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Intuitionistic fuzzy information aggregation under confidence levels

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ABSTRACT

In actuality, for example, the review of the National Science Foundation and the blind peer review of doctoral dissertation in China, the evaluation experts are requested to provide two types of information such as the performance of the evaluation objects and the familiarity with the evaluation areas (called confidence levels). However, existing information aggregation research achievements cannot be used to fusion the two types information described above effectively. In this paper, we focus on the information aggregation issue in the situation where there are confidence levels of the aggregated arguments under intuitionistic fuzzy environment. Firstly, we develop some confidence intuitionistic fuzzy weighted aggregation operators, such as the confidence intuitionistic fuzzy weighted averaging (CIFWA) operator and the confidence intuitionistic fuzzy weighted geometric (CIFWG) operator. Then, based on the Einstein operations, we proposed the confidence intuitionistic fuzzy Einstein weighted averaging (CIFEWA) operator and the confidence intuitionistic fuzzy Einstein weighted geometric (CIFEWG) operator. Finally, a practical example about the review of the doctoral dissertation in Chinese universities is provided to illustrate the developed intuitionistic fuzzy information aggregation operators.

1. Introduction

Fuzzy set (FS) theory proposed by Zadeh [1], is a powerful tool and has been applied to various fields. However, FS theory only has a membership degree which is not perfect in expressing the fuzziness of the subjective world. The intuitionistic fuzzy set (IFS) theory is an extension of FS theory and it was developed by Atanassov [2]. IFS is characterized by a membership degree and a non-membership degree [2–5]. One of the research branches of IFS theory is intuitionistic fuzzy multi-criteria group decision making and have attracted many attentions from researchers [6–15]. To aggregate all the performance on attributes for alternatives is a very critical step in decision making problem and the aggregation operators play an important role during the information fusion process.

Many scholars are interested in intuitionistic fuzzy information aggregation operators. The intuitionistic fuzzy weighted averaging (IFWA) operator and intuitionistic fuzzy weighted geometric (IFWG) operator are two widely cited operators and they were introduced by Xu [16] and Xu and Yager [17] respectively. Based on which, the IFOWA operator, IFOWG operator, intuitionistic fuzzy hybrid averaging (IFHA) operator, intuitionistic fuzzy hybrid geometric (IFHG) operator, generalized IFWA, generalized IFWG, generalized IFOWA, generalized IFOWG are proposed [18]. Combined with the Bonferroni mean (BM), intuitionistic fuzzy Bonferroni mean (IFBM) and weighted IFBM are introduced by Xu [19]. Later, Xia et al. [20] proposed a series of extended IFBM operators, such as the GIFBM and weighted GIFBM. Inspired by the power aggregation operators [21,22], some intuitionistic fuzzy power operators are proposed, such as IFPWA, IFPWG, IFPOWA and IFPOWG [23]. The intuitionistic fuzzy power operators and intuitionistic fuzzy Bonferroni operators are two types of correlated aggregate operators; they are able to describe the relationships quantitatively from the objective perspective. Choquet integral based intuitionistic fuzzy aggregation operators, such as the intuitionistic fuzzy Choquet average (IFCA) operator, the IFCG operator [24,25], the quasi intuitionistic fuzzy Choquet ordered averaging (QIFCOA) operator [26], and induced generalized intuitionistic fuzzy Choquet ordered averaging (I-GIFCOA) operator [27] are also able to depict the interrelations between the aggregated arguments. However, they are different from the intuitionistic fuzzy power operators and intuitionistic fuzzy Bonferroni operators, since they are depict the interrelations from the subjective perspective.

In order to fusion the intuitionistic fuzzy preference information, Xia et al. [28] proposed some intuitionistic multiplicative preference information aggregation operators, such as intuitionistic multiplicative weighted averaging (IMWA) operator, intuitionistic multiplicative weighted geometric (IMWG) operator, generalized IMWA operator and generalized IMWG operator. Furthermore, Xia and Xu [29] proposed

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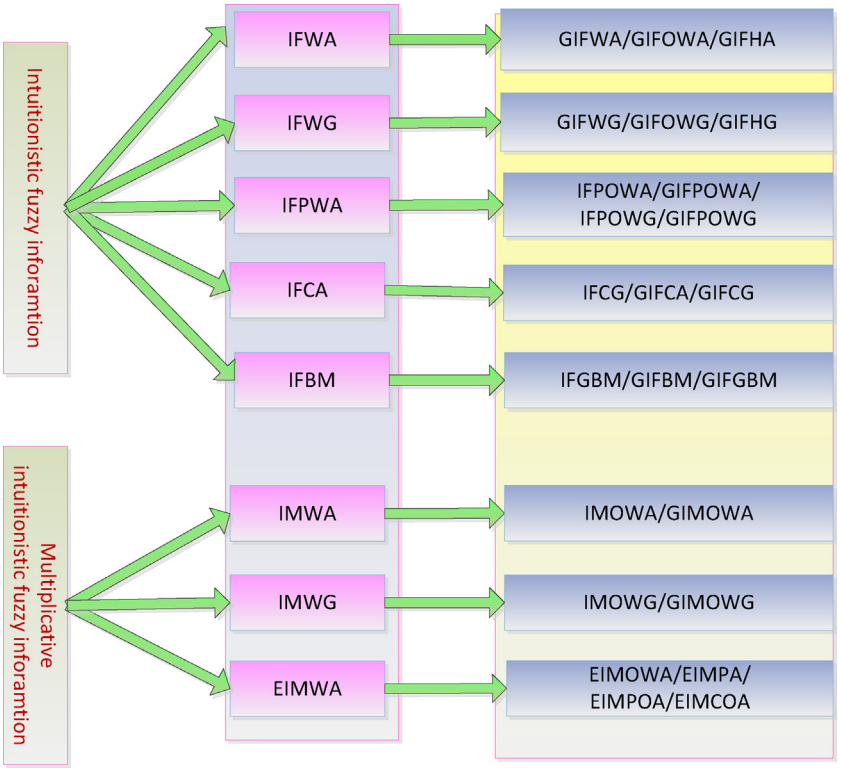

Fig. 1. The development of the intuitionistic fuzzy aggregation operators.

some extended intuitionistic multiplicative preference information aggregation operators, such as extended intuitionistic multiplicative weighted averaging (EIMWA) operator, extended intuitionistic multiplicative power averaging (EIMPA) operator, extended intuitionistic multiplicative Choquet averaging (EIMCA) operator, extended intuitionistic multiplicative power ordered averaging (EIMPOA) operator and extended intuitionistic multiplicative Choquet ordered averaging (EIMCOA) operator. Fig. 1 shows the development and the relations of the above described aggregation operators.

But despite these remarkable achievements, the intuitionistic fuzzy information aggregation method is far from an unmitigated perfection. Most of the existing aggregation operators not consider the confidence level of the aggregated arguments provided by the information providers. However, in many real decision making problems, such as the blind peer review of doctoral dissertation in China, the evaluation experts are requested to provide two types of information such as the performance of the evaluation objects and the familiarity with the evaluation areas (called confidence levels) [30,31]. In this paper, we focus on the intuitionistic fuzzy information aggregation issue in the situation where the confidences levels of the aggregated arguments are asked to be considered. The main research contents can be summarized as following five parts, (1) confidence intuitionistic fuzzy aggregation operator; (2) confidence intuitionistic fuzzy ordered aggregation operator; (3) confidence intuitionistic fuzzy Einstein aggregation operator; (4) confidence intuitionistic fuzzy Einstein ordered aggregation operator; (5) group decision making method based on the above operators.

The logistic relationship of above main content can be vivid compared to the construction of two – story house which shown in Fig. 2. This paper focuses on intuitionistic fuzzy set and information aggregation theory and uses them as the theory basis and methodology, just as the foundation of the house. Then this paper studied confidence intuitionistic fuzzy aggregation operators and confidence intuitionistic fuzzy ordered aggregation operators, the two are two supporting pillars of the house's first floor and presents the progressive relationship. Meanwhile, based on Intuitionistic fuzzy Einstein operations, this paper further studied confidence intuitionistic fuzzy Einstein aggregation operators and confidence intuitionistic fuzzy Einstein ordered aggregation operators, the two also have the progressive relationship and refer to the supporting pillars of the second floor. At the end, an approach to intuitionistic fuzzy group decision making under confidence levels is introduced based on the proposed aggregation operators, it can be compared to the roof of the house.

2. Some basic concepts

The Bulgarian scholar Atanossv [2] extended the fuzzy set theory [1] and introduced the intuitionistic fuzzy set (IFS) theory. The Definition of IFS was defined as follows and has been cited thousands of times. It could be found in most of the research papers about IFS theory.

Definition 1. The concept of intuitionistic fuzzy set (IFS) A on X is defined as follows:

$$A = \{ < x, \mu_A(x), v_A(x) > \Big| \, x \in X\} \tag{1}$$

where the functions $\mu_A(x)$ and $v_A(x)$ denote the degrees of membership and non-membership of the element $x \in X$ to the set A, respectively.

In Eq. (1), the $\mu_A(x)$ and $v_A(x)$ are functions with the values between closed interval [0, 1]. In addition, the sum of $\mu_A(x)$ and $v_A(x)$ are also values between closed interval [0, 1].

For convenience, Xu [16] named $\alpha = (\mu_\alpha, v_\alpha)$ an intuitionistic fuzzy number (IFN).