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ORIGINAL ARTICLE

A Centroid-based Ranking Method of Trapezoidal Intuitionistic Fuzzy Numbers and Its Application to MCDM Problems

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Abstract The objective of this paper is to introduce a novel method to compare trapezoidal intuitionistic fuzzy numbers (TrIFNs). Till now little research has been done regarding the ranking of TrIFNs. This paper first reviews the existing ranking methods and shows their drawbacks by using several examples. In order to overcome the drawbacks of the existing methods, a new ranking method of TrIFNs is developed by utilizing the concept of centroid point. For this purpose, centroid point for TrIFN is also defined. The rationality validation of the proposed centroid formulae is proved. Further, the ranking method is applied to a multi-criteria decision making (MCDM) problem in which the ratings of the alternatives on criteria are expressed with TrIFNs. Finally, the effectiveness and applicability of the proposed ranking method are illustrated with an aerospace research organization center selection example. This article has also justified the proposed approach by analyzing a comparative study.

Keywords Intuitionistic fuzzy number · Ranking · Centroid point · Multi-criteria decision making

1. Introduction

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An important generalization of classical fuzzy set theory [1] is the theory of intuitionistic fuzzy set (IFS), introduced by Atanassov [2]. Fuzzy set, projected as a framework for modeling uncertainty, assigns to each element of the universe of discourse a degree of membership between zero and one. The degree of non-membership is considered as complement to one of the membership degree. But IFS implicates the fact that the non-membership degree is not always complement to the membership degree. There may arise some hesitation degree and these membership, non-membership and hesitation degrees to an alternative can be suitably modeled by intuitionistic fuzzy values (IFVs) (which are the basic components of IFSs [3]). Thus, there are some situations where IFS theory is more suitable to deal with incomplete or inexact information present in real-world applications. Eventually, in less than three decades since its first appearance, IFS theory has been investigated by many authors and applied in different areas including decision making. Now in modeling a decision making problem, ranking is an important issue. In this regard, various ranking methods of IFSs have been proposed and used for decision making problems [3-16]. Nevertheless, the research concentrated on the finite universe of discourse only. In view of this, from the concept of IFSs, intuitionistic fuzzy numbers (IFNs) have been defined [17-22] with the universe of discourse as the real line. The domains of IFSs are discrete universe of discourses. The concept of IFNs can be viewed as an extensive approach to define an IFS in the case when available information is not sufficient enough to define a conventional IFS based on discrete sets. Moreover, in information integration process, discrete sets may loss partial information [23-26] while continuous sets maintain the integrity of information and, thus, are more capable to model incomplete and abundant information than discrete sets. With this view, extending the concept of discrete sets to continuous sets, IFNs have been defined which can more suitably model imprecise data involved in real-world decision making problems.

In recent times, IFNs have received increasing [22, 26-31] attention because of their ability to handle imprecise and abundant information in decision making situation. The aim of the present study is not to cover all the range of IFNs but merely to address the ranking of IFNs and its application to MCDM problems. Now, the traditional ranking methods for comparing IFSs cannot deal with IFNs, as the former is based on discrete sets and later on continuous sets. In this view, to rank and compare IFNs, several ranking methods have been proposed. In 2008, Nayagam et al. [32] introduced a new score function for ranking triangular IFNs (TIFNs) and further they modified it in [33]. Wang and Zhong [34] used both the score and accuracy functions to rank TrIFNs and developed an MCDM problem based on the proposed ranking process. By calculating normalized Hamming distances from IFNs to positive and negative ideal solutions, a ranking method was provided by Wei [35] and subsequently a group decision making problem was also investigated. Wei and Tang [36] proposed a method for ranking IFNs by utilizing possibility degree and applied it for solving an MCDM problem. A new ranking method was developed by Li [37] on the basis of the idea of a ratio to the value index and ambiguity index of TIFNs. By utilizing the same value index and ambiguity index, Dubey and Mehra [38] proposed a new ranking function to rank IFNs. Rezvani [39] also proposed a ranking process of TrIFNs by determining value and ambiguity of TrIFNs.