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A Dynamic Interval Decision-Making Method Based on GRA

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Abstract

According to the basic theory of grey relational analysis, this paper constructs a three-dimensional grey interval relation degree model for the three dimensions of time, index and scheme. On its basis, it sets up and solves a single-targeted optimization model, and obtains each scheme's affiliate degree for the positive/negative ideal scheme and also arranges the schemes in sequence. The result shows that the three-dimensional grey relation degree simplifies the traditional dynamic multi-attribute decision-making method and can better resolve the dynamic multi-attribute decision-making method of interval numbers. Finally, this paper proves the practicality and efficiency of the model through a case study.

Keywords:grey system; interval number; grey relational analysis; dynamic multi-attribute decision-making

1.Introduction

Grey relational analysis is one of the main contents of grey system theory [1], which is an analytical method based on grey relation space and better fuses the features of metric space and topological space. Its basic idea is to judge the inter-factor relation degree according to the proximity and similarity degree of the order change between curves. Owing to the fact that the grey relation degree does not impose high requirements for the size of the samples and does not need typical distribution rules and has small computational amount and the results of qualitative and quantitative analysis can be matched, which can widely applied in the management decision-making field.

In the social and economical lives, there exist a large number of comprehensive decision-making problems of complicated system influenced by dynamic multi-attribute indexes. The basic features of such kind of problems are to add the time space on the basis of decision space and target space and are the three-dimensional decision sequential problems of time, index and scheme. As for such problems, we can not directly use the grey relation degree. Literature [2] combines the ideal point method of multi-attribute decision-making and the extended grey relation degree to apply the grey relational analysis to the dynamic multi-attribute decision-making for the first time. On the basis of Literature [3] utilizes the square and minimum of relation dissimilarity degree to ascertain the affiliate degree and improves the resolution of the ordering results. Literature [4] gives three kinds of relation coefficients and selects

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different types of relation coefficients according to the features of different indexes and also gives the decision sorting and total sequencing in each time quantum, but this method has strong subjective element, so the ordering result is different from that of Literature [2]. Literature [5] takes development character into consideration and utilizes the "rewards and punishment" principle to have a preliminary process of the indexes and constructs an optimized index system and ensures the weight of each index in the optimized index system. But owing to the difference of index weight, the ordering result is also different from Literature [2]. Literature[6] uses the vague concept and the theoretical ideas of setting pair analysis to propose a linear transformation operator [-1,1] that is easy to calculate and is quite practical and uses this method to seek the negative/positive ideal scheme in each time quantum and establishes a decision-making model based on the dynamic multi-attribute grey relational analysis.

The already existed interval number relation decision–making models[7-8] separate the interval number decision matrix into upper-bound matrix and lower-bound matrix and then uses the upper-bound and lower-bound matrixes and their relation with the virtual positive ideal scheme and negative ideal scheme to set up optimization decision model. By doing this, the original interval number is separated purposefully and makes the result not match the reality. So according to the theory of grey relation degree, the nearer of the geometry of the sequence curves, the more they will correlate with each other and constructs a grey interval relation model based on the three dimensions of time, index and scheme. Combined with ideal point method of the multi-attribute decision, through the computation of interval number relation degree in order to set up an optimized affiliate degree model, this paper tries to seek the best decision scheme of the dynamic multi-attribute decision problem with interval numbers.

2.The processing methods for standardization of the interval number decision matrix

Definition 1 Assume that multi-attribute decision problem has n evaluation objects or formulated decision schemes to form the scheme set S, $S = \{S_1, S_2, \cdots, S_n\}$; m evaluation indexes or attributes form a index set A, $A = \{A_1, A_2, \cdots, A_m\}$; the attribute value of scheme S_i for index A_j is $[x_{ij}^L, x_{ij}^U]$ $(i = 1,2,\cdots,n;\ j = 1,2,\cdots,m)$. So the interval number decision matrix of scheme set S for index set A is

$$X = \begin{bmatrix} [x_{11}^L, x_{11}^U] & [x_{12}^L, x_{12}^U] & \cdots & [x_{1m}^L, x_{1m}^U] \\ [x_{21}^L, x_{21}^U] & [x_{22}^L, x_{22}^U] & \cdots & [x_{2m}^L, x_{2m}^U] \\ \cdots & \cdots & \cdots & \cdots \\ [x_{n1}^L, x_{n1}^U] & [x_{n2}^L, x_{n2}^U] & \cdots & [x_{nm}^L, x_{nm}^U] \end{bmatrix} \quad (1)$$

The index attribute set $A = \{A_1, A_2, \cdots, A_m\}$ generally can be divided into two types, namely "benefit type" and "cost type". The "benefit type" index means that the larger the value is, the better the value is; while the "cost type" index means that the smaller the value is, the better the value is.

Owing to the fact that the index centralized indexes have different dimensions, when making a decision, it is hard to compare them directly, so we need to have a normalization process with the original decision matrix:

If A_j is benefit type index, then

$$r_{ij}^L = \frac{x_{ij}^L}{\sum_{i=1}^{n} x_{ij}^U}, r_{ij}^U = \frac{x_{ij}^U}{\sum_{i=1}^{n} x_{ij}^L} \quad (2)$$

If A_j is cost type index, then