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ESTIMATION METHOD BASED ON AN UEWAA OPERATOR AND ITS APPLICATION

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ABSTRACT

This paper bring forward a kind of estimation method based on UEWAA (Uncertain Enhanced Weight Arithmetic Average) operators, which establishes an estimation attribute set, a weight vector, and an estimation matrix. Then a queue vector is acquired and the best optimized project is gotten. Finally, the availability of this method is validated by an FMC (Flight Management Computer) repair example. And the conclusion is that this method is quantitatively effective but not accurate, which means that it can only provide the decision-maker some references.

Keywords: *Estimation Method, UEWAA Operator, Weight, Attribute, Aircraft Component Repair*

1. INTRODUCTION

Currently, there are some uncertain language estimation problems in many industries including the aircraft component repairs. And it means that the estimation and validation to those repair enterprises are weak, even poor with only literatures in the aircraft component repair industry. So the focus of this paper is how to quantitatively estimate the repair ability of those repair enterprises and what enterprise has the best repair level to the same component by ranking.

In the aircraft repair industry, ranking the ability of repair enterprises is a very important information to the airlines companies and aircraft manufactures since the prices of aircraft components are so expensive. However, this kind of estimation can help them decrease the management costs and acquire better component repair qualities by choosing the best repair enterprise.

This paper imports an UEWAA (Uncertain Enhanced Weight Arithmetic Average) operator of fuzzy multi-attributes decision method, which its attributes' weights are real numbers but its attributes are uncertain languages[1]. For the aircraft component repair, with the common cognition of aircraft repair industry, the method makes sure several estimation parameters of repair abilities of aircraft repair enterprises and establishes an analysis model, then validates its correctness and validity with a FMC (Flight Management Computer) repair case.

2. NEW ESTIMATION METHOD BASED ON THE UEWAA OPERATOR

2.1 UEWAA Operator Introduction

The UEWAA operator is designed to solve the multi-attribute decision problem that attribute weights are real numbers but their values are uncertain language. It's a kind of uncertain multi-attribute decision methods and is widely used on uncertain theory decision and optimization as described in XU Z S (2004) [2].

2.2 Estimation Method Model

The estimation method needs to establish a model as per the following steps as did XU Z S (2003) [3]-[4].

Step 1: To a certain multi-attribute decision problem, program set and attribute set are supposed as X and U individually. Attribute's weight vector is

$$\omega = (\omega_1, \omega_2, \ldots, \omega_m), \omega_j \geq 0 (j \in M), \sum_{j=1}^{m} \omega_j = 1 \cdot$$

The decision-maker provides the uncertain language estimation level $\tilde{r}_{ij}$ with the program $x_i \in X$ based on the attribute $u_j \in U$, then

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estimation matrix $\tilde{R}=(\tilde{r}_{ij})_{n\times m}$ can be acquired with $r_{ij}\in\tilde{S}$.

Step 2: The language estimation information of Row i in Matrix $\tilde{R}$ is massed by the use of UEWAA operator. Then the integrative attribute estimation level $\tilde{z}_i(\omega)(i\in N)$ of the decision program x_i is gotten. That is

$$\tilde{z}_i(\omega)=UEWAA_\omega(\tilde{r}_{i1},\tilde{r}_{i1},...,\tilde{r}_{im})=\omega_1\tilde{r}_{i1}\oplus\omega_2\tilde{r}_{i2}\oplus...\oplus\omega_m\tilde{r}_{im}, i\in N$$

.

Step 3: With the possibility formula $p(\tilde{\mu}\geq\tilde{\nu})=\max\left\{1-\max\left(\frac{d-a}{l_{ab}+l_{cd}},0\right),0\right\}$, Possibility p among the integrative attribute estimation level $\tilde{z}_i(\omega)(i\in N)$ of every program can be calculated. Then possibility matrix $P=(p_{ij})_{n\times n}$ is also established.

Step 4: By making use of the zone number queue formula

$$v_i=\frac{1}{n(n-1)}\left(\sum_{j=1}^{n}p_{ij}+\tfrac{n}{2}-1\right), i\in N,$$

the queue vector $v=(v_1,v_2,...,v_n)$ of the possibility matrix P is acquired. Then by queuing the different program with the level of vectors, the optimized program can be obtained.

3. APPLIED EXAMPLE OF THE UEWAA ESTIMATION MEHTOD

3.1 Current Repair Ability of Repair Enterprises

By 2007, the part numbers of civil aircrafts that can be repaired by the repair enterprises approved by CAAC (Civil Aviation Administration of China) are 37189. Among of these parts, the percent of the parts that can be repaired by domestic repair enterprises is 29%, but 87% by foreign repair enterprises as shown in Figure 1 [5]. The difference of repair ability between domestic repair enterprises and foreign repair enterprises is obvious.

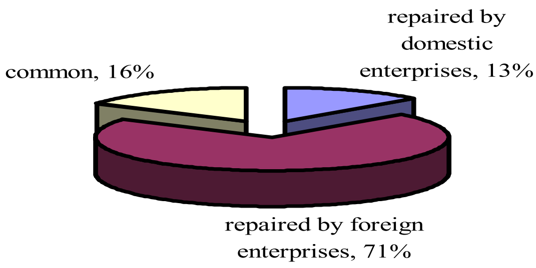

Figure 1: Contrast of Repairable Part Numbers In and Out of China

From the website of CAAC, in fact, most of the parts in ATA (Aviation Transportation Association) Chapter 27, Chapter 32, and Chapter 72 can only be repaired by foreign enterprises, because the parts from these systems are complex and difficult to be repaired.

3.2 Current Reliability Analysis Method

To the repair ability estimation of different enterprises to the same component, the reliability office of airlines companies analyzes the use reliability data which is produced by component reuses after repair, such as component unscheduled removal data. Then the reliability office issues the component repair investigation as per reliability alerts and acquires the reliability report to this component (Figure 2). The reliability analysis method is a kind of statistic analysis which needs large data about component faults, repair status. If the data quantity is enough, the analysis result can be authentic. But in fact, the fault rate of components is often low and repair records are rare, then the result of reliability analysis method will lose the validity and authenticity [6].

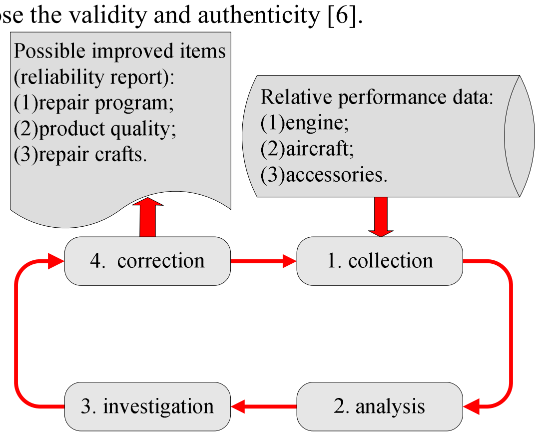

Figure 2: Aircraft Maintenance Reliability Analysis Method

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Thus, this paper induces a kind of new estimation method of aircraft and components repair enterprises, which is based on the UEWAA operator.

3.3 Application of UEWAA Estimation Method

3.3.1 assumptions

As per above method, it need assume the estimation attributes and one component to repair.

Generally speaking, according to the practice experiences airlines companies synthetically estimate the repair ability of repair enterprises as per the following nine attributes: l_1 --customer satisfaction degree; l_2--repair service attitude; l_3--repair speed; l_4 --repair quality; l_5 --technology advisory level; l_6 --information level; l_7 --management level; l_8 --fee rationality; l_9 --company scale. That is, attribute set $L=\{l_1,l_2,l_3,l_4,l_5,l_6,l_7,l_8,l_9\}$ is established [7].

Supposing a component to repair, such as FMC (Flight Management Computer) and totally 5 qualified repair enterprises in the market, a repair enterprises set $X=\{x_1,x_2,x_3,x_4,x_5\}$ will be established.

3.3.2 application analysis

Now according to the assumptions and above estimation method based on the UEWAA operator, the repair ability of five repair enterprises will be estimated.

Step 1: Endow the attribute set of nine attributes with weights. Supposing its weight vector is $\omega=(0.10,0.05,0.10,0.2,0.05,0.13,0.15,0.10,0.12)$ and language estimation scale is $S=\{s_\alpha \mid \alpha=-5,\ldots,5\}$ which is described as {extraordinarily bad, very bad, bad, preferably bad, little bad, ordinary, little good, preferably good, good, very good, extraordinarily good}, uncertain language estimation level $\tilde{r}_{ij}$ and estimation matrix $\tilde{R}=(\tilde{r}_{ij})_{n\times m}$, where $r_{ij}\in S$ can be obtained under the attribute set L of repair enterprises set $x_i\in X$. So decision-makers of airlines companies make use of language estimation scale to obtain the relative repair enterprise estimation matrix $\tilde{R}$ as shown in Table 1 (placed in the end of the paper).

Step 2: The language estimation information of Row i in Matrix $\tilde{R}$ is massed by the use of UEWAA operator. Then the integrative attribute estimation level $\tilde{z}_i(\omega)(i=1,2,\ldots,5)$ of the individual repair enterprise x_i is gotten.

$$\tilde{z}_1(\omega)=0.10\times[s_0,s_2]\oplus 0.05\times[s_1,s_3]\oplus 0.10\times[s_{-3},s_{-1}]\oplus 0.2\times[s_2,s_4]\oplus 0.05\times[s_3,s_4]\oplus$$
$$0.13\times[s_2,s_4]\oplus 0.15\times[s_3,s_4]\oplus 0.10\times[s_3,s_4]\oplus 0.12\times[s_2,s_4]$$
$$=[s_{1.6},s_{3.35}],$$

$$\tilde{z}_2(\omega)=0.10\times[s_{-1},s_0]\oplus 0.05\times[s_{-5},s_{-3}]\oplus 0.10\times[s_{-3},s_{-2}]\oplus 0.2\times[s_0,s_2]\oplus 0.05\times[s_{-1},s_1]\oplus$$
$$0.13\times[s_3,s_4]\oplus 0.15\times[s_2,s_3]\oplus 0.10\times[s_2,s_4]\oplus 0.12\times[s_1,s_2]=[s_{-2.39},s_{-0.09}],$$

$$\tilde{z}_3(\omega)=0.10\times[s_3,s_4]\oplus 0.05\times[s_2,s_3]\oplus 0.10\times[s_3,s_5]\oplus 0.2\times[s_3,s_4]\oplus 0.05\times[s_4,s_5]\oplus$$
$$0.13\times[s_4,s_5]\oplus 0.15\times[s_3,s_5]\oplus 0.10\times[s_2,s_3]\oplus 0.12\times[s_4,s_5]=[s_{3.15},s_{4.4}],$$

$$\tilde{z}_4(\omega)=0.10\times[s_{-2},s_{-1}]\oplus 0.05\times[s_0,s_2]\oplus 0.10\times[s_1,s_2]\oplus 0.2\times[s_2,s_3]\oplus 0.05\times[s_3,s_4]\oplus$$
$$0.13\times[s_2,s_3]\oplus 0.15\times[s_3,s_4]\oplus 0.10\times[s_0,s_1]\oplus 0.12\times[s_1,s_3]$$
$$=[s_{1.28},s_{2.75}],$$

$$\tilde{z}_5(\omega)=0.10\times[s_{-3},s_{-2}]\oplus 0.05\times[s_1,s_2]\oplus 0.10\times[s_{-2},s_{-1}]\oplus 0.2\times[s_{-1},s_0]\oplus 0.05\times[s_0,s_2]\oplus$$
$$0.13\times[s_0,s_1]\oplus 0.15\times[s_1,s_2]\oplus 0.10\times[s_2,s_3]\oplus 0.12\times[s_0,s_2]=[s_{-0.3},s_{0.87}].$$

Step 3: The possibility degree p_{ij} among the integrative attribute estimation level $\tilde{z}_i(\omega)(i=1,2,\ldots,5)$ of every repair enterprise can be calculated with the possibility formula

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$$p(\tilde{\mu} \geq \tilde{\nu}) = \max\left\{1 - \max\left(\frac{d-a}{l_{ab}+l_{cd}}, 0\right), 0\right\}$$

,

then the possibility matrix P is obtained as did Xu Z S (2003).

$$p_{1j} = \{0.5, 1, 0.0667, 0.6429, 1\}$$

$$(j = 1, 2, ..., 5)$$

$$p_{2j} = \{0, 0.5, 0, 0, 0.0605\} \quad (j = 1, 2, ..., 5)$$

$$p_{3j} = \{0.9333, 0, 0.5, 1, 1\} \quad (j = 1, 2, ..., 5)$$

$$p_{4j} = \{0.2159, 1, 0, 0.5, 1\} \quad (j = 1, 2, ..., 5)$$

$$p_{5j} = \{0, 0.9395, 0, 0, 0.5\} \quad (j = 1, 2, ..., 5)$$

i.e., the possibility matrix is:

$$P = \begin{bmatrix} 0.5 & 1 & 0.0667 & 0.6429 & 1 \\ 0 & 0.5 & 0 & 0 & 0.0605 \\ 0.9333 & 0 & 0.5 & 1 & 1 \\ 0.2159 & 1 & 0 & 0.5 & 1 \\ 0 & 0.9395 & 0 & 0 & 0.5 \end{bmatrix}$$

.

Step 4: With the zone number queue formula, the queue vector of possibility matrix P is $v = (0.2355, 0.1033, 0.2467, 0.2108, 0.1470)$. Then by queuing each level of vectors, the ability sequence of different repair enterprises is $x_3 \succ x_1 \succ x_4 \succ x_5 \succ x_2$.

That is, to the component FMC, the repair ability of repair enterprise x_3 among the five repair enterprises is the best.

4. RESULTS AND DISCUSSION

After the above analyses, the flow chart of estimation method based on the UEWAA operator is shown as Figure 3. With the chart it's clear for everyone how to use the UEWAA operator to make an estimation.

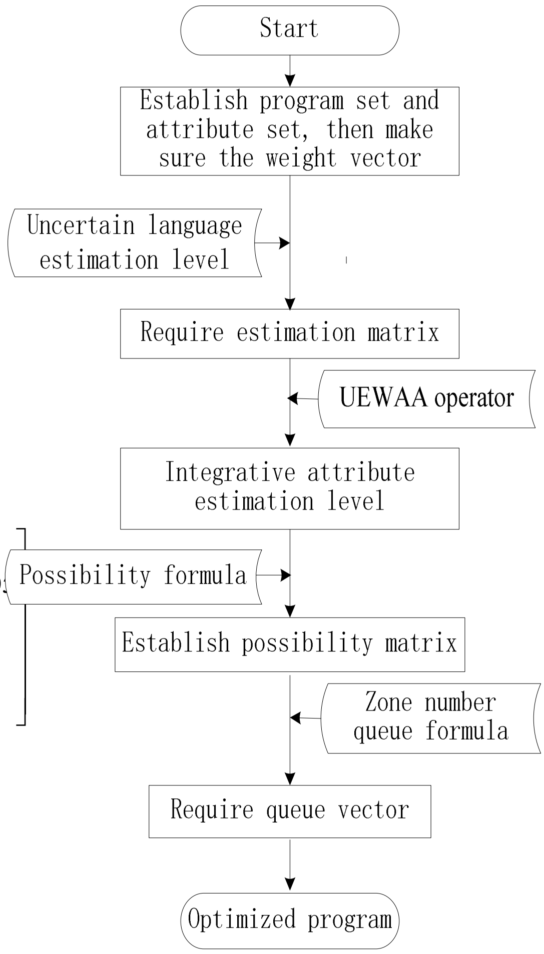

Figure 3: Flow Chart Of Estimation Method Based On The UEWAA Operator

Through the above applied example, the estimation method based on the UEWAA operator is validated. However, the estimation result for the example is theoretically calculated by the mathematics method. Its truth is still depended on the fact, which means that the estimation method only supplies a kind of computational way to help relative companies to make a decision.

For the UEWAA operator itself, there are some uncertainties in it. For the weight vector, it shows subjective, which means if the weights change the results will change. Hence, it's important to deeply consider how to make sure the weight vector.

And for the attribute set, they are changed in different applied examples, which should take right attributes into account.

Furthermore, the uncertain language estimation level is subjective, which is not very accurate and should influence the accuracy of estimation results.

In a word, this estimation method based on the UEWAA operator can only supply the decision-

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maker a reference since it has so many uncertain and subjective factors. And the validation criteria of this method depends if the calculated result is according with the real case.

5. CONCLUSION

This paper introduces a kind of uncertain multi-attribute decision method—estimation method based on a UEWAA operator [8]. Then, with the component repair of FMC as an example, the availability of this method is validated. At the same time the flow chart of estimation method is given.

With its application to engineering practices, the following things should be noticed.

(1) This method can only supply the decision-maker a reference, which it need math the calculated result with the real case.

(2) By changing the estimation attributes, different estimation result would be obtained. That satisfies the different demand of different companies.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Table 1: Estimation Matrix $\tilde{R}$

Repair enterprise	l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9
x_1	$[s_0, s_2]$	$[s_1, s_3]$	$[s_{-3}, s_{-1}]$	$[s_2, s_4]$	$[s_3, s_4]$	$[s_2, s_4]$	$[s_3, s_4]$	$[s_3, s_4]$	$[s_2, s_4]$
x_2	$[s_{-1}, s_0]$	$[s_{-5}, s_{-3}]$	$[s_{-3}, s_{-2}]$	$[s_0, s_2]$	$[s_{-1}, s_1]$	$[s_3, s_4]$	$[s_2, s_3]$	$[s_2, s_4]$	$[s_1, s_2]$
x_3	$[s_3, s_4]$	$[s_2, s_3]$	$[s_3, s_5]$	$[s_3, s_4]$	$[s_4, s_5]$	$[s_4, s_5]$	$[s_3, s_5]$	$[s_2, s_3]$	$[s_4, s_5]$
x_4	$[s_{-2}, s_{-1}]$	$[s_0, s_2]$	$[s_1, s_2]$	$[s_2, s_3]$	$[s_3, s_4]$	$[s_2, s_3]$	$[s_3, s_4]$	$[s_0, s_1]$	$[s_1, s_3]$
x_5	$[s_{-3}, s_{-2}]$	$[s_1, s_2]$	$[s_{-2}, s_{-1}]$	$[s_{-1}, s_0]$	$[s_0, s_2]$	$[s_0, s_1]$	$[s_1, s_2]$	$[s_2, s_3]$	$[s_0, s_2]$