A New Interval Type-2 Fuzzy Decision Method with an Extended Relative Preference Relation and Entropy to Project Critical Path Selection

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ABSTRACT

Considering uncertainty in multi-criteria decision making (MCDM) is an important issue in today’s business and management problems. In this article, to use advantages of IT2FSs, a novel interval type-2 fuzzy multi-criteria decision method is presented with an extended entropy and relative preference relation. To tackle vagueness and uncertainty of real-world problems, the IT2FSs are used and applied to a modified MCDM method. Furthermore, an entropy method is developed under an IT2F environment and for obtaining the final weight of each criterion, a relative preference relation is hybridized with an entropy method. Also, the weight of each decision maker (DM) is calculated by a new IT2F-order preference method by means of the relative closeness. Finally, an existing example about the project critical path selection by considering effective criteria, such as time, cost, quality and safety, is adopted from the literature and solved to indicate the capability of introduced method.

KEYWORDS

Entropy Method, Interval Type-2 Fuzzy Sets (IT2FSs), IT2F-Order Preference Relation, Multi-Criteria Analysis, Project Critical Path Selection

1. INTRODUCTION

Multi-criteria decision making (MCDM) is a useful way for decision making under conflict criteria. The MCDM methods assist to find the best alternative from a set of candidate alternative with considering conflicting criteria (Hashemi et al., 2013; Mousavi et al., 2014). One of the well-known classical MCDM methods is the technique for order of preference by similarity to ideal solution (TOPSIS). In past, classical MCDM methods were offered under precise environments, while in reality decision environments have vagueness and uncertainty (e.g., Vahdani et al., 2014; Gitinavard et al., 2016a, 2016b). Under many conditions, crisp data are inadequate to model real-life situations. The fuzzy sets theory is a powerful tool to deal with uncertainty which derives from real-world situations; in other words, the evaluation ratings and criteria weights are presented by fuzzy sets. TOPSIS method as well-known MCDM approach has been developed under fuzzy environment for group decision-making problems in last decade. Furthermore, a fuzzy TOPSIS approach based on subjective and objective weights presented by Wang and Lee (2009). Vahdani et al. (2013) introduced a modified TOPSIS method under interval-valued fuzzy sets, which could reflect both subjective judgments and objective information in real situations. Moreover, entropy method has been used in

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many case of TOPSIS method. Also, Yue (2011) developed TOPSIS method to compute the weight of each DM by interval fuzzy numbers for group decision-making problems.

The entropy method has been developed in recent years in fuzzy environments. For instance, Hwang et al. (2011) presented an entropy method based on Sugeno integral with an interval type-2 fuzzy (IT2F) environment. Zamri and Abdullah (2013) introduced a linguistic variable in IT2F entropy weight of a decision-making method. They used the distance concept and developed it to entropy method under an IT2F environment. Furthermore, Hafezalkotob and Hafezalkotob (2016) proposed a fuzzy entropy method based on Shannon entropy concept. They used defuzzification method at first of calculation entropy method.

To review the recent research in fuzzy MCDM area, Yu et al. (2017) proposed a satisfactory degree method by nonlinear programing for solving multi-attribute decision-making problems, in which ratings of alternatives on attributes were expressed via interval-valued intuitionistic fuzzy sets. Zhu and Li (2016) introduced a new axiomatical entropy for intuitionistic fuzzy sets. Also, Li and Ren (2015) developed an effective method for solving multi-attributes decision-making problems and a new ranking function in an intuitionistic fuzzy environment. Moreover, Li (2011) expressed a new closeness coefficient based nonlinear programing model for solving multi-attribute decision-making problems. Furthermore, Li (2014) published a book in the case of decision and game theory in the management with intuitionistic fuzzy sets.

In recent years, many fuzzy MCDM methods have been introduced. Interval-valued fuzzy (IVF) sets can provide more flexibility to represent the imprecise and vague information resulting from a lack of data (Vahdani et al., 2010; Mousavi et al., 2013). IVF-MCDM methods have been presented in several studies (e.g., Vahdani et al., 2013, 2014). Regarding to the recent MCDM methods under IVF sets, Kuo and Liang (2012) proposed a soft computing method of performance evaluation with MCDM based on IVF numbers. Moreover, Vahdani et al. (2014) presented a multiple criteria complex proportional assessment method for robot selection with IVF numbers. Furthermore, Mohagheghi et al. (2015) expressed an optimization model for project portfolio selection under an IVF environment. On the other hand, type-2 fuzzy set (T2FS) is more powerful than IVF sets and conventional fuzzy sets. The concept of a T2FS, initially expressed by Zadeh (1975), can be regarded as an extension of the concept of a type-1 fuzzy set. The main difference between the two kinds of fuzzy sets is that the membership of a type-1 fuzzy set are crisp numbers whereas the memberships of a type-2 fuzzy set are type-1 fuzzy sets. Hence, T2FSs involve more uncertainties than type-1 fuzzy sets.

Interval type-2 fuzzy sets who introduced by Mendel et al. (2006) is the most widely used type-2 fuzzy sets and have been successfully applied to many practical fields. In classical fuzzy MCDM to solve the problems, the defuzzification was used, but it causes loss of fuzzy messages. In addition, relative preference relation is a useful way to eliminate defuzzification issues. Relative preference relation has been used in several cases; for instance, Wang (2014) introduced a criteria weighting approach that combined the concepts of fuzzy quality function deployment and relative preference relation. Moreover, Wang (2015) presented a ranking method based on relative preference relation for triangle and trapezoidal fuzzy numbers.

Through the previous studies, fuzzy ranking methods are commonly classified into two varied categories. The first category is based on the defuzzification. Various methods of defuzzification have been proposed. In the first category, fuzzy numbers are often defuzzified into crisp numbers in the related literature. The ranking is then done based on these crisp numbers. Though it is easy to compute, the main drawback of this type is that defuzzification tends to loss some information, and thus, it is unable to grasp the sense of uncertainty. The other category is based on the fuzzy preference relation. The advantage of this type is that uncertainties of fuzzy numbers are kept during the ranking process. Yuan (1991) proposed the criteria for measuring ranking method. Lee (2000) developed a fuzzy ranking method based on fuzzy preference relation satisfying all criteria proposed by Yuan (1991). Also, Lee (2005) introduced a fuzzy multi-criteria decision making model for selection of distribution centers by means of fuzzy preference relation.
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