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A GRA-based intuitionistic fuzzy multi-criteria group decision making method for personnel selection ☆

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ABSTRACT

Due to the increasing competition of globalization, selection of the most appropriate personnel is one of the key factors for an organization's success.The importance and complexity of the personnel selection problem call for the method combining both subjective and objective assessments rather than just subjective decisions. The aim of this paper is to develop a new method for solving the decision making process. An intuitionistic fuzzy multi-criteria group decision making method with grey relational analysis (GRA) is proposed. Intuitionistic fuzzy weighted averaging (IFWA) operator is utilized to aggregate individual opinions of decision makers into a group opinion. Intuitionistic fuzzy entropy is used to obtain the entropy weights of the criteria. GRA is applied to the ranking and selection of alternatives. A numerical example for personnel selection is given to illustrate the proposed method finally.

1. Introduction

Personnel selection is the process of choosing, among the candidates applying for a defined job in the company, the ones who have the qualifications required to perform the job in the best way. It is one of the chief phases of human resources management. With the increasing competition in the global market, modern organizations face great challenges. The future survival of companies depends mainly on the contribution of their personnel to companies. Employee or personnel performances such as knowledge, capability, skill and other abilities play an important role in the success of an organization. Therefore, in order to remain a place in the market, it is necessary for companies to put more emphasis on personnel selection process.

Personnel selection process should provide reliable and valid information about candidates. There are some traditional techniques used in this process, mainly, completion of application forms, initial interview, employment test and background investigation (Robertson & Smith, 2001). These traditional methods generally come to a conclusion on the basis of the subjective judgment of decision makers, which makes the accuracy of the results highly questionable. In order to select the most suitable personnel to perform the defined job, combining the subjective judgment and the objective analysis to develop effective selection approaches is very critical. The multi-criteria nature of the problem makes Multi-Criteria Decision Making (MCDM) methods and fuzzy logic ideal cope with this. Several authors have used some MCDM methods and the fuzzy set theory to deal with the personnel selection problem. Liang and Wang (1994) developed an fuzzy MCDM algorithm for personnel selection. Chen and Cheng (2005) proposed a fuzzy group decision support system based on metric distance method to solve the information system in personnel selection problem. Karsak (2001) presented a fuzzy MCDM approach based on ideal and anti-ideal solutions for the selection of the most suitable candidate. Gibney and Shang (2007) and Güngör, Serhadlıoğlu, and Kesen (2009) described the use of the analytical hierarchy process (AHP) in the personnel selection process, respectively. Dağdeviren (2010) proposed a hybrid model which employs analytical network process (ANP) and modified TOPSIS for supporting the personnel selection process in the manufacturing systems. Dursun and Karsak (2010) presented a fuzzy MCDM approach by using TOPSIS with 2-tuples for personnel selection.

In the type of fuzzy multi-criteria model, Grey relational analysis (GRA) is suggested as a tool for implementing a multiple criteria performance scheme, which is used to identify solutions from a finite set of alternatives (Kuo, Yang, & Huang, 2008; Lin, Lee, & Chang, 2009; Tseng, 2010). Developed by Deng (1989), GRA is an impact evaluation model that can measure the degree of similarity or difference between two sequences based on the relation. The basic principle is as follows: if a comparability sequence translated from an alternative has the highest grey relational grade between the reference sequence and itself, then the alternative will be the best choice.

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This paper proposes an intuitionistic fuzzy multi-criteria group decision making method with GRA for personnel selection problem. All decision making information are difficult to precisely express by crisp date in the personnel selection problem. Intuitionistic fuzzy sets introduced by Atanassov (1986) are suitable ways to deal with this situation. And, in fact, it has been applied to many decision making problems under uncertain environment. In group decision making process, intuitionistic fuzzy weighted averaging (IFWA) operator proposed by Xu (2007) is utilized to aggregate all individual decision makers' opinions into a group opinion. Intuitionistic fuzzy entropy is used to obtain the entropy weights of the criteria. GRA method is one of the popular methods in multi-criteria decision making problem, since it can be operated and understood easily. Therefore, GRA method combines with intuitionistic fuzzy set, which has not been studied yet, has enormous chance of success for personnel selection process.

The remainder of this paper is organized as follows: Section 2 gives some basic concepts and related knowledge of IFSs. An intuitionistic fuzzy multi-criteria group decision making method based on GRA is developed in Section 3. In Section 4, a numerical example is presented to illustrate the proposed approach and demonstrate its feasibility and practicality. Finally, a short conclusion is given.

2. IFSs and related knowledge

2.1. IFSs

Firstly, let's introduce the concept of IFSs.

Definition 1. Let X be a fixed set, an IFS A in X is given by Atanassov (1986) as follows:

$$A = \{(x, \mu_A(x), \nu_A(x)) | x \in X\}, \tag{1}$$

where the functions $\mu_A(x)$: $X \to [0,1]$, $x \in X \to \mu_A(x) \in [0,1]$ and $\nu_A(x)$: $X \to [0,1]$, $x \in X \to \nu_A(x) \in [0,1]$ satisfy the condition $0 \leqslant \mu_A(x) + \nu_A(x) \leqslant 1$, for all $x \in X$.

The numbers $\mu_A(x)$ and $\nu_A(x)$ denote the degree of membership and the degree of nonmembership of the element $x \in X$ to the set A, respectively. In addition, $\pi_A(x) = 1 - \mu_A(x) - \nu_A(x)$ is called the intuitionistic fuzzy index of the element $x \in X$ in A, representing the degree of indeterminacy or the degree of hesitancy of x to A. It is obvious that $0 \leqslant \pi_A(x) \leqslant 1$, for all $x \in X$.

For convenience of computation, we call $\alpha = (\mu_\alpha, \nu_\alpha, \pi_\alpha)$ an intuitionistic fuzzy number (IFN), where $\mu_\alpha \in [0,1]$, $\nu_\alpha \in [0,1]$, $\mu_\alpha + \nu_\alpha \leqslant 1$, $\pi_\alpha = 1 - \mu_\alpha - \nu_\alpha$.

For an IFN $\alpha = (\mu_\alpha, \nu_\alpha, \pi_\alpha)$, if the value μ_α gets bigger and the value ν_α gets smaller, then the IFN α gets greater. Obviously, $\alpha^+ = (1,0,0)$ and $\alpha^- = (0,1,0)$ are the largest and the smallest IFNs, respectively.

2.2. Conversion between linguistic variables and IFNs

A linguistic variable is a variable whose value is natural language phrase. It is very useful in dealing with situations which are too complex or too ill-defined to be described properly in conventional quantitative expressions. For example, the ratings of alternatives with respect to qualitative criteria could be expressed using linguistic variables such as very good, good, fair, poor, very poor, etc. Such linguistic variables can be converted into IFNs in Table 1.

2.3. Distance between two IFNs

Similar to the normalized Hamming distance between IFSs, we define a distance measure between two IFNs as follows:

Table 1
Conversion between linguistic variables and IFNs.

Linguistic variables	IFNs
Extreme poor (EP)/Extreme low (EL)	(0.05,0.95,0.00)
Very poor (VP)/Very Low (VL)	(0.15,0.80,0.05)
Poor (P)/Low (L)	(0.25,0.65,0.10)
Medium poor (MP)/Medium Low (ML)	(0.35,0.55,0.10)
Fair (F)/Medium (M)	(0.50,0.40,0.10)
Medium good (MG)/Medium High (MH)	(0.65,0.25,0.10)
Good (G)/High (H)	(0.75,0.15,0.10)
Very good (VG)/Very high (VH)	(0.85,0.10,0.05)
Extreme good (EG)/Extreme high (EH)	(0.95,0.05,0.00)

Definition 2. Let $\alpha_1 = (\mu_{\alpha_1}, \nu_{\alpha_1}, \pi_{\alpha_1})$ and $\alpha_2 = (\mu_{\alpha_2}, \nu_{\alpha_2}, \pi_{\alpha_2})$ be two IFNs, then

$$d(\alpha_1, \alpha_2) = \frac{1}{2}(|\mu_{\alpha_1} - \mu_{\alpha_2}| + |\nu_{\alpha_1} - \nu_{\alpha_2}| + |\pi_{\alpha_1} - \pi_{\alpha_2}|) \tag{2}$$

is called the distance between α_1 and α_2 (Xu & Yager, 2008).

3. Proposed method

In this section, we develop a procedure for intuitionistic fuzzy multi-criteria group decision making using GRA.

For a multi-criteria group decision making problem, let $X = \{x_1, x_2, \ldots, x_m\} (m \geqslant 2)$ be a finite set of alternatives, $D = \{d_1, d_2, \ldots, d_t\} (t \geqslant 2)$ be a set of decision makers, and $C = \{c_1, c_2, \ldots, c_n\}$ be a set of criteria. The weight information of the criteria and the decision-makers are completely unknown. For simplicity, we denote $M = \{1,2,\ldots,m\}$, $N = \{1,2,\ldots,n\}$, $T = \{1,2,\ldots,t\}$.

Step 1. Construct intuitionistic fuzzy decision matrices of decision makers. Assume that the rating of alternative $x_i (i \in M)$ with respect to criterion $c_j (j \in N)$ given by the kth decision maker d_k $(k \in T)$ is linguistic variable $f_{ij}^{(k)}$, which can be expressed in IFS $r_{ij}^{(k)} = \left(\mu_{ij}^{(k)}, \nu_{ij}^{(k)}, \pi_{ij}^{(k)}\right)$ in Table 1. Hence, a multi-criteria group decision making problem can be concisely expressed in matrix format as follows:

$$R^{(k)} = \left(r_{ij}^{(k)}\right)_{m\times n} = \begin{bmatrix} r_{11}^{(k)} & r_{12}^{(k)} & \cdots & r_{1n}^{(k)} \\ r_{21}^{(k)} & r_{22}^{(k)} & \cdots & r_{2n}^{(k)} \\ \vdots & \vdots & & \vdots \\ r_{m1}^{(k)} & r_{m2}^{(k)} & \cdots & r_{mn}^{(k)} \end{bmatrix}, \quad k \in T, \tag{3}$$

where $r_{ij}^{(k)} = \left(\mu_{ij}^{(k)}, \nu_{ij}^{(k)}, \pi_{ij}^{(k)}\right)$.

Step 2. Determine the weights of decision makers. The importance of the decision makers are considered as linguistic variables, which can be expressed in IFNs in Table 2. Let $D_k = (\mu_k, \nu_k, \pi_k)$ be an intuitionistic fuzzy number for rating of the kth decision maker. Then the weight of the kth decision maker can be obtained (Boran, Genc, Kurt, & Akay, 2009) as:

Table 2
Linguistic variables for the importance of decision makers.

Linguistic variables	IFNs
Very importance	(0.90,0.05,0.05)
Importance	(0.75,0.20,0.05)
Medium	(0.50,0.40,0.10)
Unimportance	(0.25,0.60,0.15)
Very unimportance	(0.10,0.80,0.10)