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The decision method of basic fuzzy soft set in the application of the asphalt pavement maintenance sorting

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ABSTRCT
In order to determine the order of pavement maintenance plan, according to the survey data of pavement condition: road surface roughness, deflection, pavement damage condition and traffic volume, combined with related soft sets theory, this paper put forward a new decision making method about determination of pavement maintenance scheduling by fuzzy soft set. At last, using the method, combining with example to sort project that need maintenance, the same sort results with other methods are obtained, and the feasibility, ease and simplicity of this method are proved.
Keywords - asphalt pavement, maintenance sorting, soft set, decision-making method

I. INTRODUCTION

Under the action of vehicle load and natural factors, the use of performance and structure performance of asphalt pavement will gradually decline, so it is very important to maintenance and repair the road timely and effective. But under the limitation of the budget, project need pavement maintenance have priorities. For this, we have to use a certain method choosing the most need in road network. Sorting, widely used, is one of the important methods in the pavement management system around the world. the method According to the engineering experience of decision makers of determining the project priorities is simple and easy, but engineering experience varies from place to place, people, when, uncertainty is bigger. By analysising these experience judgment, the paper puts forward and quantifies the main factors influencing the experience judgment, then to develop a prioritization rules and the use of these rules for project scheduling, can get relatively stable results in [1]. Pavement performance is the most important factor of affect the sorting result. These road, inadequate structural strength, seriously damaged, the smoothness of the road, are more in need of maintenance, and highway with large traffic volume also should be a priority. In this paper, a kind of objective decision method based on fuzzy soft set was put forward, project sorting using this method for pavement maintenance can reach to the results more objective and simple.

II. SOFT SET THEORY

In 1990, Molodtsov[2] System introduced some of the basic theory and application of soft set, this marks the birth of soft sets and its theory. Then the related properties of soft sets is given by Maji and Boy[3], and the soft set theory is used for decision making; Maji and Biswas[4], in 2003, further expound the soft set related definition and the characteristics of the basic operation, and these action prompt decision theory and method of soft set to produce have become possible.

Definition 1[2] U is the initial field, E is the parameter set. Sequence of (F, E) is called soft set if and only if F is a mapping of power set from E to set U, namely F: E→P (U), P (U) is the power set of U.

Case 1[5] U is the set of house, U= {h_1, h_2, h_3, h_4, h_5, h_6}. E is the parameter set, each parameter is a word or sentence, E= {e_1 (expensive), e_2 (beautiful), e_3 (wood), e_4 (cheap), e_5 (environment)}.

Assume that F (e_1) = {h_2, h_4}, F (e_2) = {h_1, h_3}, F (e_3) = {h_3, h_4, h_5}, F (e_4) = {h_1, h_3, h_5}, F (e_5) = {h_1}. (F, E) is the soft set on the U.

Soft set (F, E) describes the attractiveness of the house, the table form as table 1:

Table1. Soft Set (F, E)

U	e_1	e_2	e_3	e_4	e_5
h_1	0	1	0	1	1
h_2	1	0	0	0	0
h_3	0	1	1	1	0
h_4	1	0	1	0	0
h_5	0	0	1	1	0
h_6	0	0	0	0	0

Definition 2[6] U is the initial field, E is a set of parameters, §(U) said all of fuzzy subset collection on U. Make A∈E, the sequence of (F, A) is known as

a basic fuzzy soft set on U, F is a mapping, F: A→ §(U).

In other words, a fuzzy soft set is Parameter set composed of fuzzy subsets on field U. if ε∈A. F (ε) can be regarded as A fuzzy soft set of the ε approximation of fuzzy set (F, A).

Case 2[5] U is the set of house, U = {h_1, h_2, h_3, h_4, h_5, h_6}. E is the set parameters, and each parameter is a word or a sentence, E = {e_1 (expensive), e_2 (beautiful), e_3 (wood), e_4 (cheap), e_5 (environment)}.

Assume that F (e_1) = {0.5/h_1, 1.0/h_2, 0.4/h_3, 1.0/h_4, 0.3/h_5, 0.0/h_6},
F (e_2) = {1.0/h_1, 0.4/h_2, 1.0/h_3, 0.4/h_4, 0.6/h_5, 0.8/h_6},
F (e_3) = {0.2/h_1, 0.3/h_2, 1.0/h_3, 1.0/h_4, 1.0/h_5, 0.0/h_6},
F (e_4) = {1.0/h_1, 0.0/h_2, 1.0/h_3, 0.2/h_4, 1.0/h_5, 0.2/h_6},
F (e_5) = {1.0/h_1, 0.1/h_2, 0.5/h_3, 0.3/h_4, 0.2/h_5, 0.3/h_6}.
(F, E) is the basic fuzzy soft set on U.

Fuzzy soft set (F, E) describes The attractiveness of the house to buyers, in order to facilitate the computer store, (F, E) will be said with the form, according to table 2:

Table2. Basic fuzzy Soft Set (F, E)

U	e_1	e_2	e_3	e_4	e_5
h_1	0.5	1.0	0.2	1.0	1.0
h_2	1.0	0.4	0.3	0.0	0.1
h_3	0.4	1.0	1.0	1.0	0.5
h_4	1.0	0.4	1.0	0.2	0.3
h_5	0.3	0.6	1.0	1.0	0.2
h_6	0.0	0.8	0.0	0.2	0.3

III. THE DECISION METHOD OF MULTI-ATTRIBUTE FUZZY SOFT SET

Assuming that the pavement need maintenance or reconstruction is m within the entire road network, the alternative project sets h= { h1, h2,⋯, hi }, i∈m, m= {1, 2⋯, m}, m≥2; the number of index reflecting this project is n, the decision attribute set ε= {ε1, ε2,⋯, εj}, j∈n, n= {1, 2,⋯, n}, n≥2; D= [rij] m×n is the standardization of decision matrix of the multiple attribute decision making problems, in which rij said attribute values of alternative project hi under the background of the decision attribute εj, rij is conventional fuzzy number, 0≤rij≤1. Alternative project set U= { h1, h2,⋯, hi } consider a filed, decision attribute set E= {ε1, ε2,⋯, εj} as the parameter set, the general multiple attribute decision making method of basic fuzzy soft set was build, the specific content is as follows:

First of all, the decision attribute usually have different dimensions, orders of magnitude and attribute category (efficiency attribute and cost type attribute). There is no unified metrics between different decision attribute, in order to eliminate the influence on the result of decisions of dimension, orders of magnitude, category, must to standardized the decision attribute values. Efficiency type attribute refers to the attribute of attribute value the larger the better, cost attribute refers to the attribute of attribute value the smaller the better. Using different formulas standardized the two types of attributes: Efficiency attribute index was calculated by the following formula:

$$r_{ij}=\frac{a_{ij}-\min(a_{ij})}{\max(a_{ij})-\min(a_{ij})}$$

Cost type attribute index according to the following formula:

$$r_{ij}=\frac{\max(a_{ij})-a_{ij}}{\max(a_{ij})-\min(a_{ij})}$$

i=1,2,⋯,m ; j=1,2,⋯,n

The decision-making information matrix V= (aij)m×n form original data was converted into standardized matrix D= (rij) m×n, then according to the decision matrix D= (rij) m×n build basic fuzzy soft set (F, E). Based on domain objects, the mapping F of basic fuzzy soft set(F, E) can be said in the binary table. As table 3:

Table3. The tabular form of basic fuzzy Soft Set (F, E)

U	ε_1	ε_2	ε_3	⋯	ε_j
h_1	r_{11}	r_{12}	r_{13}	⋯	r_{1j}
h_2	r_{21}	r_{22}	r_{23}	⋯	r_{2j}
h_3	r_{31}	r_{32}	r_{33}	⋯	r_{3j}
⋯	⋯	⋯	⋯	⋯	⋯
h_i	r_{i1}	r_{i2}	r_{i3}	⋯	r_{ij}

Table {h1, h2,⋯, hi} is field, namely all alternatives of the multiple attribute decision making problems; ε1,ε2,⋯, εj as the parameter set, namely all decision attribute of the multiple attribute decision making problems; rij said attribute value of decision-making objects (alternatives) hi about the parameter (decision attribute) εj.

Secondly, according to the data in table 3, calculate choice value Ci of decision-making object hi of the basic fuzzy soft set (F, E). Option value calculated by the next equation:

$$C_i=\sum_{k=1}^{m} r_{ij} \quad \cdots\cdots\cdots\cdots \text{(Equation 1)}$$

Where rij means fuzzy comprehensive evaluation value of object hi about parameter εj, m said the number of parameters.

Finally, according to the choice value of all decision-making object, calculated decision values ri

of decision object (alternatives) hi (∀ hi∈U). Decision value ri were calculated by the next equation:

$r_i=\sum_{h_j \in U} (c_i - c_j)$ ····· (Equation 2)

The larger of ri, the better of the pavement performance, so the object have minimal decision value ri should be maintained at the earliest.

IV. APPLICATION

The feasibility and effectiveness of basic fuzzy soft set multiple attribute decision making method be verified by the example of road maintenance decision problem in the paper [7].

The survey data of asphalt pavement using state in a region as table 4, sorting the 5 need maintenance road.

In the four decision attribute deflection and IRI belongs to the cost index, the pavement condition index PCI and traffic are efficiency index.

The data of decision attribute value dealing with the standardization of the five alternatives such as in table 5.

Table4. The data of road states

road	deflection (10^{-2}/mm)	IRI (m/km)	PCI	Traffic (vehicles/day and night)
1	100	10	56	1500
2	110	13	50	2000
3	105	12	60	2300
4	112	15	50	2500
5	100	16	49	2500

Table5. Alternative decision making attribute value

road	deflection	IRI	PCI	Traffic
1	1	1	0.6363	1
2	0.1666	0.5	0.09091	0.5
3	0.5833	0.666	1	0.2
4	0	0.1666	0.09091	0
5	1	0	0	0

The five alternatives as filed, the four decision attributes as parameter set, basic fuzzy soft set (F, E) can be set up, such as table 6:

Table6. The basic fuzzy Soft Set (F, E)

U	ε_1	ε_2	ε_3	ε_4
h_1	1	1	0.6363	1
h_2	0.1666	0.5	0.09091	0.5
h_3	0.5833	0.666	1	0.2
h_4	0	0.1666	0.09091	0
h_5	1	0	0	0

In the table, filed is the five alternatives, namely U= {h1, h2, h3, h4, h5,}; Parameter set E is the four decision attribute, namely E= {ε1, ε2, ε3, ε4}, ε1 said deflection value, ε2 said IRI, ε3 said PCI, ε4 said traffic.

So according to the data table 6, calculate by the equation one the choice value Ci of the five alternatives hi (∀ hi ∈U):

$C_1 = 3.6364$, $C_2 = 1.2576$, $C_3 = 2.45$, $C_4 = 0.2576$, $C_5 = 1$

According to the choice value of the five roads, calculate by the formula two the decision values r_i of the 5 alternatives h_i (∀ hi∈U):

r_1=9.58, r_2=-2.31, r_3=3.65, r_4=-7.32, r_5=-3.60

According to the above decision value size: $r_4 < r_5 < r_2 < r_3 < r_1$, so the order of road maintenance plan is: $r_4 \rightarrow r_5 \rightarrow r_2 \rightarrow r_3 \rightarrow r_1$. That is to say, under the condition of the limited funding, road 4 should be maintained at the earliest.

V. CONCLUSIONS

This paper obtained the same sequence of maintenance with the literature [7], but the multiple attribute decision making method in the literature [7] need complex computation, this multiple attribute

decision making method of calculation is more simple. The solution to the problem of multiple attribute decision making method to avoid the human subjectivity and randomness is put forward in this paper, and the results more objective. The calculation method is easy and simple at the same time, high maneuverability. It provides a reference for the maintenance or rebuilding project decisions.

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