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Research on Evaluation of Intelligent Equipment Support Scheme Based on Intuitionistic Fuzzy Multi-Attribute

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Abstract. How to scientifically evaluate the intelligent equipment support scheme is the key and difficult point of intelligent equipment support, and the evaluation conclusion is very important for intelligent equipment maintenance support and supply activities. This paper focuses on the characteristics of intelligent equipment support, and puts forward the evaluation theory and method based on intuitionistic fuzzy multi-attribute decision making. From the calculation steps of the evaluation model and the results of the case analysis, it can be seen that the scientific and feasible problems of the intelligent equipment support scheme can be solved, and the scientific nature of the intelligent equipment support scheme can be improved.

Keywords. Equipment support, intuitionistic fuzzy, multi-attribute decision making, scheme evaluation

1. Introduction

The intelligent equipment support scheme is the necessary guarantee for all kinds of equipment support activities of intelligent equipment. Usually, according to the requirements of intelligent equipment support and the actual conditions of equipment support in the process of carrying out the task, according to the orders and instructions of superior commanders and equipment support institutions, several practical intelligent equipment support schemes are formed, such as the basic scheme, feasible scheme and optimal scheme of intelligent equipment support [1][2]. How to evaluate and optimize these intelligent equipment support schemes is the basic premise for further assisting commanders to make determinations, make equipment support plans, and efficiently complete equipment support operations. At present, due to the complexity of intelligent equipment technology, the requirements for equipment support force application, equipment spare parts reserve supply, and equipment support methods are high [3]. Therefore, there are many factors to consider in formulating intelligent equipment support plans, involving complex variable factors. In addition, the understanding of the structure of intelligent equipment support scheme is not comprehensive and detailed enough [3]. The selection method of multiple intelligent equipment support schemes formed is usually limited to the research and discussion between commanders. The quality of different intelligent equipment support schemes depends more on the experience of commanders at all levels [4]. The judgment has not yet formed an effective

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scientific method to evaluate the intelligent equipment support scheme scientifically and reasonably, select a more scientific and reliable scheme, and provide a more reliable basis for the intelligent equipment support action.

Fuzzy mathematics has been widely used in the evaluation of combat effectiveness of equipment, service assessment, army adaptability and so on. The traditional fuzzy comprehensive evaluation method is not flexible enough. But, intuitionistic fuzzy theory has obvious advantages in dealing with heterogeneous multi-attribute comprehensive evaluation problems. Many scholars at home and abroad have proposed a variety of intuitionistic fuzzy aggregation operators and intuitionistic fuzzy number ranking methods, and applied them to multi-attribute decision-making problems, and achieved fruitful research results. this paper studies the evaluation and decision-making of intelligent equipment support scheme by means of intuitionistic fuzzy theory and multi-attribute decision-making method [5][6].

The decision-making of intelligent equipment support scheme based on intuitionistic fuzzy multi-attribute dec ision-making method is based on the factors that affect the evaluation and decision-making of intelligent equipment support [7]. According to the combination of qualitative and quantitative characteristics of each index value, the influence weight of each index is determined by intuitionistic fuzzy membership of each index value, and finally the equipment support scheme is sorted by the value of decision rule.

2. Intuitionistic fuzzy set knowledge

Intuitionistic fuzzy set theory is an extension of fuzzy set theory, which considers the information of membership degree, non-membership degree and hesitation degree, and can more objectively reflect the fuzziness of events. Intuitionistic fuzzy multi-attribute decision-making is to use intuitionistic fuzzy sets to solve multi-attribute decision-making problems, which can effectively deal with decision-making problems with uncertain information [8][9]. Aiming at the multi-attribute decision-making problem of uncertain information in the evaluation process of intelligent equipment support scheme, this paper adopts intuitionistic fuzzy multi-attribute set to deal with it.

Firstly, the interval intuitional fuzzy score matrix of each attribute is constructed. Then the weight of decision maker is obtained according to interval intuitionistic fuzzy entropy. Then, the interval intuitionistic fuzzy comprehensive decision matrix is obtained by using the interval intuitionistic fuzzy set integration operator and decision maker weight. Thirdly, according to the obtained interval intuitionistic fuzzy comprehensive decision matrix, the weight of each attribute is obtained by using the maximum deviation method, and the score interval matrix of each scheme is obtained by improving the score function. Finally, the decision maker attribute is integrated with the score interval matrix to calculate the final score of each scheme. Calculating the score is worth making a final ranking of the alternatives.

Intuitionistic fuzzy multiple attribute decision making is an extension of multiple attribute decision making. The basic model of fuzzy multiple attribute decision making can be described as follows:

We assume X is a non-empty set, it is called an intuitionistic fuzzy set. We call Intuitionistic $A = \{\langle x,\ \mu_A(x), v_A(x)\rangle | x \in E\}$ fuzzy sets. In part of it $\mu_A(x)$ and $v_A(x)$ They are the membership degree and non-membership degree of the elements in the X set respectively. That is:

$$\mu_A(x) : X \to [0,1], x \in X \to \mu_A(x) \in [0,1] \tag{1}$$

$$v_A(x) : X \to [0,1], x \in X \to v_A(x) \in [0,1] \tag{2}$$

And also to be satisfied $0 \le v_A(x) + {}_A(x) \le 1, x \in X, \pi_A(x) = 1 - \mu_A(x) - v_A(x), x \in X$, It indicates that the element x in X belongs to the hesitancy or uncertainty of A.

Algorithms between intuitionistic fuzzy numbers:

We assume $\alpha = (\mu_a, v_a), \alpha_1 = (\mu_{\alpha 1}, v_{a1})$, $\alpha_2 = (\mu_{\alpha 2}, v_{a2})$, They are intuitionistic fuzzy numbers respectively.

$$①\alpha_1 \oplus a_2 = (\mu_{\alpha 1}(x) + \mu_{a2}(x) - \mu_{\alpha 1}(x)\mu_{a2}(x), v_{a1}(x)v_{a2}(x))$$

$$②\alpha_1 \otimes a_2 = (\mu_{\alpha 1}(x)\mu_{a2}(x), v_{a1}(x) + v_{a2}(x) - v_{\alpha 1}(x)v_{a2}(x)$$

$$③\lambda\alpha = (1 - (1 - \mu_\alpha(x)^n), (v_a(x)^n))$$

$$④\alpha^\lambda = (\mu_a(x)^\lambda, 1 - (1 - v_a(x)^\lambda)$$

For any intuitionistic fuzzy number $x = (\mu_x, v_x)$

3. Intuitionistic fuzzy multiple attribute decision making method

The mathematical expression of intuitionistic fuzzy multi-attribute decision making method is:

Assume that $A = \{A_1, A_2, \cdots, A_m\}$ is m alternative equipment support schemes. $G = \{G_1, G_2, \cdots, G_m\}$ is n independent attributes. $\omega = (\omega_1, \omega_2, \cdots, \omega_n)^T, \omega_j \in [0,1] (j = 1,2, \cdots, n)$ is the weight of attributes.

It satisfies the following constraints, $\sum_{j=1}^n \omega_j^2 = 1$, According to the multi-attribute decision making method, the calculation steps of intuitionistic fuzzy decision making are constructed.

$$①E_j = \sum_{i=1}^{n} \frac{min(\mu(r_{ij}), v(r_{ij})) + \pi(r_{ij})}{max(\mu(r_{ij}), v(r_{ij})) + \pi(r_{ij})}$$

$$②z_i(\omega) = \sum_{i=1}^{n} r_{ij}\, \omega_j, i \in \{1,2, \cdots, n\}$$

$$③S_i(x) = \mu_i + \frac{1 + \mu_i - v_i}{2}$$

It is assumed that the precise and fuzzy concepts in decision-making problems can be expressed by trapezoidal fuzzy numbers, and the fuzzy utility function is in the form of simple weighted average, that is:

$$\widetilde{U}_i = \sum_{j=1}^n \widetilde{w}_j \cdot \tilde{x}_{ij} / \sum_{j=1}^n \widetilde{w}_j, i = 1, 2, \cdots, m \tag{3}$$

4. Case analysis

The intelligent equipment support scheme is the necessary support for various maintenance and supply activities, and it is the basic premise to further assist the commander to make a determination and make a good equipment support plan. It is assumed that the preliminary determined intelligent equipment support scheme isA_1, A_2, A_3, A_4.According to the determination requirements of the superior equipment support agency, multiple equipment support schemes are often formed. In the combat preparation stage, the understanding of equipment support scheme is not comprehensive and detailed enough [10]. The selection method of multiple equipment support schemes is usually limited to the discussion between commanders. The quality of a scheme depends more on the experience of commanders at all levels. There is no effective method to form a more reasonable interpretation of the support scheme. It can not be measured by a strict standard, but a vague concept. Therefore, the fuzzy decision method is introduced to determine the maintenance plan. The equipment support plan is the commander 's organized planning of all aspects of support activities during the combat preparation process [11][12]. The paper starts from the importance of the content elements of the plan relative to the equipment support effect, and establishes the evaluation index on the basis of the structural analysis of the equipment support plan.

Table 1. Scale judgment of content elements of intelligent equipment support scheme

Importance	Scale explanation
1	The importance of indicators is the same
3	The former is slightly more important than the latter
5	The former is important than the latter
7	The former is more important than the latter
9	The former is very important than the latter
Reciprocal of the scale	Comparing the two elements of the same level, the former is less important than the latter.

Then, the scale comparison matrix Q can be obtained by referring to Table 1.

$$Q = \begin{bmatrix} q_{11} & q_{12} & \cdots & q_{1n} \\ q_{21} & q_{22} & \cdots & q_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ q_{n1} & q_{n2} & \cdots & q_{nn} \end{bmatrix} \tag{4}$$

It is assumed that the set of intelligent equipment support schemes is $A = \{A_1,\ A_2,\ A_3\}$.

Through the commander 's research and discussion, the integrated intelligent equipment support scheme needs to analyze the relevant equipment support instructions of the level and the superior, the analysis of the enemy situation in the battlefield, the analysis of the current situation of various equipment support forces and combat forces, and the systematic and targeted formulation of various support elements [6]. Tasks, equipment methods, action methods, etc. are analyzed. Considering the influence of intelligent equipment support conditions, equipment reserve supply, equipment support force use and performance reliability.

The following indicators are selected to form the attribute set: C_1 is equipment support ability, C_2 is availability, C_3 is security risk, C_4 is support effectiveness, C_5 is material damage supply.

Establish equipment support attribute set $C = \{C_1, C_2, C_3, C_4, C_5\}$. The evaluation results of guarantee scheme and decision attribute can be obtained, as shown in Table 2.

Table 2. Guarantee the evaluation results of scheme set and attribute set

Support plan	C1	C2	C3	C4	C5
A1	good	More good	good	good	general
A2	general	general	general	good	More good
A3	bad	worse	bad	general	general
A4	general	general	general	general	Very good

Suppose that there are four intelligent equipment support schemesA_1, A_2, A_3, A_4.

The scientificity, reliability and feasibility of the guarantee scheme are considered when making decisions. Through statistical analysis, three intuitional fuzzy decision matrices satisfying the constraint conditions are obtained, as shown in Table 3.

Table 3. The corresponding relationship between qualitative description and fuzzy number membership function

	Scientific	Reliability	Feasibility
A1	$(0.50, 0.35)$	$(0.55, 0.25)$	$(0.35, 0.35)$
A2	$(0.65, 0.25)$	$(0.75, 0.15)$	$(0.20, 0.55)$
A3	$(0.25, 0.5)$	$(0.35, 0.35)$	$(0.35, 0.35)$
A4	$(0.45, 0.15)$	$(0.50, 0.50)$	$(0.45, 0.35)$

5. Conclusion

The formulation of intelligent equipment support scheme involves many aspects of evaluation indexes [13]. The evaluation standards of different indexes are quite different, and cannot be completely measured by a judgment standard. It is necessary to introduce the method of fuzzy decision-making to comprehensively evaluate the limited maintenance scheme, which belongs to the concept of fuzzy evaluation. The decision matrix is given by using the method of qualitative and quantitative description, and it is feasible to introduce the intuitionistic fuzzy multi-attribute decision-making method to comprehensively analyze and evaluate the scheme.

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