Arithmetic Behaviors of P-Norm Generalized Trapezoidal Intuitionistic Fuzzy Numbers with Application to Circuit Analysis

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ABSTRACT

P-norm Generalized Trapezoidal Intuitionistic Fuzzy Number is the most generalized form of Fuzzy as well as Intuitionistic Fuzzy Number. It has a huge application while solving various problems in imprecise environment. In this paper the authors have discussed some basic arithmetic operations of p-norm Generalized Trapezoidal Intuitionistic Fuzzy Numbers using two different methods (extension principle method and vertex method) and have solved a problem of circuit analysis taking the given data as p-norm Generalized Trapezoidal Intuitionistic Fuzzy Numbers.

KEYWORDS

Circuit Analysis, Generalized Trapezoidal Intuitionistic Fuzzy Number (GTrIFN), Intuitionistic Fuzzy Number (IFN), P-Norm Generalized Trapezoidal Intuitionistic Fuzzy Number \(((GTrIFN)p)\), Vertex Method

1. INTRODUCTION

At present days fuzzy and intuitionistic fuzzy sets are vastly used in pure and applied science. In 1965 Zadeh introduced fuzzy set theory. Zadeh (1965) and Dubois and Prade (1978) were the first who introduced the concept of fuzzy number and fuzzy arithmetic. In 1985 Chen (1985) further developed the theory and applications of Generalized Fuzzy Number (GFN). Chen (1985) also proposed the function principle, which could be used as the fuzzy numbers arithmetic operations between generalised fuzzy numbers, where these fuzzy arithmetic operations can deal with the generalised fuzzy numbers. In 1987 Dong and Shah (1987) introduced Vertex Method using which the value of the functions of interval variable and fuzzy variable can be easily evaluated. There are so many papers (Bansla, 2011; Kumar, Sing, Kaur, & Kaur, 2010; Garrido, 2011; Lee & Yun, 2011; Chakraborty & Guha, 2010; Banerjee & Roy, 2012; Yun, Ryu, & Park, 2009) where arithmetic behaviors of various fuzzy numbers have been discussed.

Intuitionistic fuzzy sets (IFS) have been introduced by Krassimir Atanassov (1983) as an extension of Lotfi Zadeh’s notion of fuzzy set, which itself extends the classical notion of a set. The concept of IFS can be viewed as an alternative concept to define a fuzzy set in case where available information is insufficient for the definition of an imprecise concept by means of a conventional fuzzy set. In fuzzy sets the degree of acceptance is considered only but IFS is characterized by a membership function and a non-membership function so that the sum of both values is less than one. Basic arithmetic operations

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of TIFNs is defined by Deng-Feng Li (n. d.) using membership and non-membership values. Further the arithmetic operations of different types of TIFNs are discussed by several authors (Shaw & Roy, 2012; Mahapatra & Roy, 2013; Aggarwal & Gupta, 2014; Rezvani, 2013; Xu & Yager, 2006; Xu, 2007).

In this paper the authors have reviewed some basic definitions of Intuitionistic fuzzy set theory and defined P-norm Generalized Trapezoidal Intuitionistic Fuzzy Number \( (GTrIFN)_p \) which is the most generalized form of Fuzzy as well as Intuitionistic Fuzzy Number. In Section-3 they have shown the detail procedure to compute the results of some basic arithmetic operations by using extension principle method and vertex method. Further as an application they have solved a problem of circuit theory using \( (GTrIFN)_p \).

2. MATHEMATICAL PRELIMINARIES

**Definition-2.1: Intuitionistic Fuzzy Set (IFS) (Atanassov, 1999):** Let \( U = \{x_1, x_2, \ldots, x_n\} \) be a finite universal set. An Intuitionistic Fuzzy Set \( \tilde{A}^i \) in a given universal set \( U \) is an object having the form \( \tilde{A}^i = \{x_i, \mu_{\tilde{A}^i}(x_i), \nu_{\tilde{A}^i}(x_i) : x_i \in U\} \) where the functions \( \mu_{\tilde{A}^i} : U \rightarrow [0,1] \); i.e., \( x_i \in U \rightarrow \mu_{\tilde{A}^i}(x_i) \in [0,1] \) and \( \nu_{\tilde{A}^i} : U \rightarrow [0,1] \); i.e., \( x_i \in U \rightarrow \nu_{\tilde{A}^i}(x_i) \in [0,1] \) define the degree of membership and the degree of non-membership of an element \( x_i \in U \), such that they satisfy the following conditions:

\[
0 \leq \mu_{\tilde{A}^i}(x_i) + \nu_{\tilde{A}^i}(x_i) \leq 1, \forall x_i \in U
\]

which is known as Intuitionistic Condition. The degree of acceptance \( \mu_{\tilde{A}^i}(x_i) \) and of non-acceptance \( \nu_{\tilde{A}^i}(x_i) \) can be arbitrary.

**Definition-2.2: \((\alpha, \beta)\) -cuts(Atanassov, 1999):** A set of \((\alpha, \beta)\) -cut, generated by IFS \( \tilde{A}^i \), where \( \alpha, \beta \in [0,1] \) are fixed numbers such that \( \alpha + \beta \leq 1 \) is defined as:

\[
\tilde{A}^i_{\alpha,\beta} = \begin{cases} 
(x, \mu_{\tilde{A}^i}(x), \nu_{\tilde{A}^i}(x)) ; x \in U \\
\mu_{\tilde{A}^i}(x) \geq \alpha, \nu_{\tilde{A}^i}(x) \leq \beta ; \alpha, \beta \in [0,1] 
\end{cases}
\]

where \((\alpha, \beta)\) -cut, denoted by \( \tilde{A}^i_{\alpha,\beta} \), is defined as the crisp set of elements \( x \) which belong to \( \tilde{A}^i \) at least to the degree \( \alpha \) and which does belong to \( \tilde{A}^i \) at most to the degree \( \beta \).

**Definition-2.3: Extension Principle for IFS (Li, n. d.):** Let us take the universal set \( X \) and let us choose some \( \tilde{A}^i \in \text{IFS}(X) \). Then the extension principle for IFSs states that \( f(\tilde{A}^i) \in \text{IFS}(Y) \) such that for every \( y \in Y \) :
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