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A Fuzzy Decision Making for Floatplane Evaluation and Selection

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ABSTRACT

This paper is aimed to present a fuzzy decision-making approach to deal with the floatplane selection and evaluation. For improving the efficiency and accuracy of decision-making, proposed method is thinned down the objective weight of decision-makers and subjective weight to criteria. Then an interactive decision-making flow is designed. Candidate floatplanes are ranked by Zohouri *et al* (2011) method, lastly.

Keywords: *Multiple Criteria Decision Making (FMCDM), Aircraft Selection and Evaluation (ASE).*

1. INTRODUCTION

In order to select the most suitable aircraft to perform the defined mission, combining the subjective judgment and the objective analysis to develop effective selection approaches is very critical. The intention of an aircraft selection and evaluation (ASE) process depends primarily on assessing the differences among applicants and predicting the potential performance. This process is essentially considered as a multiple criteria decision-making (MCDM) problem that is affected by different tangible and intangible criteria. To the best of our knowledge, considerable studies and researches have never been for ASE problem. In Multiple criteria decision making (MCDM) problems, decision makers often confront the problem of electing among alternatives that have disagree criterion. Since human judgments and preferences are often vague and complex, and decision makers cannot appraise their preferences with an exact scale, we can only give linguistic evaluations instead of exact evaluations**.**

Multiple criteria decision making was introduced as a favorable and important area of study in the early 1970'es. Since then the number of theories and models, which could be used as a basis for more methodical and reasoning decision making with multiple criteria, has continued to extend at a fixed rate. A number of reviews show the dynamism of the area and the throng of methods that have been extended (Bana and Vincle, 1990).

In recent years, whether the subject or objective weights which are computed in most researches are the general weights of decision-makers. Saaty (1980) makes the analytic hierarchy process (AHP) method using pair wise comparison. A corresponding pair wise comparison matrix is established. Criteria weights are obtained by combining various evaluations in a methodical manner. The uncertainty and imprecision of the weighting operation are indirectly modeled. Takeda (1998) further generalize this method to indicate the DM's uncertainty about the appraisals in the corresponding matrix. Laarhoven and Pedrycz (1983), Buckley (1985) extend this method to direct regard the uncertainty and imprecision of the pair wise comparison operation using fuzzy set theory. Some researchers think these methods may cause the rank reversal occurrence, and the computation involved can be absolutely complex and intricate when fuzzy numbers are used in the pair wise comparison operation. Therefore, Von Winterfeldt and Edwards (1986) propose a direct ranking and rating method. DMs first rank all criteria in the order of their weightiness, and then give each criterion an appraised numerical value to indicate its relative weightiness. Criteria weights are obtained by normalizing these appraised values. Mareschal (1988) and Fischer (1985) use a mathematical programming model with sensitivity analysis to assign the intervals of weights, inside which the identical ranking result is produced. This method gives DMs flexibility in assessing criteria weights and helps them better understand how criteria weights influence the decision consequence, thus lessening their cognitive burden in determining accurate weights. However, this operation may become boring and difficult to organize as the number of criteria increases. When Bellman and Zadeh (1965) , and a few years later Zimmermann (1996) , introduced fuzzy sets into the field, they cleared the way for a new kind of methods to deal with problems which had been impenetrable to and remote with standard MCDM techniques (Chang 1996) .

Associated rank of each alternative is a crucial step in MCDM. Now, several fuzzy set ranking methods are exist (Bortolan and Degam 1985, Prodanovic 2002). Due to complexity of the problem, attempts have been made to suggest a more acceptable approach for ranking of various alternatives in fuzzy environment. Because

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of intricacy of notable and utilizing methods, will be propound a simple ranking method (Zohouri *et al* 2011). Therefore, alternatives are ranked by finale method, lastly.

2.0 Background Information

In this section, some basic definitions of fuzzy sets, fuzzy numbers and linguistic variables are reviewed from Buckley (1985), Kaufmann and Gupta (1991). The basic definitions and notations below will be used throughout this paper until otherwise stated.

Definition 1: A fuzzy number is a fuzzy subset in the universe of discourse X that is both convex and normal. Fig. 1 shows three fuzzy numbers $\widetilde{N}$ in the universe of discourse X that conforms to this definition (Zadeh (1965)).

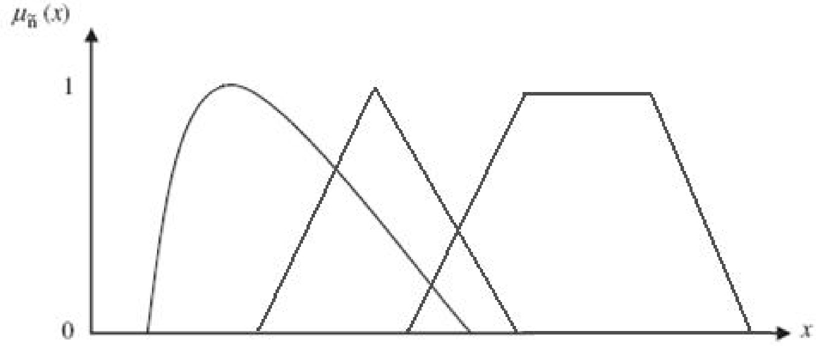

Figure 1: fuzzy number $\widetilde{N}$

We use triangular fuzzy numbers. A triangular fuzzy number $\widetilde{N}$ can be defined by a triplet $(a_1 a_2, a_3)$. Its conceptual schema and mathematical form is shown by equation (1).

$$\mu_{\widetilde{N}}(x) = \begin{cases} 0 & x \leq a_1; \\ \frac{x-a_1}{a_2-a_1} & a_1 < x \leq a_2 ; \\ \frac{a_3-x}{a_3-a_2} & a_2 < x \leq a_3 ; \\ 0 & x > a_3; \end{cases} \quad (1)$$

Where (a_1, a_2, a_3) denote as left hand number, middle number and right-hand number of $\widetilde{N}$ respectively.

Definition 2: Assuming that both $\widetilde{N} = (a_1, a_2, a_3)$ and $\widetilde{M} = (b_1, b_2, b_3)$ are fuzzy number and $c$is positive real numbers, then the basic operations such as multiplication, addition, distance, maximum and minimum on fuzzy triangular numbers are defined as follows respectively (Zadeh (1965)).

$$\frac{\widetilde{N}}{\widetilde{M}} \approx \frac{a_1 + 2a_2 + a_3}{b_1 + 2b_2 + b_3}$$
$$c \times \widetilde{N} = (c \times a_1, c \times a_2 , c \times a_3)$$
$$\widetilde{N} + \widetilde{M} = (a_1 + b_1, a_2 + b_2, a_3 + b_3)$$
$$d(\widetilde{N}, \widetilde{M}) = \frac{a_1 + 2a_2 + a_3}{4} - \frac{b_1 + 2b_2 + b_3}{4}$$
$$Max\{(a_i, b_i, c_i)_{i=1,\dots,n}\} = (max(a_i), max(b_i), max(c_i))$$
$$Min\{(a_i, b_i, c_i)_{i=1,\dots,n}\} = (min(a_i), min(b_i), min(c_i)) \quad (2)$$

Definition 3: While variables in mathematics usually take numerical values, in fuzzy logic applications, the non-numeric linguistic variables (Zadeh (1975)) are often used to facilitate the expression of rules and facts. A linguistic variable such as *age* may have a value such as *young* or its antonym *old*.

3.0 Proposed method

Assume there $\boldsymbol{m}$ alternative $\boldsymbol{A_i}, \boldsymbol{i = 1, \dots, m}$ to be evaluated against $\boldsymbol{n}$ criteria $\boldsymbol{C_j}, \boldsymbol{j = 1, \dots, n}$. All elements of decision matrix are fuzzy numbers and demonstrate by $(\boldsymbol{y^l_{ij}}, \boldsymbol{y^m_{ij}}, \boldsymbol{y^r_{ij}})$. Then, these elements are achieved by the brainstorming techniques from decision makers. In attention to the all values of decision matrix have not same scale measurement we have to normalize them.

Table1: decision matrix filled by TFNs

	C_1	C_2	$\cdots$	C_n
A_1	$(y^l_{11}, y^m_{11}, y^r_{11})$	$(y^l_{12}, y^m_{12}, y^r_{12})$	$\cdots$	$(y^l_{1n}, y^m_{1n}, y^r_{1n})$
$\vdots$				
A_m	$(y^l_{m1}, y^m_{m1}, y^r_{m1})$	$(y^l_{m2}, y^m_{m2}, y^r_{m2})$	$\cdots$	$(y^l_{mn}, y^m_{mn}, y^r_{mn})$

Implement of the proposed method is dependent on following steps:

Step 1: Some of the criteria have positive concepts, thus decision maker (DM) want to increase them (e.g. productivity), in contrast some of criteria have negative concept where DM would like to decrease them (e.g. cost).We normalize any columns separately. If j^{th} criterion of decision matrix has been positive concept, then i^{th} row at the j^{th} column element of decision matrix is normalized by equation (3):

$$\tilde{y}_{ij} = \left(\frac{y_{ij}^{l} - Min_{i\in(1,2,\ldots,m)} y_{ij}^{l}}{Max_{i\in(1,2,\ldots,m)}\, y_{ij}^{r} - Min_{i\in(1,2,\ldots,m)} y_{ij}^{l}}, \frac{y_{ij}^{m} - Min_{i\in(1,2,\ldots,m)} y_{ij}^{l}}{Max_{i\in(1,2,\ldots,m)}\, y_{ij}^{r} - Min_{i\in(1,2,\ldots,m)} y_{ij}^{l}}, \frac{y_{ij}^{r} - Min_{i\in(1,2,\ldots,m)} y_{ij}^{l}}{Max_{i\in(1,2,\ldots,m)}\, y_{ij}^{r} - Min_{i\in(1,2,\ldots,m)} y_{ij}^{l}}\right) \quad (3)$$

Mutually, if j^{th} criterion of decision matrix has been positive concept, then i^{th} row at the j^{th} column element of decision matrix is normalized by following relation:

$$\tilde{y}_{ij} = \left(\frac{Max_{i\in(1,2,\ldots,m)}\, y_{ij}^{r} - y_{ij}^{l}}{Max_{i\in(1,2,\ldots,m)}\, y_{ij}^{r} - Min_{i\in(1,2,\ldots,m)} y_{ij}^{l}}, \frac{Max_{i\in(1,2,\ldots,m)}\, y_{ij}^{r} - y_{ij}^{m}}{Max_{i\in(1,2,\ldots,m)}\, y_{ij}^{r} - Min_{i\in(1,2,\ldots,m)} y_{ij}^{l}}, \frac{Max_{i\in(1,2,\ldots,m)}\, y_{ij}^{r} - y_{ij}^{r}}{Max_{i\in(1,2,\ldots,m)}\, y_{ij}^{r} - Min_{i\in(1,2,\ldots,m)} y_{ij}^{l}}\right) \quad (4)$$

Step 2: Decision-makers weight can be divided into two classes based on the factors determining it. One class is the subject weights which are assigned by considering the prior information of decision-makers, and the assigned weights is integrated quantity representation of the knowledge, experience, capability, expectation and so on. Another one is the objective weights which are assigned based on the adverse judgment of decision-makers' estimation results. This step tries to give a new weight determination approach to retain the merits of both subjective and objective approaches (Tien 2009, Hobbs 1980).

Step 2.1: objective weights (w_j^o): The objective modes select weights through mathematical calculation, which quits subjective judgment information of decision makers. Diversity weight is a parameter that clarifies how much diverse alternatives approach one another in respect to a certain criterion. The greater the value of the diversity, the smaller the diversity weight, then the smaller the differences of diverse alternatives in this specific criterion, and the less information the specific criterion affords, and the less important this criterion becomes in the decision making operation. In this paper we give a Fuzzy Diversity Weight, while for fuzzy numbers could not use the crisp formula to calculate the entropies of fuzzy numbers directly. Zohouri *et al* (2011) used the entropy theory, but in that sight we would first transform the fuzzy numbers into crisp numbers, and then calculate their respective entropies. It is a non-real subject due to decreasing the fuzzy concepts. So, we propose following relations for using the fuzzy numbers and associated uncertainty. Thereafter, average x_{ij} is computed according to the following equation:

$$x_j = \frac{1}{m}\sum_{i=1}^{m} \tilde{y}_{ij} \quad (5)$$

Then, the fuzzy diversity of the j^{th} criterion can be calculated with the following:

$$\overline{E_j} = Min\{d^2(x_j, Min_{i\in(1,2,\ldots,m)}\tilde{y}_{ij}), d^2(x_j, Max_{i\in(1,2,\ldots,m)}\tilde{y}_{ij},)\} \quad (6)$$

Now, it is calculated the objective weight of j^{th} criterion with the following equation:

$$W_j^o = \frac{\overline{E_j}}{\sum_{j=1}^{n}(\overline{E_j})} \quad (7)$$

Step 2.2 : subjective weights (w_j^s) : Weights assigned by subjective modes can specify the subjective judgments of decision makers, thus makes the rankings of alternatives in Fuzzy MCDM problem have more discretional factors. For calculating the subjective weights, it is specialized a linguistic value to each criterion. Note that, they are values of importance linguistic variable. The corresponding linguistic values of the i^{th} criterion are denoted simply as MFC_i. Relative importance of each criterion defined by:

$$RI_i = \frac{MFC_i}{\frac{1}{n}\sum_{j=1}^{n} MFC_j} \quad (8)$$

Therefore, subjective weight of i^{th} criterion achieve by relation 9:

$$w_i^s = \frac{a^{RI_i}}{\sum_{j=1}^{n} a^{RI_j}} \quad (9)$$

The parameter a is greater and not equal than one. If it is equal one, subjective weights achieve in same value.

Step 2.3: Calculation of the combined weights of criterion: Derive the combined weight of j^{th} criterion by geometric average according to

$$w_j = (w_j^o)^{\alpha} \times (w_j^s)^{\gamma} \quad (10)$$

Where α and γ represent the relative weightiness of the objective weights and the subjective weights to decision makers respectively, such that $\alpha + \gamma = 1$. Combined fuzzy weight is such as marker that not only shows how much important a criterion is to the decision maker, but also shows how much various the values of the criterion in various alternatives are.

Step 3: Weighting the normalized matrix: At this stage, we multiplied normalized matrix in weight vector. M-times TFNs are resulted by this multiplication. In fact, the results show the value of each alternative.

Step 4: Ranking: when the values of each alternative are obtained, we must to be ranked them. Several techniques exist in literature to rank the fuzzy numbers. To do this, this section introduced Zohouri *et al* (2011) method for ranking of fuzzy numbers based on the distance of numbers value to their minimum and maximum (see for detail in Definition 3).

Let $(a_i, b_i, c_i),\ i = 1, \dots, n$ be the fuzzy numbers. To define the index of each alternative first we obtain the distance of each alternative value from maximum and minimum of all alternatives. The unique point of this method is that the number is more important, if its distance is higher than minimum and so is lower than maximum value, simultaneously. In contrast, we must to obtain the average of per fuzzy number where it is acquired by equation (11):

$$\tilde{x}_{(a_i,b_i,c_i)} = \frac{(a_i+b_i+c_i)}{3} \tag{11}$$

As mentioned above, Eq. (12) will be considered as the ranking index in which the larger value of index is the better the ranking of each fuzzy number.

$$Index_{(a_i,b_i,c_i)} = \frac{d((a_i,b_i,c_i),(a_{min},b_{min},c_{min}))}{d((a_{max},b_{max},c_{max}),(a_i,b_i,c_i))} \times \tilde{x}_{(a_i,b_i,c_i)} \tag{12}$$

In next stage, we use the proposed method in a condensation case study.

4. Floatplane Evaluation Example

In this section, we illustrate the application of our approach on evaluating the performance of floatplane and test the contribution of our approach. A coastguard organization wants to select an appropriate floatplane to outsource their demandable brake pads. Let us assume that there are four alternatives A_1, A_2, A_3 and A_4. Two coastguard managers, three communication and avionic experts will evaluate these alternatives using the performance criteria. The criteria for floatplane quality were generous and different as

* At least two seats subject to although four would be nice.
* Construction is all metal or wood and composite.
* Closed in cockpit (an open cockpit in winter would not make me satisfy).
* At least 3 hours cross country endurance.
* Fuel capacity
* Rate of climb
* How much is it going to cost me to handle this aircraft?
* Greater than120 mph cruise.
* Able to use a converted either Corvair or VW engine.
* It has to look cool.
* Useful load and so on.

Hence, they have decided to use brainstorming technique for evaluating the floatplane quality corresponding to each criterion and criteria screening. Finally, expert presented three essential criteria for candidate floatplanes evaluation and selection:

Three main criteria have been chosen including cruise speed (C_1), overall construction status i.e. cockpit width, cool looks, seats, formative materials etc.(C_2), cost (C_3) and fuel capacity (C_4).The decision makers provide linguistic terms to the criteria using Table 2 and to the four alternatives for each of the criteria using Table 1. Figure2 shows each fuzzy linguistic term to its correspondent fuzzy numbers for each criterion. Note that either Positive or negative concept of each criterion is included in following figure.

Table 2.a
Fuzzy linguistic terms for criterion C_1 and C_2

Importance	Abbreviation	Fuzzy Number
Very low	VL	(0,0,1)
Low	L	(0,1,3)
Medium low	ML	(1,3,5)
Medium	M	(3,5,7)
Medium high	MH	(5,7,9)
High	H	(7,9,10)
Very high	VH	(9,9,10)

Table 2.b
Fuzzy linguistic terms for criterion C_3

Importance	Abbreviation	Fuzzy Number
Very low	VL	(0,0,50)
Low	L	(50,150,200)
Medium low	ML	(50,150,200)
Medium	M	(150,200,250)
Medium high	MH	(200,250,350)
High	H	(250,350,400)
Very high	VH	(350,350,400)

Decision maker completes the decision matrix based on himself/herself idea and fuzzy linguistic terms (See to Table 2). Nevertheless, same scaling of decision matrix's elements, achieved decision maker ideas are transformed into normalized matrix. The decision matrix and its normalization are shown in Table 3. Note that, ***step 1*** is performed by this process.

Table3: Decision matrix and its normalization

	Alternative	C_1	C_2	C_3	C_4
Decision matrix	A_1	(7,9,10)	(1,3,5)	(200,250,350)	(40,42,45)
	A_2	(1,3,5)	(9,9,10)	(200,250,350)	(40,42,45)
	A_3	(3,5,7)	(5,7,9)	(50,150,200)	(50,55,57)
	A_4	(5,7,9)	(1,3,5)	(150,200,250)	(35,40,42)
Normalized decision matrix	A_1	(0.68,0.90,0.93)	(0.12,0.33,0.64)	(0.13,0.19,0.35)	(0.12,0.21,0.33)
	A_2	(0.12,0.33,0.64)	(0.93,0.93,0.98)	(0.13,0.19,0.35)	(0.12,0.21,0.33)
	A_3	(0.36,0.48,0.81)	(0.56,0.83,0.88)	(0.35,0.35,0.91)	(0.36,0.36,0.94)
	A_4	(0.56,0.83,0.88)	(0.12,0.33,0.64)	(0.18,0.42,0.42)	(0.28,0.36,0.36)

In multi criterion decision making (MCDM), criteria have not same importance. Therefore, next stage must assign an appropriate weight for each criterion. According to ***Step 2.1***, criteria weighting by diverse study ignore decision maker's judgment about each criterion. This means that obtained objective weights are less often optional. Achieved diversity of each criterion and corresponding objective weights, are shown in Table 4:

Table 4: Diversity and objective weights of each criterion based on normalized matrix's elements

Criterion	C_1	C_2	C_3	C_4
$\bar{E}_j$ value	0.91	0.82	0.96	0.84
Objective weight	0.26	0.23	0.27	0.24

It is ran ***Step 2.2*** for specifying the subjective judgments of decision maker. Hence, Table 5 shows linguistic values of the ith criterion are used simply as MFC_i. According to approach of ***Step 2.2***, Relative importance matrix and obtained subjective weights are calculated systematically. Results are shown in Table 6.

Table 5

Linguistic terms and their membership function.

Linguistic terms	Abbreviation	Membership function
Extremely unimportant	EU	(1,1,3)
Very unimportant	VU	(1,3,5)
Important	I	(3,5,7)
Very important	VI	(5,7,9)
Extremely important	EI	(7,9,9)

Table 6

Relative importance and subjective weights

	C_1	C_2	C_3	C_4
MFC_i	VU	EI	I	VI
w_j^s	0.19	0.38	0.23	0.2

It is combined weight of jth criterion by geometric average according to equation 8. In view of ***Step 3***, achieved weights affect normalized matrix. Finally, in ***Step 4***, we use equation 10 to ranking the fuzzy numbers are acquired in the previous step. As mentioned before, the ranking order depends on two parameters of W_j^T. Accordingly, we used a different value of α to identify which subjective and objective weights of criteria is most influence. Table 7 gives the total weights of each criteria and various ranking of each alternative based on different value of α.

Table 7: Total weights of each criteria and final ranking with regard to different $\boldsymbol{\alpha}$

α	w_1	w_2	w_3	w_4	Rank			
					A_1	A_2	A_3	A_4
0.15	0.20	0.35	0.24	0.21	**1**	3	4	2
0.25	0.21	0.34	0.24	0.21	**1**	3	4	2
0.40	0.22	0.31	0.25	0.22	**1**	3	4	2
0.65	0.23	0.27	0.26	0.23	2	4	3	**1**
0.85	0.25	0.25	0.26	0.23	2	4	3	**1**

As demonstrated in table 10, with emphasis on subjective judgment A_1 is the better alternative than A_4. Hence, with ignorant to decision maker's idea A_4 is the better alternative than A_1.

5. Conclusion

The main purpose of this paper is to develop a fuzzy based method to select information systems appropriately for an organization from available alternatives. In this regard, a novel approach is proposed for solving MCDM problems in a fuzzy environment for aircraft selection and evaluation (ASE) problem. To determine the performance of the proposed method, we apply the proposed method in a brief case study in the floatplane evaluation and selection field. The consolidated methodology aimed at the construction of particular approaches allowing differential importance weights to be determined, so in this manuscript illustrated an integrated approach of objective and subjective weighting to lead the simplicity of decision making. Lastly, Alternatives' ranking is studied in different combinations with respect to random values of α.

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REFERENCES

[1] Abbasbandy S ,Asady B , (2006). Ranking of fuzzy numbers by sign distance, Information Science.176 .2405-2416.
[2] Barkhordary M, Allahviranloo T , Hajjari T , (2007). Novel ranking method of fuzzy numbers. First Joint Congress on Fuzzy and Intelligent Systems Ferdowsi University of Mashhad, Iran 29-31 .
[3] Bender M ,Simonovic S P , (2000). A fuzzy compromise approach to water resource structures planning under uncertainty, Fuzzy Sets and Structures 115: 35-44.
[4] Bortolan G , Degam R , (1985). A review of some methods for ranking fuzzy subsets, Fuzzy Sets System.15.1-19.
[5] Buckley JJ, (1985). Ranking alternatives using fuzzy numbers, fuzzy sets and structures 15
[6] Chang DY, (1996). Fuzzy analytic hierarchy process; extend analysis method, Fuzzy sets and systems . 12, pp 43-51 .
[7] Cheng L , Peng B , (1988) .The Fuzzy Relation Equation with Union or Intersection Preserving Operator, Fuzzy Sets and Structures, 25 .191-204.
[8] Fernandez E ,Olmedo R , (2005).An agent model based on ideas of concordance and discordance for group ranking problems .Decision support structures . 39(3).
[9] Fischer G W, (1985). Range sensitivity of criterion weights in multi-criterion value model, organizational behavior & human decision operations 62
[10] Haghighi M, Zowghi M, Zohouri B, (2012). Fuzzy Quantities Ranking Based on Higher Membership Functions and X Values. Innova Ciencia, Volume 4 (1).
[11] Laarhoven P J M ,PedryczW, (1983). A fuzzy extension of saaty's priority theory, Fuzzy sets and structures 11
[12] Liou T S , Wang M J , (1992). Ranking fuzzy numbers with integral value, Fuzzy Sets and Structures 50: 247-255.
[13] Mehregan M R , Safari H , (2006).Combination of fuzzy TOPSIS and fuzzy ranking for multi criterion decision making. Lecture notes in computer science.
[14] Prodanovic P,(2002). Fuzzy set ranking methods and multiple expert decision making , project report.
[15] Saaty T L , (1980). The analytic hierarchy process, McGraw – Hill, New York ,
[16] Sakawa M , (1993).Fuzzy sets and interactive multi objective optimization, applied information Technology , plenum Pres , New York
[17] Takeda E ,CoggerK O ,Yu P L, (1998).Appraising criterion weights using eigenvectors: A comparative study .Europian Journal of operational Research 29
[18] Tien-Chin Wang, Hsien-Da Lee,(2009) . Developing a fuzzy TOPSIS approach based on subjective weights and objective weights. Expert Systems with Applications 36 . 8980–8985 .
[19] Wang Y J , Lee H S , (2007). Generalizing TOPSIS for fuzzy multiple-criteria group decision making . Computers and Mathematics with Applications, 53, 1762–1772.
[20] Yang JB,Wang YM,XU DL, et al.(2006). The evidential reasoning approach for MADA under both probabilistic and fuzzy uncertainties .European journal of operational research .171(1) .
[21] Yehch, Deng HP . (2004). A practical approach to fuzzy utilities comparison in fuzzy multi criteria analysis .International journal of approximate reasoning 35(2) .
[22] Zadeh LA ,(1965) .Fuzzy sets , information and control 8, 338-353
[23] Zimermann H.J. (1996), Fuzzy set theory and its applications; Third Edition, Kluwer Academic Publishers; Boston.
[24] Zohouri B, Zowghi M, Haghighi M. (2011), Fuzzy Decision Making via Multiple Attribute, World Academy of Science, Engineering and Technology, 75.