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PERSONNEL APPOINTMENTS: A PYTHAGOREAN FUZZY SETS APPROACH USING SIMILARITY MEASURE

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Abstract: This paper explores the advantage of Pythagorean fuzzy sets in personnel appointments by employing normalized Euclidean similarity to find the similarity between applicants to each positions. The choice of Euclidean similarity for Pythagorean fuzzy sets by incorporating the three traditional parameters, is because it gives a reliable similarity with respect to other similarity measures for Pythagorean fuzzy sets that incorporate the three traditional parameters as studied in literature. By finding the similarity of the applicants and positions (both in Pythagorean fuzzy pairs/values), in the light of the qualifications require by the organisation, we determine the suitable applicants for the available positions. Also, we propose the notions of level sets of Pythagorean fuzzy sets and Pythagorean fuzzy pairs.

Keywords: Fuzzy set, Intuitionistic fuzzy set, Personnel appointments, Pythagorean fuzzy pairs, Pythagorean fuzzy set, Similarity measure

1. Introduction

The adventure into fuzzy sets by Zadeh [35] dawn a new beginning in non-classical sets. Out of the several generalizations of fuzzy set theory for various objectives, the notion introduced by Atanassov [1, 2] called intuitionistic fuzzy sets (IFSs) is quite interesting and useful. IFS incorporates both membership function, μ and non-membership function, ν with hesitation margin, π (that is, neither membership nor non-membership functions) such that $\mu+\nu\leq 1$. Fuzzy sets are IFSs but the converse is not necessarily true [2]. In fact, there are situations where IFS theory is more appropriate to deal with. Sequel to the introduction of IFSs, a lot of attentions have been paid on developing similarity measures for IFSs, as a way to apply them to solving many decision-making problems. As a result, some similarity measures were proposed, see [6, 12, 17, 24, 26, 32]. Some applications of IFSs have been carried out using measures, as can be found in [7, 11-13, 25, 26].

Notwithstanding, there are cases when $\mu+\nu\geq 1$. This situation can only be captured by a construct, called Pythagorean fuzzy sets (PFSs). Pythagorean fuzzy set (PFS) proposed in [28-30] is a new tool to deal with vagueness considering the membership grade, μ and non-membership grade, ν satisfying the condition $\mu+\nu\geq 1$ or $\mu+\nu\leq 1$ such that, $0\leq\mu^2+\nu^2\leq 1$. That is, PFS generalizes IFS. Honestly speaking, the origin of Pythagorean fuzzy sets emanated from intuitionistic fuzzy sets of second type (IFSST) introduced in [3]. As a generalized set, PFS has close relationship with IFS. PFSs can be used to characterize the uncertain information more sufficiently and accurately than IFSs. Since inception, the theory of PFSs has been extensively researched [22, 23, 31]. Pythagorean fuzzy set has attracted great attentions of many scholars, and the concept has been applied to several application areas [8, 9, 14, 15, 18, 19, 28, 30, 34].

Similarity and dissimilarity measures for PFSs have been studied from different perspectives. Some authors have researched on measures for PFSs by considering four or more parameters in [16, 21, 33], which are not the traditional parameters of PFSs as noted in [28-31]. In [27], some similarity measures between PFSs based on the cosine function were proposed by considering the degree of membership, degree of non-membership and degree of hesitation, and applied to pattern recognition and medical diagnosis. A similarity measure for PFSs based on the combination of cosine similarity measure and Euclidean distance measure featuring only membership and non-membership degrees were introduced in [20]. Of recent, some dissimilarity and similarity measures for PFSs which satisfied the metric distance conditions were introduced in [10] by incorporating the three conventional parameters of PFSs.

Personnel appointment is one of the most uncertain exercise in the domain of decision-making. A failure in personnel appointment will lead to the liquidation of an organization. Thus, this justifies the reason why we attempt to solve recruitment exercise using the notion of PFSs, which have been proven to be resourceful in tackling uncertainty more effectively than IFSs.

This paper studies PFSs, and presents an exploration into an application of PFSs to personnel appointments using normalised Euclidean similarity for applicants and available positions to determine which applicant is suitable for a particular position. The notion of Pythagorean fuzzy pairs is introduced (as extension of intuitionistic fuzzy pairs in [4, 5]). We reiterate the concept of similarity measure for PFS. When the reliability test of the measures were conducted, it follows that normalized Euclidean similarity for PFS yields the best similarity; this informs its choice in the study. The rest of the paper is thus presented; Section 2 provides some preliminaries on fuzzy sets, IFS and PFS, while Section 3 covers some similarity measures for PFSs with their numerical verifications. In Section 4, we present an application of PFS to personnel appointment using Euclidean similarity measure. Finally, Section 5 concludes the paper and provides direction for future studies.

2. Basic notions of Pythagorean fuzzy sets

We recall some basic notions of fuzzy sets, IFSs and PFSs.

Definition 2.1 [35]**.** Let X be a nonempty set. A fuzzy set A in X is characterized by a membership function

$$\mu_A : X \to [0,1].$$

That is,

$$\mu_A(x) = \begin{cases} 1, & if\ x\ is\ totally\ in\ X \\ 0, if\ x\ is\ not\ in\ X \\ (0,1), if\ x\ is\ partly\ in\ X \end{cases}$$

Alternatively, a fuzzy set A in X is an object having the form $A = \{< \mu_A(x) > | x \in X\}$ or $A = \{< \frac{\mu_A(x)}{x}) > | x \in X\}$

where the function

$$\mu_A(x) : X \to [0,1]$$

defines the degree of membership of the element, $x \in X$.

Definition 2.2 [2]**.** Let a nonempty set X be fixed. An IFS A of X is an object having the form

$$A = \{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$$

or

$$A = \{\langle \frac{\mu_A(x), \nu_A(x)}{x} \rangle \mid x \in X\},$$

where the functions

$$\mu_A(x) : X \to [0,1]\ and\ \nu_A(x) : X \to [0,1]$$

define the degree of membership and the degree of non-membership, respectively of the element $x \in X$ to A, which is a subset of X, and for every $x \in X$,

$$0 \le \mu_A(x) + \nu_A(x) \le 1.$$

For each A in X,

$$\pi_A(x) = 1 - \mu_A(x) - \nu_A(x)$$

is the intuitionistic fuzzy set index or hesitation margin of x in X. The hesitation margin $\pi_A(x)$ is the degree of non-determinacy of $x \in X$, to the set A and $\pi_A(x) \in [0,1]$. The hesitation margin is the function that expresses lack of knowledge of whether $x \in X$ or $x \notin X$. Thus,

$$\mu_A(x) + \nu_A(x) + \pi_A(x) = 1.$$

Definition 2.3 [28]**.** Let X be a universal set. Then, a Pythagorean fuzzy set A which is a set of ordered pairs over X, is defined by

$$A = \{\langle x, \mu_A(x), \nu_A(x)\rangle \mid x \in X\}$$