International Journal of Mathematics and Physical Sciences Research ISSN 2348-5736 (Online)
Vol. 2, Issue 1, pp: (21-26), Month: April 2014 - September 2014, Available at: www.researchpublish.com

Fuzzy Systems and Its Applications

J. Jerlin Femi[1], R. Vaithiyalingam[2]

Research scholar, PRIST University, Puducherry,
Assistant Professor in Mathematics, PRIST University, Puducherry.

Abstract: **This problem describes model of dwelling selection, using fuzzy matrix theory. Two types of buildings are under consideration: traditional single flat dwelling house and loft flat dwelling house. Four alternatives of cooling system are taking into account; fan based cooling, air cooler based cooling, windows AC based and split AC based systems. Alternatives are described by criteria set. Values of the criteria are determined by simulation and according to the statistic. Fuzzy matrix games theory applied for decision aiding. The problem solution result shows that fuzzy matrix games theory is appropriate for such purpose.**

Keywords: **Dwelling – a place where people live, MCDM – Multi Criteria Decision Making, Flat – a set of rooms on one floor of a building as a residence, Loft – an upper room for storing things, AC – Air Conditioner.**

I. INTRODUCTION

Decision making in real life is selection process among feasible alternatives, taking into account several criteria. Various decision making approaches have been proposed to tackle the problem. The multi-criteria decision aid (MCDA) has been one of the very fast growing areas of operation research during the last decade. The MCDA often deals with ranking of alternatives from the best to worst ones based on multiple criteria. Traditional optimization, statistical and econometric analysis approaches used within the engineering context are often based on the assumption that the considered problem is well formulated and decision-makers usually consider the existence of a single objective, evaluation criterion or point of view that underlies the conducted analysis. Since the suitability of a dwelling-house for living depends on a number of attributes, like temperature, noise isolation, annual heat requirements, etc., a multi-attribute decision making (MADM) method are used for their assessment. Multi-criteria classification problem have gained significant interest among researchers working on MCDA. The criteria are often qualitative and conflicting. A decision should be made by taking relevant opinions from the experts because inherent complexity and uncertainty in a business environment necessitate the participation of many experts in the decision making process.

In contemporary management, the performance is evaluated against multiple criteria rather than considering a single factor-cost. In decision-making involving multiple criteria, the basic problem stated analysts and decision-makers concerns the way by which the final decision should be made. Multi-criteria decision making (MCDM) is not a perspective answer but a transparent and informative decision process which helps to uncover how people's intuitive decision procedures can be informed by a structured rational analytic process. MCDM is concerned with the ranking of decision alternatives based on preference judgments made on decision alternatives over a number of criteria.

Fuzzy theory has been regarded as a very important technique for quality management of distributed manufacturing system and attracts the attention of academic and industry. There are some modern works with fuzzy sets multi-criteria decision making all the proposed works use fuzzy multi-criteria decision making methods in different areas; domestic energy, renewable energy selection, invasive species management, selection of site, selection of the forestation areas and in the industrial co operation program transaction strategies. In this work the fuzzy set theory is used to help the customer in selection the living apartment and also to select the better selection for engineer to construct the pipe line for the water supplying system in the city.

II. CASE STUDY

One flat dwelling house and loft type apartment were selected for investigation. All the values are determined by simulation, according to the prices of the market. There are alternatives with four types of cooling system;

- Fan based cooling system,
- Air cooler based cooling system,
- Window AC based cooling system,
- Split AC based cooling system.

Alternative are described as follows;
A_1 – One flat dwelling house with fan based cooling,
A_2 – One flat dwelling house with air cooler based cooling,
A_3 – One flat dwelling house with Window AC based cooling,
A_4 – One flat dwelling house with split AC based cooling,
A_5 – loft flat dwelling house with fan based cooling,
A_6 – loft flat dwelling house with air cooler based cooling,
A_7 – loft flat dwelling house with window AC based cooling,
A_8 – loft flat dwelling house with split AC based cooling,

Ten criteria, of each alternative, which describes apartment's life cycle, were selected for decision making. They are,

x_1 – material, used for construction process,
x_2 – energy, used for construction process,
x_3 – water, used for construction process,
x_4 – energy use for 50 years operation phase,
x_5 – enclosures with cool losses,
x_6 – CO_2 use for 50 year operation phase,
x_7 – price of the apartment,
x_8 – labor costs,
x_9 –electricity annual price,
x_{10} –price of energy use for 50 year operation phase,

III. PROBLEM

Initial decision making matrix with 8 alternatives and 10 criteria is presented in table I.

TABLE I

Criteria	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}
A_i	Min	min	Min	Min	min	Min	min	Min	Min	Min
A_1	1.6	31.5	51.4	7969.0	308.0	2966.0	869.6	1005.0	800.6	3586.1
A_2	2.1	41.3	67.4	7054.0	308.0	1522.0	886.9	1012.0	317.1	3174.3
A_3	1.8	35.4	57.8	8843.0	308.0	314.0	897.4	1010.0	211.4	3979.4
A_4	2.3	45.3	73.8	7317.0	308.0	257.0	932.2	1004.0	268.2	3292.4
A_5	1.5	27.1	41.7	5903.0	362.5	2194.0	724.6	1220.0	800.6	2656.4
A_6	1.9	35.5	54.5	5149.0	362.5	1112.0	739.1	1229.0	317.1	2452.1
A_7	1.7	30.5	46.9	6408.0	362.5	228.0	747.8	1209.0	211.4	2883.6
A_8	2.2	39.1	60.0	5586.0	362.5	196.0	776.8	1202.0	268.2	2513.7

Table –II shows the inner impact factors of the decision making matrix. These criteria selected as the factors, which impact only the inner factors of the construction process ($x_1 - x_5$ criteria).

TABLE II: INNER IMPACT FACTORS

A_i	x_1	x_2	x_3	x_4	x_5
A_1	1.6	31.5	51.4	7969.0	308.0
A_2	2.1	41.3	67.4	7054.0	308
A_3	1.8	35.4	57.8	8843.0	308
A_4	2.3	45.3	73.8	7317.0	308
A_5	1.5	27.1	41.7	5903.0	362.5
A_6	1.9	35.5	54.5	5149.0	362.5
A_7	1.7	30.5	46.9	6408.0	362.5
A_8	2.2	39.1	60.0	5586.0	362.5
a_0	1.5	27.1	41.7	5149.0	308.0
a_d	1.9	36.2	57.7	6996.0	335.3
a_m	2.3	45.3	73.8	8843.0	362.5

Table –III shows the outer impact factors, which impact on the construction process or the construction process impact on the environment ($x_6 - x_{10}$ criteria). Value of each criterion is described by three values: a_0 – is the lowest value of the j-th criteria, a_m – is the highest value of the j-th criterion, a_d – is the average between a_0 and a_m values.

TABLE III: OUTER IMPACT FACTORS

A_i	x_6	x_7	x_8	x_9	x_{10}
A_1	2966.0	869.6	1005.0	800.6	3586.1
A_2	1522.0	886.9	1012.0	317.1	3174.3
A_3	314.0	897.4	1010.0	211.4	3979.4
A_4	257.0	932.2	1004.0	268.2	3292.4
A_5	2194.0	724.6	1220.0	800.6	2656.4
A_6	1112.0	739.1	1229.0	317.1	2452.1
A_7	228.0	747.8	1209.0	211.4	2883.6
A_8	196.0	776.8	1202.0	268.2	2513.7
a_0	196.0	724.6	1004.0	211.4	2452.1
a_d	1581.0	828.4	1116.5	505.9	3215.7
a_m	2966.0	932.2	1229.0	800.6	3979.4

IV. RESULTS AND DISCUSSION

Coefficients A, …., H are calculated for inner impact factors in table – IV for outer impact factor in table – V. They are calculated according on the equations (4 - 6).

Dependency values of the inner impact factors are presented in the table – VI, according on the methodology, which is presented in table –I. Dependency values for the outer impact factors are presented in the table – VII, according on the methodology, which is presented in table – II. In table – IX is shown final fuzzy decision making matrix, according on the methodology, which is presented in table –III and table – IV.

TABLE IV: INNER IMPACT FACTOR'S A, B, C, D, E, F,G, H VALUES

	x_1	x_2	x_3	x_4	x_5
A	-4.216599152	-0.00033553	-6.0011E-05	-3.99192E-11	-1.23568E-05
B	24.15947678	0.036436025	0.010395047	8.36929E-07	0.012427797
C	-44.21871738	-1.236167373	-0.553586156	-0.005443661	-4.138862525

D	26.20228189	13.41905768	9.360210363	11.28999679	456.8629208
E	-4.216599152	-0.00033553	-6.0011E-05	-3.99192E-11	-1.23568E-05
F	24.1627495	0.036437112	0.010393951	8.38718E-07	0.012428006
G	-44.23121916	-1.236246014	-0.553459588	-0.005468691	-4.139002405
H	26.21422109	13.42048101	9.356556553	11.3775504	456.8863681

TABLE V: OUTER IMPACT FACTOR'S A, B, C, D, E, F,G, H VALUES

	x_1	x_2	x_3	x_4	x_5
A	-9.40734E-11	-2.23701E-07	-1.75645E-07	-9.77283E-09	-5.61145E-10
B	4.46264E-07	0.000555957	0.000588309	1.48371E-05	5.41378E-06
C	-0.000164094	-0.453339934	-0.650165576	-0.00496235	-0.016427981
D	0.015727037	121.69385	237.5025178	0.478301473	16.00461744
E	-9.40734E-11	-2.23701E-07	-1.75645E-07	-9.77283E-09	-5.61145E-10
F	4.46116E-07	0.000555932	0.000588337	1.48318E-05	5.41306E-06
G	-0.000163624	-0.453297484	-0.650227906	-0.004956997	-0.01642336
H	0.015355336	121.676267	237.5373136	0.476947174	15.99718644

TABLE VI: DEPENDENCY VALUES OF THE INNER IMPACT FACTORS

A_i	x_1	x_2	x_3	x_4	x_5	μ_i
A_1	0.029	0.145	0.218	0.857	0.000	0.250
A_2	0.836	0.879	0.897	0.523	0.000	0.627
A_3	0.294	0.436	0.502	1.000	0.000	0.445
A_4	1.000	1.000	1.000	0.629	0.000	0.726
A_5	0.000	0.000	0.000	0.108	1.000	0.222
A_6	0.652	0.444	0.352	0.000	1.000	0.490
A_7	0.149	0.092	0.070	0.270	1.000	0.316
A_8	0.946	0.731	0.605	0.039	1.000	0.664

TABLE VII: DEPENDENCY VALUES OF THE OUTER IMPACT FACTORS

A_i	$x_6(\mu_{i1})$	$x_7(\mu_{i2})$	$x_8(\mu_{i3})$	$x_9(\mu_{i4})$	$x_{10}(\mu_{i5})$
A_1	1.000	0.782	0.000	1.000	0.835
A_2	0.468	0.878	0.004	0.085	0.459
A_3	0.005	0.925	0.002	0.000	1.000
A_4	0.001	1.000	0.000	0.026	0.575
A_5	0.810	0.000	0.995	1.000	0.049
A_6	0.256	0.014	1.000	0.085	0.000
A_7	0.000	0.035	0.977	0.000	0.194
A_8	0.000	0.158	0.960	0.026	0.005

TABLE VIII: FUZZY GAME DECISION MAKING MATRIX

$$\mu_{ij}^* = \min(\mu_i, \mu_{ij})$$

A_i	x_6	x_7	x_8	x_9	x_{10}
A_1	0.250	0.250	0.000	0.250	0.250
A_2	0.468	0.627	0.004	0.085	0.459
A_3	0.005	0.445	0.002	0.000	0.445
A_4	0.001	0.726	0.000	0.026	0.575
A_5	0.222	0.000	0.222	0.222	0.049
A_6	0.256	0.014	0.490	0.085	0.000

A_7	0.000	0.035	0.316	0.000	0.194
A_8	0.000	0.158	0.664	0.026	0.005

TABLE IX: GENERAL DECISION MAKING MATRIX

A_i	μ_i	x_6	x_7	x_8	x_9	x_{10}	minimax
A_1	0.250	0.250	0.250	0.000	0.250	0.250	0.000
A_2	0.627	0.468	0.627	0.004	0.085	0.459	0.004
A_3	0.445	0.005	0.445	0.002	0.000	0.445	0.000
A_4	0.726	0.001	0.726	0.000	0.026	0.575	0.000
A_5	0.222	0.222	0.000	0.222	0.222	0.049	0.000
A_6	0.490	0.256	0.014	0.490	0.085	0.000	0.000
A_7	0.316	0.000	0.035	0.316	0.000	0.194	0.000
A_8	0.664	0.000	0.158	0.664	0.026	0.005	0.000

As the calculation goes through a very long determination faze and is transformed with big algorithms, so the results are not so exact. And this case study shows only one suitable alternative – the best alternatives is A_2 (one flat dwelling house with air cooler based cooling system). This can be impacted of the closest values of the criteria to the average results of a_d value. As the fuzzy set theory calculations is according on the triangle diagram frame work, with three point, which in this case study are described as (a_0, a_d, a_m), in which the dependency values are $\mu(a_0) = 0$, $\mu(a_d) = 0.5$, $\mu(a_m) = 1$.

We are discussing about the conclusion to this problem in later. Now we are going to introduce the second problem that involves decision making in civil engineering to select the better alternative among the nine different set of alternatives.

V. CONCLUSION

Choosing apartment for living is multiple criteria problem. This case study shows the possibility to use the fuzzy set theory, combining with fuzzy games in decision making in choosing apartment for living. Also, the problems used combined technique's methodology to combine fuzzy sets and decision making. According to the fuzzy set theory general matrix is divided into two general decision making matrix of inner impact factors and outer impact factors.

Second part of the calculation is by the help of fuzzy games compose the general decision making matrix. Results are ranked according on the minimax principle. Determination process goes threw a long calculation and values are transformed with a big algorithms, so the results are not so exact. But it doesn't impact on the choosing right solution.

The fuzzy set theory is appropriate to use in difference areas, because of its possibility to be adapt in a lot of ways of decision making. But it is still not popular in decision making in civil engineering.

Therefore, for the above problem among the eight different alternatives the best alternatives is A_2 i.e. One flat dwelling house with air cooler based cooling system is one among the best. Because it is the most rational value. Hence a decision maker can choose A_2 for his comfortable living.

REFERENCES

[1] L.A.Zadeh: Fuzzy sets; information and control, No. 8, 1965, pp. 338 – 353.
[2] Brams, S.J: (1994). Game theory and literature; Games and Economics behavior, 6(1), 32 – 54.
[3] Robert J. Thierauf and Robert C. Klekamp: Decision making Through Operations Research, Second Edition.
[4] Panneerselvam. R: Operations Research.
[5] Bellmann,R.E. and Zadeh ,L.A. (1970). Decision making in a fuzzy environment. Management Science, 17, 141 -164.
[6] Hui E.C.M., Lau O.M.F.,: A fuzzy decision making approach for protofolio management with direct real estate investment, International Journal of Strategic property management, Vol. 13, No.2, 2009, pp. 191 – 2004.
[7] Anand J., Herath G.: A critical review of multi – criteria decision making methods with special references to forest management and planning, Ecological Economics, Vol. 68, No. 10, 2009, pp. 2535 – 2548.

[8] Leberling H.: On finding compromise solutions in multi – criteria problems using fuzzy min operator, Fuzzy sets and systems, No.6, 1981, pp. 105 – 108.
[9] Peldschus F., Zavadskas E.K.: Fuzzy matrix games multi – criteria model for decision making in engineering, Informatica, Vol. 16, No. 1, 2005, pp. 107 – 120.
[10] Peldschus F.: Experience of the game theory application in construction management, Technological and Economuc development of Economy, Vol. 14, No. 4, 2008, pp. 531 – 545.
[11] Albrycht, J., and M.Matloka (1985). On fuzzy multi – valued functions. Part – 2. Some topological properties. Fuzzy sets and systems, 15, 193 – 197.
[12] Zadeh L.A.: Fuzzy Algorithms, Information and control, No. 12, 1968, pp. 94 – 102.