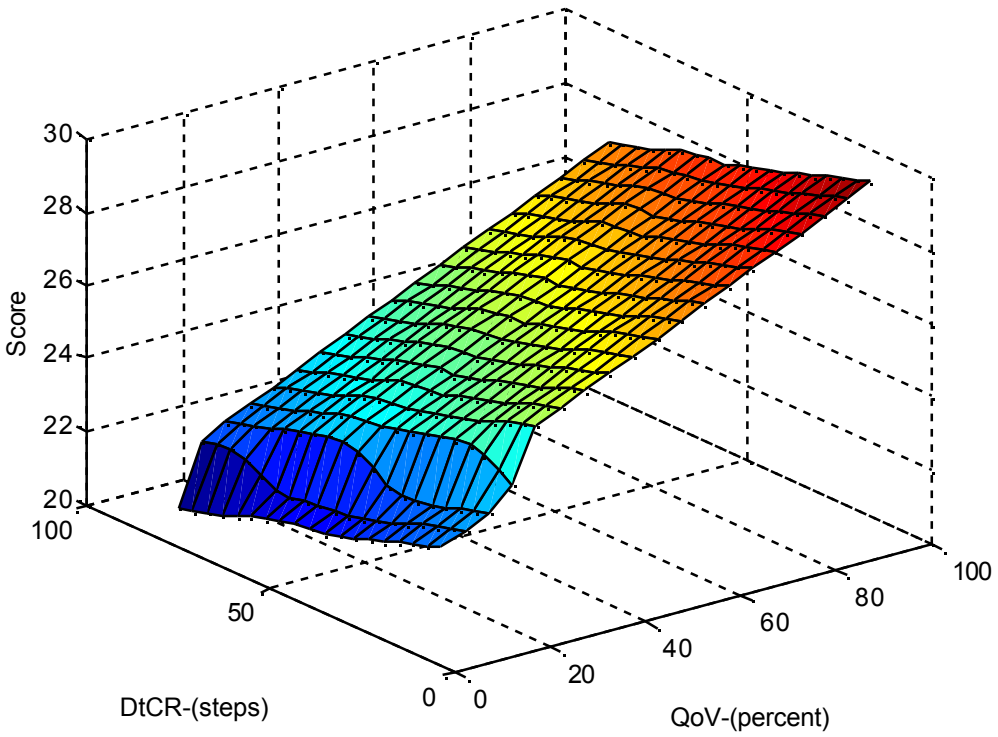


Figure. Z. The relation surface of Score due to DtCR and QoV when (DtRA=0; SoAA=0)

3.3. Results and Discussion

Table 3.10. includes the total scores of each property by using the tree methods.
For example, the case Type 1.1-B is graded as 23 rating in the traditional method whereas 19.7 rating in the fuzzy logic method, and 21.73 rating in the NN method. Because of the rounding property of traditional method, one has to pay a higher price on account of a rougher valuation.

On the other hand, the case Type 1-7.B is graded as 32 rating in the traditional method whereas 36.3 rating in the fuzzy logic method and 33,3 rating in the NN one . In this case one pays a lower price in traditional method. In this way the difference of ratings between traditional method and the other methods may reaches up to 4.3 units.

Table 3.10: The Comparison of the Traditional Method and Fuzzy Logic Method Total Scores for Each Property

Case Number	Property Name	DtRA	SoAA	QoV	DtR	TOTAL SCORE		
		Step	m^2	%	Step	Traditional Method Score	Fuzzy Logic Method Score [1]	NN Method Score
1	Type1-1.A	322	109,57	90	43	25	26.1	26,12624
2	Type 1-1.B	322	101,69	30	43	23	19.7	21,73124
3	Type 1-2.A	291	49,98	30	44	17	17.7	17,73788
4	Type 1-2.B	291	173,34	80	44	34	33.5	33,08995
5	Type 1-3.A	419	276,07	30	19	30	29.1	24,90753
6	Type 1-3.B	419	93,80	70	19	17	19.5	20,27197
7	Type 1-3.C	419	118,74	10	19	17	17.4	17,76365
8	Type 1-4.A	426	144,32	10	19	17	21	20,0543
9	Type 1-4.B	426	103,75	10	19	17	16	15,96501
10	Type 1-4.C	426	121,67	10	19	17	17.8	17,77942
11	Type 1-5.A	374	294,11	30	77	32	33.1	25,80023
12	Type 1-5.B	374	129,04	20	77	22	20.6	20,85803
13	Type 1-5.C	374	143,27	20	77	22	22.1	22,28493
14	Type 1-6.A	309	115,77	10	57	20	22.1	20,90091
15	Type 1-6.B	309	105,59	85	57	25	25.3	25,68194
16	Type 1-6.C	309	125,43	30	57	23	24	24,39453
17	Type 1-7.A	349	143,34	90	48	25	29.2	28,28908
18	Type 1-7.B	349	188,53	100	48	**32**	**36.3**	33,29609
19	Type 1-7.C	349	219,31	100	48	37	38.8	36,12494
20	Type 1-8.A	429	194,39	60	19	27	29.7	29,23208
21	Type 1-8.B	429	208,46	100	19	34	33.1	32,94623
22	Type 1-10.A	386	161,75	10	75	24	22.3	22,99546
23	Type 1-10.B	386	252,31	90	75	34	35.4	33,75526
24	Type 1-10.C	386	150,89	90	75	29	28.8	26,86274
25	Type 1-11.A	417	165,50	40	43	24	22.9	24,91467
26	Type 1-11.B	417	185,43	40	43	24	27	26,83836
27	Type 1-11.C	417	180,62	20	43	24	25	25,19282

Traditional method has deficiency result in the abrupt changes in borderline cases. For example, considering the intervals in Table.3, scores of the "Size of around Area" are 5 and 10 for 100 m^2 and for 101 m^2, respectively. This causes to 5 units deviation for 1 m^2. In our cases Type 1-1.B and Type 1-3.B, which are 101, 69 m^2 and 93.80 m^2, respectively, could be given as examples for this situation. In this way, Type 1-3.B is evaluated in the same category as a case which is 51 m^2. This rough grading causes misevaluation of location quality. Graphical representation for score assignment of the 27 cases due to the tree models is illustrated in Figure.Z

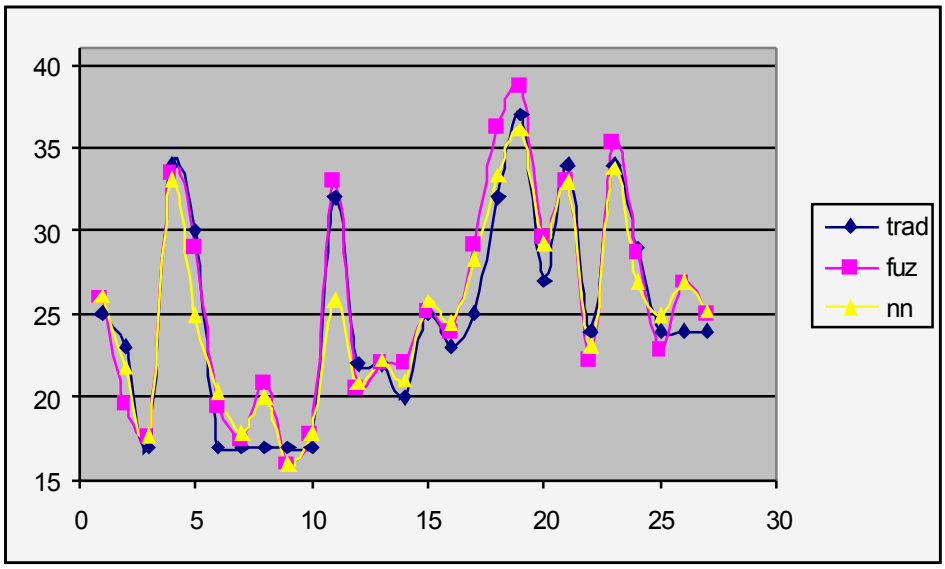


Figure.Z. Graphical illustration of the Comparison Results

4. Conclusion

In this study we examine the applications of grading property at the neighborhood level based on property location quality by testing traditional, fuzzy logic and NN methods.

It is observed that the traditional method has deficiency result in the abrupt changes in borderline cases. This change is because of having the same value for a wide range in traditional method. This rough evaluation possibly will cause misevaluation of location quality. Thus, significant differences are observed between traditional and rival methods in application of grading property at the neighborhood level.

Fuzzy and NN methods take whole effects into consideration. They use continuous and different score value assignment to each input value. This will provide us more realistic and special score assignment for each situations.

Constitution of linguistic rules due to our past experiences, assignment- adjustment of linguistic membership functions and reorganizing them to new conditions are cumbersome in fuzzy logic method. NN use numerical values and adjust the input-output relation automatically in a short time. These make it the most practical method due to the two other methods.

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