



Original article

## Some aspects of picture fuzzy set

Palash Dutta\*, Silpashree Ganju

*Department of Mathematics, Dibrugarh University, 786001, India*

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### Abstract

Picture fuzzy set (PFS) is a recently developed tool to deal with uncertainty which is a direct extension of intuitionistic fuzzy set (IFS) that can model uncertainty in such situations involving more answers of these types: yes, abstain, no. In this paper,  $(\alpha, \delta, \beta)$ -cut and strong  $(\alpha, \delta, \beta)$ -cut of PFS have been defined and decomposition theorems of PFS are proved. Later on extension principle for PFS has been defined and studied some of its properties. Finally, picture fuzzy arithmetic based on extension principle has been performed with examples.

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*Keywords:* Fuzzy set; Fuzzy arithmetic; Extension principle; Picture fuzzy set

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### 1. Introduction

Fuzzy set theory developed by Zadeh [1], plays an important role in decision making under uncertain environment. Various direct/indirect extensions of fuzzy set have been made and successfully applied in most of the problems of real world situation. An important generalization of fuzzy set theory is the theory of intuitionistic fuzzy set (IFS), introduced by Atanassov [2] ascribing a membership degree and a non-membership degree separately in such a way that sum of the two degrees must not exceed one. It is observed that fuzzy sets are IFSs but converse is not necessarily correct. Later IFS has been applied in different areas by various researchers. It is seen that one of the important concept of neutrality degree is lacking in IFS theory. Concept of neutrality degree can be seen in situations when we face human opinions involving more answers of type: yes, abstain, no, refusal. For example, in a democratic election station, the council issues 500 voting papers for a candidate. The voting results are divided into four groups accompanied with the number of papers namely “vote for” (300), “abstain” (64), “vote against” (115) and “refusal of voting” (21). Group “abstain” means that the voting paper is a white paper rejecting both “agree” and “disagree” for the candidate but still takes the vote. Group “refusal of voting” is either invalid voting papers or bypassing the vote. On the other hand, in medical diagnosis degree of neutrality can be considered. E.g., there may not have effect of the symptoms

\* Corresponding author.

E-mail addresses: [palash.dtt@gmail.com](mailto:palash.dtt@gmail.com) (P. Dutta), [silpashree1993@gmail.com](mailto:silpashree1993@gmail.com) (S. Ganju).

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temperature, headache on the diseases stomach and chest problems. Similarly, the symptoms stomach pain and chest pain have neutral effect on the diseases viral fever, malaria, typhoid etc. In this regards, Cuong and Kreinovich [3] introduced Picture fuzzy set (PFS) which is a direct extension of fuzzy set and Intuitionistic fuzzy set by incorporating the concept of positive, negative and neutral membership degree of an element. Cuong [4] studied some properties of PFSs and suggested distance measures between PFSs. Phong and co-authors [5] studied some compositions of picture fuzzy relations. Cuong and Hai [6] investigated main fuzzy logic operators: negations, conjunctions, disjunctions and implications on picture fuzzy sets and also constructed main operations for fuzzy inference processes in picture fuzzy systems. Cuong and co-workers [7] presented properties of an involutive picture negator and some corresponding De Morgan fuzzy triples on picture fuzzy sets, Viet and co-authors [8] presented picture fuzzy inference system based on membership graph, Singh [9] studied correlation coefficients of PFSs. Cuong and colleagues [10] investigated the classification of representable picture t-norms and picture t-conorms operators for picture fuzzy sets., Son [11] proposed a new distance measure between PFSs and applied in fuzzy clustering, Son [12] extended basic distance measures in PFSs and examined some of its properties. Son, Viet and Hai [13] proposed fuzzy inference system on PFSs. Peng and Dai [14] proposed an algorithm for PFS and applied in decision making based on new distance measure, Wei [15] presented some process to measure similarity between PFS, Garg [16] studied some picture fuzzy aggregation operations and their applications to multicriteria decision making.

In this paper, an attempt has been made to define  $(\alpha, \delta, \beta)$ -cut and strong  $(\alpha, \delta, \beta)$ -cut of PFS, height of PFS, level set of PFS and special picture fuzzy set study etc. Based on  $(\alpha, \delta, \beta)$ -cut and strong  $(\alpha, \delta, \beta)$ -cut of PFS decomposition theorems of PFS will be proved. Then, some properties of  $(\alpha, \delta, \beta)$ -cut of PFS will be studied. Further, extension principle for PFS will be defined and some of its properties and finally picture fuzzy arithmetic based on extension principle will be carried out.

## 2. Preliminaries

In this section some basic concept of fuzzy set, intuitionistic fuzzy set and picture fuzzy set has been reviewed.

### 2.1. Fuzzy set [1]

Fuzzy set is a set in which every element has degree of membership of belonging in it. Mathematically, let  $X$  be a universal set. Then the fuzzy subset  $A$  of  $X$  is defined by its membership function

$$\mu_A : X \rightarrow [0, 1]$$

which assign a real number  $\mu_A(x)$  in the interval  $[0, 1]$ , to each element  $x \in A$ , where the value of  $\mu_A(x)$  at  $x$  shows the grade of membership of  $x$  in  $A$ .

### 2.2. Intuitionistic fuzzy set [2]

A Intuitionistic fuzzy set  $A$  on a universe of discourse  $X$  is of the form

$$A = \{x, \mu_A(x), \nu_A(x) : x \in X\},$$

where  $\mu_A(x) \in [0, 1]$  is called the “degree of membership of  $x$  in  $A$ ”,  $\nu_A(x) \in [0, 1]$  is called the “degree of non-membership of  $x$  in  $A$ ”, and where  $\mu_A(x)$  and  $\nu_A(x)$  satisfy the following condition:

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

The amount  $\pi_A(x) = 1 - (\mu_A(x) + \nu_A(x))$  is called hesitancy of  $x$  which is reflection of lack of commitment or uncertainty associated with the membership or non-membership or both in  $A$ .

### 2.3. Picture fuzzy set [3]

A Picture Fuzzy Set (PFS)  $A$  on a universe  $X$  is an object of the form

$$A = \{(x, \mu_A(x), \eta_A(x), \nu_A(x)) | x \in X\}$$

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