Aggregation Operators of Trapezoidal Intuitionistic Fuzzy Sets to Multicriteria Decision Making

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ABSTRACT
This paper presents the trapezoidal intuitionistic fuzzy weighted averaging (TIFWA) operator, trapezoidal intuitionistic fuzzy ordered weighted averaging (TIFOWA) operator, trapezoidal intuitionistic fuzzy weighted geometric (TIFWG) operator, and trapezoidal intuitionistic fuzzy ordered weighted geometric (TIFOWG) operator to aggregate the trapezoidal intuitionistic fuzzy information and investigates their properties. Furthermore, a multicriteria decision making method based on the TIFOWA and TIFOWG operators and the score function and accuracy function of a trapezoidal intuitionistic fuzzy number is established to deal with the multicriteria decision making problem with trapezoidal intuitionistic fuzzy information. Finally, an illustrative example demonstrates the application of the proposed method.

KEYWORDS
Accuracy Function, Multicriteria Decision-Making, Score Function, Trapezoidal Intuitionistic Fuzzy Aggregation Operators, Trapezoidal Intuitionistic Fuzzy Set

INTRODUCTION
Multi-criteria decision making (MCDM) is to select the optimal alternative which behaves best from a finite set of alternatives with multiple criteria. It is a major component of decision science, whose theory has been widely applied in the fields of economy, management, engineering, etc. Many approaches have been proposed to handle the MCDM problems, such as TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution), ELECTRE (Elimination and Choice Expressing REality), PROMETHEE. Later on, with the increasing complexity of the MCDM problems in real world, it may be necessary to take the decision makers (DMs)’ risk attitudes into consideration in the process of MCDM. The prospect theory, initiated by Kahneman and Tversky, is a descriptive theory for decision making under risk. This theory incorporates three significant aspects: (1) Reference dependence. The outcomes are manifested by gains and losses according to a reference alternative. (2) Diminishing sensitivity. For gains, the DMs are risk-averse. But for losses, they are risk-preference. (3) Loss aversion. The DMs are much more sensitive to losses than gains. On the basis of the prospect theory, Gomes and Lima first established a MCDM approach, called TODIM (an acronym in Portuguese for Interactive Multi-Criteria Decision Making), which is valid to solve the MCDM problems where the DMs’ psychological behaviours are considered.

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Since (Atanassov, 1986) introduced the concept of intuitionistic fuzzy set, which is a generalization of the concept of fuzzy set (Zadeh, 1965), a lot of intuitionistic fuzzy multicriteria decision making approaches (Chen, 2011) have been developed and applied to diverse fields, like engineering, management, economics, etc. (Burillo, Bustince & Mohedano, 1994) proposed the definition of an intuitionistic fuzzy number as a generalization of an intuitionistic fuzzy set and studied perturbations of intuitionistic fuzzy number and the first properties of the correlation between these numbers. (Mitchell, 2004) considered the problem of ranking a set of intuitionistic fuzzy numbers to define a fuzzy rank and a characteristic vagueness factor for each intuitionistic fuzzy number. (Shu, Cheng, & Chang, 2006) gave the definition and operational laws of intuitionistic triangular fuzzy number and proposed an algorithm of the intuitionistic fuzzy fault-tree analysis. (Wang, 2008) introduced an intuitionistic trapezoidal fuzzy number, which is the extending of an intuitionistic triangular fuzzy number. Intuitionistic triangular fuzzy numbers and intuitionistic trapezoidal fuzzy numbers are the extending of intuitionistic fuzzy sets in some way, which extend discrete sets to continuous sets, and they are all the extension of fuzzy sets. Based on the intuitionistic trapezoidal fuzzy number, (Wang & Zhang, 2009) defined intuitionistic trapezoidal fuzzy weighted arithmetic averaging operator and weighted geometric averaging operator, and proposed an intuitionistic trapezoidal fuzzy multicriteria decision-making method with known weights based on the expected values, score function, and accuracy function of intuitionistic trapezoidal fuzzy numbers. Then based on another intuitionistic trapezoidal fuzzy number defined by (Grzegorzewski, 2003), (Ye, 2011) proposed an expected value method for intuitionistic trapezoidal fuzzy multicriteria decision-making problems. Furthermore, (Ye, 2012) presented vector similarity measures for intuitionistic trapezoidal fuzzy numbers and applied them to multicriteria group decision-making problems.

On the other hand, (Liu & Yuan, 2007) introduced the concept of a triangular intuitionistic fuzzy set. The fundamental characteristic of the triangular intuitionistic fuzzy set is that the values of its membership function and nonmembership function are triangular fuzzy numbers rather than exact numbers. Then (Wang, 2008) proposed the triangular intuitionistic fuzzy weighted geometric (TIFWG) operator, triangular intuitionistic fuzzy ordered weighted geometric (TIFOWG) operator and triangular intuitionistic fuzzy hybrid geometric (TIFHG) operator and developed an approach based on the TIFWG and the TIFHG operators to deal with multiple attribute group decision making problems with triangular intuitionistic fuzzy information. (Wang, 2008) proposed the fuzzy number intuitionistic fuzzy weighted averaging (FIFWA) operator, fuzzy number intuitionistic fuzzy ordered weighted averaging (FIFOWA) operator and fuzzy number intuitionistic fuzzy hybrid aggregation (FIFHA) operator and developed an approach based on the FIFHA operator to deal with multiple attribute decision making problems with triangular intuitionistic fuzzy information. Furthermore, Wei et al. (Wei, Zhao and Lin, 2010) developed an induced triangular intuitionistic fuzzy ordered weighted geometric (I-TIFOWG) operator and applied the I-TIFOWG operators to group decision making problems with triangular intuitionistic fuzzy information. Hence, we can see that fuzzy number (triangular fuzzy number) intuitionistic fuzzy set is a very useful tool to deal with uncertainty. More and more multicriteria decision methods (Nan, Li, & Zhang, 2010; Li, 2010; Li, Nan, & Zhang, 2010; Chen, Zhang, & Jiao, 2010; Yue, Zou, Guo, & Wang, 2011; Qiu, 2011; John Robinson, Henry Amirtharaj, 2012; Wang, 2012) have been applied under triangular intuitionistic fuzzy environment. However, these decision-making methods do not deal with decision making problems with trapezoidal intuitionistic fuzzy sets. Then trapezoidal fuzzy number is a typical fuzzy number, which are preferred in practice (Wan & Dong, 2010; Wan, 2011; Wan, 2012), and also a triangular fuzzy number is a special case of a trapezoidal fuzzy number. Therefore, (Ye, 2014) extended triangular intuitionistic fuzzy sets to trapezoidal intuitionistic fuzzy sets and proposed prioritized aggregation operators of trapezoidal intuitionistic fuzzy sets and their decision-making methods. Recently, decisions making related applications are proposed (Hanratty, 2016; Grace, 2016; Kouah, 2016).

Some previous studies have paid attention to capture the DMs’ attitudinal characters in the MCDM problems, which are useful to depict the DMs’ attitudes towards the unknown and uncertain
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