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Robustness Analysis Model for MADM Methods Based on Cloud Model

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Abstract

MADM method is the basic theory for Effectiveness evaluation. The fuzziness of methods and uncertainty of data have a crucial influence in making optimization decision. How to quantify the influence is an important theoretical problem that needs urgent solution in making robust evaluation. In this paper, cloud model is combined to build up MADM model, which is used to make evaluation as applicable MADM, determine applicable space of evaluation methods to subjects, and make optimization decision to enhance the robustness of evaluation results.

Keywords: Effectiveness Evaluation (EE); Cloud Model; Multi-attribute Decision-making (MADM); Robustness Grade Domain(RGD)

1. Introduction

Multi-attribute decision-making (MADM) method refers to the method of utilizing different data sources comprehensively to select optimization alternative. Single MADM method may make useful evaluation and quantification to alternative in specific operation environment. However, the findings in experiments represent, on the one hand, the same MADM method may lead to different results in Effectiveness Evaluation (EE) to the same alternative with different data; on the other hand, different MADM methods provide different expressions according to data of the same alternative, both of which increase the uncertainty of optimization decision based on results from MADM method[1].

Currently, there are many researches on MADM method of EE, and some MADM methods are mature quietly such as ADC[2], SEA[3], TPSIS[2,4], linear weighting[2,5], utility function[5], etc. But there are few researches on why the method is selected, how credibly the research result is, and on comparison among results from the same method, comparison among results from different methods. The reliability of MADM method is the premise of evaluation, which should be stressed. The risk of MADM method for alternative optimization represents that the intervention of different methods on evaluation alternative makes the expected optimization alternative not to be the optimal one

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possibly. Thus it's necessary to do some research on the applicability of MADM method, by which MADM method we can get the most credible optimization result.

When analyzing the robustness of MADM method, the following factors should be considered firstly, such as the subjectivity of choosing method, the fuzziness of solution process and the randomization of evaluating data, all those are the main factors which bring the uncertainty of MADM method. Cloud model can reduce this uncertainty caused by fuzziness and randomization of data. Thus, cloud model may be introduced to quantify the robustness of MADM method.

Combining with some relative research[6], the relative quantification on how to select and judge MADM method is investigated in this paper, which deepens the robustness analysis of MADM problem.

The purpose of this study is to make dynamic evaluation on how to select evaluation methods applicable to specific evaluation environment and requirements to MADM methods. Robustness analysis results of MADM methods can be referred to select optimization alternative for evaluation.

2. Cloud Model

As academician Li Deyi said in his paper, when someone makes subjective perception of objective world, randomization of fuzziness are important factors to uncertain perception, and it is difficult to differentiate[7]. Cloud model is built on the basis of random and fuzzy mathematic theory, describes the linguistic value's randomization, fuzziness and the correlation of the two, which can realize the conversion between qualitative concepts of linguistic value's description and the uncertainty of quantitative value's description.

Cloud and cloud droplet[7]: suppose that *U* is a quantitative domain of value, *C* is a qualitative concept of *U*. If $x \in U$ is a random value in *C*, the degree of certainty x for *C*, $\mu(x) \in [0,1]$ is a random value of robustness tendency, where $\mu : U \to [0,1], \forall x \in U, x \to \mu(x)$. Then the distribution of *x* in the domain *U* is called Cloud, written as *C(x)*. And each *x* is called a cloud droplet. If the corresponding domain is n-dimensional space, n-dimensional cloud would be formed.

Cloud defined above has three important characters as follows:

(1) Cloud is the distribution of a random variable *X* in the quantitative domain *U*, but *X* is not a simple random variable in probabilistic sense. For a random realizasion of *X*, $\forall x \in U, x$ has a degree of certainty, which is a random variable, not a fixed value.

(2) Cloud is consisted of cloud droplets, and there is no sequence among cloud droplets. A cloud droplet is a realization of qualitative concepts in quantity; the whole droplets can reflect the feature of concepts. So the more the cloud droplets are, the better the overall characteristic presents.

(3) The certainty degree of cloud droplets can be regarded as the degree the cloud droplets represent qualitative concepts. The more possible the cloud droplets appear, the larger the certainty degree of cloud droplets.

The overall characteristics of concepts presented by cloud may be reflected by the numerical characteristics of cloud, i.e. using *Ex*(Expectation), *En*(Entropy), and *He* (Hyper Entropy) to describe the overall characteristics of a concept. *Ex* is the point representing the mean value in domain space, or the most typical sample of quantitative concept; *En* stands for the measurement of uncertainty in domain space, which depends on both the randomness and fuzziness of concepts; *He* the measurement of uncertainty of *En*, which canbe called the entropy of entropy, and depends on both the randomness and fuzziness of entropy. The overall characteristics of domain described by three numerical characteristics is written as *C*(*Ex, En, He*), which is called characteristics vector of the cloud.

One-dimensional normal cloud[8]: Suppose that *U* is a quantitative domain described by accurate value, *C* is a qualitative concept in *U*, the quantitative value x satisfies $x \in U$, and x is a random realization of qualitative concept C. If x satisfies: $x \sim N(Ex, En'^2)$, $En' \sim N(En, He^2)$, the certainty of x to *C* satisfies the following formula:

$$\mu = e^{{(x-Ex)^2}/{2(En')^2}} \tag{1}$$

Then, the distribution of x in *U* is called normal cloud. The document[9] had made deep analysis and discussion on the universality that the normal cloud is used in uncertain information. According to the approach put forward in documents and the matching degree of sorting of alternative scheme from calculation, one-dimensional normal