



# Plithogenic sets and their application in decision making

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**Abstract:** There are various mathematical tools available to measure the level of accuracy such as Crisp, Fuzzy, Intuitionistic fuzzy sets and Neutrosophic set. Further, Plithogenic set is a generalization of these four sets. This paper aims to test whether Plithogenic aggregation operation is more effective than other sets in its accuracy, while decision making. In order to obtain a better accuracy, the Plithogenic aggregation operation such as Fuzzy set [FS], Intuitionistic fuzzy set [IFS] and Neutrosophic set [NS] used  $t$ -norm and  $t$ -conorm. An illustration is examined in this paper to prove the result of better accuracy using plithogenic aggregation operators in decision making.

**Keywords:** Plithogenic operators,  $t$ -norm,  $t$ -conorm, fuzzy union and intersection operators.

## 1. Introduction

In real life, there may be an uncertainty about any degree of membership in the variable assumption. In that situation, fuzzy sets and fuzzy logic formulated by Zadesch, 1965 (1) will become the proper mathematical tool to describe the conditions which are ambiguous. Fuzzy sets is an extension of Crisp set. That is why, fuzzy set theory has been developed for inexactness and vagueness. In mathematics, fuzzy set elements have degrees of membership functions. The membership of elements in a set is assessed by binary terms. According to a double fold condition an element either belongs or does not belong to the set in the interval  $[0, 1]$ . Fuzzy can be represented by a set of ordered pair  $A = \{x, \mu_A(x)\}$ . The contradiction of fuzzy set degree is 0. Fuzzy set is characterized by a single variable and its membership value is 1.  $t$ -norm of fuzzy constraints

the truth function of conjunction, whereas t-conorm of fuzzy constraints the truth functions of disjunction. The aggregative operators of fuzzy set are union ( $\vee_F$ ), intersection ( $\wedge_F$ ) and complement. However, in the computational aspects, membership is not enough. So we need an extension.

Intuitionistic fuzzy set [IFS], is an extension of fuzzy set and fuzzy logic, introduced by Atanassov and Baruah[9] to have a better accuracy level. Atanassov has given the definition for some operations on Intuitionistic fuzzy set and its properties [7]. IFS is based on only the membership and non-membership function. But it does not exist in the indeterminacy.

Then the next evaluation of Intuitionistic fuzzy set i.e Neutrosophic set have been developed by Smarandache [15]. It is a generalization of fuzzy sets and intuitionistic fuzzy set. It is a powerful tool to manipulate with some indeterminacy, inconsistency and incomplete information which are applied in day to day life. Neutrosophic sets deal with three components such as membership (M), indeterminacy (I) and non-membership (N) functions. It is a very helpful application to handle real life problems. But it is applicable only on three attribute values. In the stage of advanced research it is felt that the measurement of uncertainty of data needs to be handled with more attribute value so as to raise the accuracy level.

A precise level is one of the most important factors of decision making in day to day real life [30]. To, increase the preciseness, Smaranandache[21] introduced plithogenic. Plithogenic is a powerful tool which is generic of crisp set, fuzzy set, intuitionistic fuzzy set and neutrosophic set is collectively called as Plithogenic. Plithogenic is the base for all the plithogenic functions (plithogenic set, plithogenic probability, plithogenic statistics and plithogenic logic). These sets are characterized by a single appurtenance is plithogenic set. An element of Crisp set is characterized by one value (membership), fuzzy set is characterized by two values (membership, non-membership) and intuitionistic and Neutrosophic set is characterized by three values (membership, indeterminate, non- membership) but plithogenic sets are characterized by four or more values. Plithogenic is a set whose components are described by atleast one trait and each attribute may have numerous elements [30]. The linear combination of fuzzy operators are tnorm and tconorm are called as plithogenic aggregation operators (union and intersection). The aggregation operators of plithogenic set is related on contradiction degree to maximize the accuracy level.

## 2. Review of Literature

First study related to fuzzy combined operations based on conjugate pairs of t-norm and t-conorms [5]. In this paper M. J. Liberatore.et.al [11] analysed fuzzy logic as an alternative approach for modeling uncertainty in project schedule analysis. To solve a real-world problem by Fuzzy sets

of decision making on the basis of aggregation of experts opinions expressed in form of Z-valued t-norm and t-conorm operators [20]. Huchanget. al.[18] proposed some new hybrid hesitant fuzzy weighted aggregation operators, such as the hesitant fuzzy hybrid arithmetical averaging operator, the hesitant fuzzy hybrid arithmetical geometric operator and their properties satisfying the property named idempotency and used to multi-criteria single person decision making and multi-criteria group decision making respectively. Grabisch .et.al [8] represent an aggregation operator exhibits a set of mathematical properties, which depends on imposed axiomatic assumptions. MamoniDhar[16] introduced a new definition of cardinality of fuzzy sets on the basis of membership value.

Atanassov[4] introduced intuitionistic fuzzy set and its aggregative operations. Supriya.et.al[10] Kumar De, defined some operators (CON; DIL; NORM) with example, it is useful in intuitionistic fuzzy environment. Glad Deschrijver .et.al. [13] introduced the notion of intuitionistic fuzzy t-norm and t-conorm, and investigate under which conditions a similar theorem obtained. Monoranjan.et.al.[14] defined some new operations on intuitionistic neutrosophic set with examples for the implementation of the operations problems.

Neutrosophic set were introduced by FlorentinSmarandache [12], Neutrosophic set is an extension of intuitionistic fuzzy set. Hong-yu .et.al. [19] defined Interval Neutrosophic Sets and Their Application in Multicriteria Decision Making Problems.Wang.et.al [15] presented an instance of neutrosophic set called single valued neutrosophic set. Said Broumi.et.al [17] defined the distance between neutrosophic sets (NS) on the basis of the Hausdorff distance such a new distance called "extended Hausdorff distance for neutrosophic sets" or "neutrosophicHausdorff distance". Nagarajan.et.al[24] presented , Blockchain network has been used in terms of Bitcoin transaction and also the degree, total degree, minimum and maximum degree have been found using Blockchain single valued Neutrosophic graph. Nagarajan.et.al [25] proposed under triangular interval type-2 fuzzy and interval neutrosophic environments verified with the numerical example.Preethi.et.al.[23] verified the hyperstructure properties using the single valued neutrosophic set model through several hyperalgebraic structures .such as hyperrings and hyperideals. R.Jansi.et.al[26] defined the correlation measure of Pythagorean neutrosophic set with T and F are neutrosophic components and their properties . Abdel Nasser .et.al.[27] suggested Multi-Objective Optimization based on Ratio Analysis (MOORA) is the most suitable machine tools on the basis of Neutrosophic set. Smarandache, F [21,22] introduced Plithogenic, show that it is an extension of crisp set, fuzzy set, intuitionistic fuzzy set and neutrosophic set and it is applicable for many scientific experiments. Said Broumi.et.al. [28] proposed a new distance measure for the trapezoidal fuzzy neutrosophic number based on centroid with the graphical representation and its properties also proved. Nivetha et.al.[29] introduced the new concept of combined plithogenic hypersoft set and its application in multi attribute decision making

### 3. Preliminaries

In this section, preliminaries of the proposed concept are given

#### 3.1. Fuzzy Set [1]

Fuzzy can be represented by an set ordered pair  $A = \{x, \mu_A(x)\}$  where  $\mu_A(x)$  is called the membership function such that  $\mu_A(x) : X \rightarrow [0, 1]$ .

##### 3.1.1. Fuzzy set aggregative operators [1]

Let  $X$  be a non empty set in the unit interval  $[0, 1]$ . A fuzzy sets  $A$  and  $B$  are of the form.

$$A = \{x, \mu_A(x)/x \in X\} \text{ and } B = \{x, \mu_B(x)/x \in X\}$$

1.  $A \vee_F B = \min\{\mu_A(x), \mu_B(x)\}$  (where  $(\vee_F)$  Union)
2.  $A \wedge_F B = \max\{\mu_A(x), \mu_B(x)\}$  (where  $(\wedge_F)$  Intersection)
3.  $\mu_{\bar{A}}(x) = 1 - \mu_A(x)$  (Complement)

#### 3.2. Intuitionistic fuzzy set [4, 7]

A Intuitionistic fuzzy set defined by ordered triplets  $A = \{x, \mu_A(x), \rho_A(x)/x \in X\}$   $\mu_A(x) : X \rightarrow [0, 1]$  is the degree of membership function of  $x \in X$ ,  $\rho_A(x) : X \rightarrow [0, 1]$  is the degree non membership function of  $x \in X$  where  $\rho_A(x) = 1 - \mu_A(x)$  and  $0 \leq \mu_A(x) + \rho_A(x) \leq 1$ .  $\gamma_A(x) = 1 - \mu_A(x) - \rho_A(x)$  is called of hesitancy. Its membership degree is 2.

##### 3.2.2 Intuitionistic fuzzy set[IFS] aggregative operators:

Let  $X$  be a non empty set in the unit interval  $[0, 1]$ . A IFS  $A$  and  $B$  are of the form

$$A = \{x, \mu_A(x), \rho_A(x)/x \in X\} \text{ } B = \{x, \mu_B(x), \rho_B(x)/x \in X\}$$

1.  $A \vee_{IF} B = \{x, \max(\mu_A(x), \mu_B(x)), \min(\rho_A(x), \rho_B(x))\}$  where  $(\vee_{IF})$  union
2.  $A \wedge_{IF} B = \{x, \min(\mu_A(x), \mu_B(x)), \max(\rho_A(x), \rho_B(x))\}$  where  $(\wedge_{IF})$  intersection

### 4. Proposed Methodology

#### Plithogenic operator laws [23]:

Plithogenic aggregation operators are the linear combination of the fuzzy  $t_{norm}(\wedge_F)$  and  $t_{conorm}(\vee_N)$

##### Fuzzy operators:

Let  $P$  be a plithogenic set and  $w$  is an attribute value,  $w \in W$ , where  $W$  is a attribute value. The contradiction degree  $c(w_d, w) = c_0 \in [0, 1]$  between dominant attribute element and the attribute element  $c_0$ . The two expert,  $X$  and  $Y$ , each assigning single element fuzzy degree of attribute element  $w$  of  $x$  to the set  $P$  with respect to some given criteria:

$$d_X^F(W) = x \in [0, 1]$$

$$d_Y^F(W) = y \in [0, 1]$$

If  $\wedge_F$  be a fuzzy t-norm and  $\vee_F$  t - conorm respectively and the contradiction degree

$$c(w_d, w) = c_0 \in [0, 1]$$

**Fuzzy set Union with Plithogenic :**

$$x \vee_p y = (1 - c_0) [x \vee_F y] + c_0 [x \wedge_F y] \dots\dots\dots (a)$$

Proper Plithogenic intersection set means,  $c(w_d, w) = c_0 \in [0, 0.5]$  then tconorm  $(x, y) = x \vee_F y$  assigned more weight age than onto tnorm  $(x, y) = x \wedge_F y$

Improper Plithogenic intersection set means,  $c(w_d, w) = c_0 \in (0.5, 1]$  then tconorm  $(x, y) = x \vee_F y$  assigned less weight age than onto tnorm  $(x, y) = x \wedge_F y$

If  $c(w_d, w) = c_0 \in 0.5$  then the same weight {0.5} is assigned onto the tconorm  $(x, y) = x \vee_F y$  and tnorm  $(x, y) = x \wedge_F y$

**Fuzzy set Intersection with Plithogenic :**

$$x \wedge_p y = (1 - c_0) [x \wedge_F y] + c_0 [x \vee_F y] \dots\dots\dots (b)$$

Proper Plithogenic intersection set means,  $c(w_d, w) = c_0 \in [0, 0.5]$  then tnorm  $(x, y) = x \wedge_F y$  assigned more weight age than onto tconorm  $(x, y) = x \vee_F y$

Improper Plithogenic intersection set means,  $c(w_d, w) = c_0 \in (0.5, 1]$  then tnorm  $(x, y) = x \wedge_F y$  assigned less weight age than onto tconorm  $(x, y) = x \vee_F y$

If  $c(w_d, w) = c_0 \in 0.5$  then the same weight {0.5} is assigned onto the tnorm  $(x, y) = x \wedge_F y$  and tconorm  $(x, y) = x \vee_F y$

**Intuitionistic Fuzzy set operators:**

The intuitionistic fuzzy set degree of a single attribute value w of x to the Plithogenic set with some conditions –

$$d_X^{IF}(w) = (x_1, x_2) \in [0, 1]^2$$

$$d_Y^{IF}(w) = (y_1, y_2) \in [0, 1]^2$$

**Intuitionistic Fuzzy set Union with Plithogenic :**

$$(x_1, x_2) \vee_p (y_1, y_2) = (x_1 \vee_p y_1, x_2 \vee_p y_2) \dots\dots\dots (c)$$

**Intuitionistic Fuzzy set intersection with Plithogenic :**

$$(x_1, x_2) \wedge_p (y_1, y_2) = (x_1 \wedge_p y_1, x_2 \vee_p y_2) \dots\dots\dots (d)$$

### Neutrosophic set operators:

The Neutrosophic set degree of a single attribute value  $w$  of  $x$  to the plithogenic set with some conditions –

$$d_X^N(w) = (x_1, x_2, x_3) \in [0, 1]^3$$

$$d_Y^N(w) = (y_1, y_2, y_3) \in [0, 1]^3$$

### Neutrosophic set Union with Plithogenic :

$$(x_1, x_2, x_3) \vee_p (y_1, y_2, y_3) = (x_1 \vee_p y_1, 0.5 (x_2 \wedge_p y_2 + x_2 \vee_p y_2), x_3 \wedge_p y_3) \dots\dots\dots (e)$$

### Neutrosophic set intersection with Plithogenic :

$$(x_1, x_2, x_3) \wedge_p (y_1, y_2, y_3) = (x_1 \wedge_p y_1, 0.5 (x_2 \vee_p y_2 + x_2 \wedge_p y_2), x_3 \vee_p y_3) \dots\dots\dots (f)$$

### Theorems based on Plithogenic single attribute fuzzy set Unions and Intersections [21,22]:

#### Theorem 1 :

$c(w_d, w) = 0$ , then

Result 1: If on  $w_d$  one applies the tnorm, on  $w$  one also applies the tnorm.

Result 2: If on  $w_d$  one applies the tconorm, on  $w$  one also applies the tconorm.

#### Theorem 2:

$c(w_d, w) = 1$ , then

Result 1: If on  $w_d$  one applies the tnorm, on  $w$  one also applies the tconorm.

Result 2: If on  $w_d$  one applies the tconorm, on  $w$  one also applies the tnorm.

#### Theorem 3:

If  $0 < c(w_d, w) < 1$ , then on  $w$  one applies a linear combination of tnorm and tconorm.

#### Theorem 4:

Let  $x, y$  be fuzzy degrees of appurtenance of the attribute value with respect to Experts  $X$  and  $Y$  then,

$$x \wedge_p y + x \vee_p y = x \wedge_F y + x \vee_F y$$

#### Theorem 5:

Let  $x, y$  be fuzzy degrees of appurtenance of the attribute value with respect to Experts  $X$  and  $Y$ . If the degree of contradiction of  $x$  and  $y$  equal to 0.5 then

$$x \wedge_p y = x \vee_F y$$

## 5. Application:

In this phase to apply plithogenic operations, it takes four doctors and their reports so as obtain the accuracy of Plithogenic sets. There may be variation of information of the medical reports from different doctors. This may lead to uncertainties, hence an advanced operation is to be applied for higher accuracy. There is a possibility of various accuracy levels in each report. The proposed plithogenic operations that are given appurtenance will prove the increased level of accuracy.

### Numerical Example of Plithogenic single valued set

Let  $\bar{U}$  be the whole set then  $P \in \bar{U}$  a plithogenic set.

For example, the Expert values between "Doctor" and "Report",

Doctor = {doctor1, doctor2, doctor3, doctor4} and

Report = {report1, report 2, report 3, report 4}

Then the objects elements are characterized by the Cartesian product

**Doctor  $\times$  Report =**

$$\left( \begin{array}{l} (\text{doctor1, report1}), (\text{doctor1, report2}), (\text{doctor1, report3}), (\text{doctor1, report4}), \\ (\text{doctor2, report1}), (\text{doctor2, report2}), (\text{doctor2, report3}), (\text{doctor2, report4}) \\ (\text{doctor3, report1}), (\text{doctor3, report2}), (\text{doctor3, report3}), (\text{doctor3, report4}) \\ (\text{doctor4, report1}), (\text{doctor4, report2}), (\text{doctor4, report3}), (\text{doctor4, report4}) \end{array} \right)$$

Let us consider the dominant value of attribute "Doctor" be "doctor1" and of attribute "Report" be "report 1".

The attribute value contradiction fuzzy degrees are:

$$c(\text{doctor1, doctor1}) = 0$$

$$c(\text{doctor1, doctor2}) = \frac{1}{4}$$

$$c(\text{doctor1, doctor3}) = \frac{2}{4}$$

$$c(\text{doctor1, doctor4}) = \frac{3}{4}$$

$$c(\text{report1, report 1}) = 0$$

$$c(\text{report 1, report2}) = \frac{1}{4}$$

$$c(\text{report 1, report3}) = \frac{2}{4}$$

$$c(\text{report 1, report 4}) = \frac{3}{4}$$

We have two plithogenic sets  $X$  and  $Y$ . Next, we consider the Fuzzy, Intuitionistic, or Neutrosophic degrees of attribute value to a plithogenic set with respect to some experts condition.

### Single valued fuzzy set degrees appurtenance

Let  $d_X(x, w_i)$  be the appurtenance degree of the attribute value  $w_i$  of the element  $x$  to the set  $X$  and  $d_Y(x, w_i)$  be the appurtenance degree of the attribute value  $w_i$  of the element  $x$  to the set  $Y$ . Then  $w_i$  is a uni-attribute and its contradiction degree depends on uni-attribute  $w_d$  be  $c(w_d, w_i) = c_i$ .

Let us consider the fuzzy t-norm -  $x \wedge_F y = x \cdot y$  ..... (I)

The fuzzy t-conorm -  $x \vee_F y = x + y - x \cdot y$  ..... (II)

According to expert X:

$d_X : \{ \text{doctor1, doctor2, doctor3, doctor4; report1, report 2, report 3, report 4} \} \rightarrow [0,1]$

Contradiction degrees	0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$		0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$
Attribute's Values	doctor 1	doctor 2	doctor 3	doctor 4		report 1	report 2	report 3	report 4
Fuzzy Degree	0.8	0.2	0.4	0.6		0.7	0.3	0.5	0.5

According to expert Y:

$d_Y : \{ \text{doctor1, doctor2, doctor3, doctor4; report1, report 2, report 3, report 4} \} \rightarrow [0,1]$

Contradiction degrees	0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$		0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$
Attribute's Values	doctor 1	doctor 2	doctor 3	doctor 4		report 1	report 2	report 3	report 4
Fuzzy Degree	0.7	0.3	0.5	0.5		0.6	0.4	0.6	0.5



**Single attribute value fuzzy set union with Plithogenic**

Let us calculate all attribute value separately

$$d_X^F(x, \text{doctor 1}) \vee_p d_Y^F(x, \text{doctor 1}) = 0.8 \vee_p 0.7 \text{ (Contradiction degree is 0)}$$

Using the equation (a)

$$= (1 - 0) [0.8 \vee_F 0.7] + 0 [0.8 \wedge_F 0.7]$$

Using the equation (I) and (II)

$$= 0.8 + 0.7 - 0.56$$

$$= 0.94$$

$$d_X^F(x, \text{doctor 2}) \vee_p d_Y^F(x, \text{doctor 2}) = 0.2 \vee_p 0.3 \text{ (Contradiction degree is } \frac{1}{4})$$

$$= \left(1 - \frac{1}{4}\right) [0.2 \vee_F 0.3] + \frac{1}{4} [0.2 \wedge_F 0.3]$$

$$= \left(\frac{3}{4}\right) [0.2 + 0.3 - 0.2 \times 0.3] + \frac{1}{4} [0.2 \times 0.3]$$

$$= 0.35 \text{ (Using the equation (a) ,(I) and (II))}$$

Similarly, the calculation of the union of the experts results tabulated as follows.

**Single valued fuzzy set intersection with Plithogenic**

Let us calculate all attribute value separately

$$d_X^F(x, \text{doctor 1}) \wedge_F d_Y^F(x, \text{doctor 1}) = 0.8 \wedge_p 0.7 \text{ (Contradiction degree is 0)}$$

Using the equation (b)

$$= (1 - 0) [0.8 \wedge_F 0.7] + 0 [0.8 \vee_F 0.7] \text{ (Using the equation (I) and (II))}$$

$$= 0.56$$

$$d_X^F(x, \text{doctor 2}) \wedge_F d_Y^F(x, \text{doctor 2}) = 0.2 \wedge_p 0.3 \text{ (Contradiction degree is } \frac{1}{4})$$

$$= \left(1 - \frac{1}{4}\right) [0.2 \wedge_F 0.3] + \frac{1}{4} [0.2 \vee_F 0.3]$$

$$= 0.16 \text{ (Using the equation (b) ,(I) and (II))}$$

Contradiction degrees	0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$		0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$
Attribute's Values	doctor 1	doctor 2	doctor 3	doctor 4		report 1	report 2	report 3	report 4

Fuzzy Degrees of Expert X	0.8	0.2	0.4	0.6		0.7	0.3	0.5	0.5
Fuzzy Degrees of Expert Y	0.7	0.3	0.5	0.5		0.6	0.4	0.6	0.5
Fuzzy Degrees of $X_X \vee_P X_Y$	0.94	0.35	0.45	0.43		0.88	0.47	0.55	0.38
Fuzzy Degrees of $X_X \wedge_P X_Y$	0.56	0.16	0.45	0.68		0.42	0.24	0.55	0.63

Similarly, the calculation of the intersection of the expert's results tabulated as follows

The above table calculation is the linear combination of tnorm and tconorm using the equations (a), (b), (I) and (II)

### Single valued Intuitionistic fuzzy set degrees of appurtenance

According to expert X:

Contradiction degrees	0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$		0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$
Attribute's Values	doctor 1	doctor 2	doctor 3	doctor 4		report 1	report 2	report 3	report 4
Intuitionistic Fuzzy Degree	(0.6,0.5)	(0.2,0.4)	(0.1,0.3)	(0.0,1)		(0.7,0.4)	(0.4,0.5)	(0.5,0.2)	(0.2,0.3)

According to expert Y :

Contradiction degrees	0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$		0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$
Attribute's Values	doctor 1	doctor 2	doctor 3	doctor 4		report 1	report 2	report 3	report 4
Intuitionistic Fuzzy Degree	(0.8,0.7)	(0.4,0.5)	(0.3,0.6)	(0.1,0.4)		(0.6,0.5)	(0.5,0.3)	(0.3,0.3)	(0.3,0.1)

Single attribute value Intuitionistic Fuzzy set union with Plithogenic;

$$d_X^{IF}(x, \text{doctor1}) \vee_P d_Y^{IF}(x, \text{doctor1}) = (0.6, 0.5) \vee_P (0.8, 0.7) \text{ (contradiction degree is 0)}$$

Using the equation (c)

$$= (0.6 \vee_P 0.8, 0.5 \wedge_P 0.7)$$

Using the equation (a and b)

$$= ((1-0) [0.6 \vee_F 0.8] + 0[0.6 \wedge_F 0.8], (1-0) [0.5 \wedge_F 0.7] + 0[0.5 \vee_F 0.7])$$

Using the equation (I and II)

$$= (0.48, 0.85)$$

$$\begin{aligned}
d_X^{IF}(x, doctor3) \vee_P d_Y^{IF}(x, doctor3) &= (0.1, 0.3) \vee_P (0.3, 0.6) \text{ (contradiction degree is } \frac{2}{4}) \\
&= (0.1 \vee_P 0.3, 0.3 \wedge_P 0.6) \\
&= ((1 - \frac{2}{4})[0.1 \vee_F 0.3] + \frac{2}{4}[0.1 \wedge_F 0.3], (1 - \frac{2}{4})[0.3 \wedge_F 0.6] + \frac{2}{4}[0.3 \vee_F 0.6]) \\
&= (0.20, 0.45)
\end{aligned}$$

Single attribute value Intuitionistic Fuzzy set intersection with Plithogenic;

$$d_X^{IF}(x, doctor1) \wedge_P d_Y^{IF}(x, doctor1) = (0.6, 0.5) \wedge_P (0.8, 0.7) \text{ (contradiction degree is 0)}$$

Using the equation (d )

$$= (0.6 \wedge_P 0.8, 0.5 \vee_P 0.7)$$

Using the equation (a and b)

$$= ((1-0)[0.6 \wedge_F 0.8] + 0[0.6 \vee_F 0.8], (1-0)[0.5 \vee_F 0.7] + 0[0.5 \wedge_F 0.7])$$

Using the equation (I and II)

$$= (0.92, 0.35)$$

$$d_X^{IF}(x, doctor3) \wedge_P d_Y^{IF}(x, doctor3) = (0.1, 0.3) \wedge_P (0.3, 0.6) \text{ (contradiction degree is } \frac{2}{4})$$

Using the equation (d )

$$= (0.1 \wedge_P 0.3, 0.3 \vee_P 0.6)$$

Using the equation (a and b)

$$= ((1 - \frac{2}{4})[0.1 \wedge_F 0.3] + \frac{2}{4}[0.1 \vee_F 0.3], (1 - \frac{2}{4})[0.3 \vee_F 0.6] + \frac{2}{4}[0.3 \wedge_F 0.6])$$

Using the equation (I and II)

$$= (0.20, 0.45)$$

Similarly, the calculation of the union and intersection of the expert's intuitionistic fuzzy results tabulated as follows.

Contradiction degrees	0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$		0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$
Attribute's Values	doctor 1	doctor 2	doctor 3	doctor 4		report 1	report 2	report 3	report 4
Intuitionistic fuzzy degrees Expert X	(0.6,0.5)	(0.2,0.4)	(0.1,0.3)	(0,0.1)		(0.7,0.4)	(0.4,0.5)	(0.5,0.2)	(0.2,0.3)

Intuitionistic fuzzy degrees Expert Y	(0.8,0.7)	(0.4,0.5)	(0.3,0.6)	(0.1,0.4)		(0.6,0.5)	(0.5,0.3)	(0.3,0.3)	(0.3,0.1)
Intuitionistic Fuzzy Degrees of $X_X \vee_P X_Y$	0.92,0.35	0.41,0.33	0.20,0.45	0.03,0.36		0.88,0.2	0.58,0.28	0.4,0.25	0.16,0.29
Intuitionistic Fuzzy Degrees of $X_X \wedge_P X_Y$	0.48,0.85	0.19,0.58	0.2,0.45	0.08,0.15		0.42,0.7	0.33,0.53	0.4,0.25	0.35,0.12

The above table calculation is the linear combination of tnorm and tconorm using the equations (c), (d), (I) and (II)

Single valued Neutrosophic set degrees of appurtenance :

According to expert X:

Contradiction degrees	0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$		0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$
Attribute's Values	doctor 1	doctor 2	doctor 3	doctor 4		report 1	report 2	report 3	report 4
Neutrosophic Degree	0.4,0.2, 0.6	0.2,0.4, 0.5	0.4,0.1, 0.5	0.5,0.2, 0.3		0.6,0.2, 0.5	0.4,0.1, 0.5	0.5,0.3, 0.4	0.3,0.1, 0.3

According to expert Y:

Contradiction degrees	0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$		0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$
Attribute's Values	doctor 1	doctor 2	doctor 3	doctor 4		report 1	report 2	report 3	report 4
Neutrosophic Degree	0.6,0.1,0.3	0.5,0.2, 0.4	0.4,0.3, 0.3	0.7,0.1, 0.6		0.5,0.1, 0.3	0.4,0.2, 0.4	0.6,0.3, 0.5	0.4,0.1, 0.5

Single attribute value Neutrosophic set union with Plithogenic;

$$d_X^N(x, doctor1) \vee_P d_Y^N(x, doctor1) = (0.4, 0.2, 0.6) \vee_P (0.6, 0.1, 0.3) \text{ (contradiction degree is 0)}$$

Using the equation (e)

$$= (0.4 \vee_p 0.6, 0.5(0.2 \wedge_p 0.1 + 0.2 \vee_p 0.1), 0.6 \wedge_p 0.3)$$

Using the equation (a) and (b)

$$= ((1-0) [0.4 \vee_F 0.6] + 0[0.4 \wedge_F 0.6], 0.5(((1-0) [0.2 \wedge_F 0.1] + 0[0.2 \vee_F 0.1])( \\ ((1-0) [0.2 \vee_F 0.1] + 0[0.2 \wedge_F 0.1])), (1-0) [0.6 \wedge_F 0.3] + 0[0.6 \vee_F 0.3])$$

Using the equation (I and II)

$$= (0.76, 0.15, 0.18)$$

$$d_X^{IF}(x, \text{doctor3}) \vee_p d_Y^{IF}(x, \text{doctor3}) = (0.4, 0.1, 0.5) \vee_p (0.4, 0.3, 0.3) \text{ (contradiction degree is } \frac{2}{4})$$

$$= (0.4 \vee_p 0.4, 0.5(0.1 \wedge_p 0.3 + 0.1 \vee_p 0.3), 0.5 \wedge_p 0.3)$$

$$= ((1 - \frac{2}{4})[0.4 \vee_F 0.4] + \frac{2}{4}[0.4 \wedge_F 0.4], 0.5((1 - \frac{2}{4})[0.1 \wedge_F 0.3] + \frac{2}{4}[0.1 \vee_F 0.3]$$

$$+ (1 - \frac{2}{4})[0.1 \vee_F 0.3] + \frac{2}{4}[0.1 \wedge_F 0.3]), (1 - \frac{2}{4})[0.5 \wedge_F 0.3] + \frac{2}{4}[0.5 \vee_F 0.3])$$

$$= (0.40, 0.20, 40)$$

Single attribute value Neutrosophic set intersection with Plithogenic;

$$d_X^N(x, \text{doctor1}) \wedge_p d_Y^N(x, \text{doctor1}) = (0.4, 0.2, 0.6) \wedge_p (0.6, 0.1, 0.3) \text{ (contradiction degree is 0)}$$

Using the equation (f)

$$= (0.4 \wedge_p 0.6, 0.5 (0.2 \wedge_p 0.1 + 0.2 \vee_p 0.1), 0.6 \vee_p 0.3)$$

Using the equation (a) and (b)

$$= ((1-0) [0.4 \wedge_F 0.6] + 0 [0.4 \vee_F 0.6], 0.5(((1-0) [0.2 \vee_F 0.1] \\ + 0[0.2 \wedge_F 0.1]) ((1-0) [0.2 \vee_F 0.1] + 0 [0.2 \wedge_F 0.1])), (1-0) \\ [0.6 \vee_F 0.3] + 0[0.6 \wedge_F 0.3])$$

Using the equation (I and II)

$$= (0.24, 0.15, 0.72)$$

$$d_X^N(x, \text{doctor3}) \wedge_p d_Y^N(x, \text{doctor3}) = (0.4, 0.1, 0.5) \wedge_p (0.4, 0.3, 0.3) \text{ (contradiction degree is } \frac{2}{4})$$

Using the equation (f)

$$= (0.4 \wedge_p 0.4, 0.5 (0.1 \wedge_p 0.3 + 0.1 \vee_p 0.3), 0.5 \vee_p 0.3)$$

Using the equation (a) and (b)

$$= \left( \left( 1 - \frac{2}{4} \right) [0.4 \wedge_P 0.4] + \frac{2}{4} [0.4 \vee_F 0.4], 0.5 \left( \left( 1 - \frac{2}{4} \right) [0.1 \wedge_F 0.3] + \frac{2}{4} [0.1 \vee_F 0.3] \right. \right. \\ \left. \left. + \left( 1 - \frac{2}{4} \right) [0.1 \vee_F 0.3] + \frac{2}{4} [0.1 \wedge_F 0.3] \right), \left( 1 - \frac{2}{4} \right) [0.5 \vee_F 0.3] + \frac{2}{4} [0.5 \wedge_P 0.3] \right)$$

Using the equation (I and II)

$$= (0.40, 0.20, 40)$$

Similarly, the calculation of the union and intersection of the experts, intuitionistic fuzzy results tabulated as follows.

Contradiction degrees		0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$		0	$\frac{1}{4}$	$\frac{2}{4}$	$\frac{3}{4}$
Attribute's Values		doctor 1	doctor 2	doctor 3	doctor 4		report 1	report 2	report 3	report 4
Neutrosophic set	Expert X	0.4,0.2,0.6	0.2,0.4,0.5	0.4,0.1,0.5	0.5,0.2,0.3		0.6,0.2,0.5	0.4,0.1,0.5	0.5,0.3,0.4	0.3,0.1,0.3
	Expert Y	0.6,0.1,0.3	0.5,0.2,0.4	0.4,0.3,0.3	0.7,0.1,0.6		0.5,0.1,0.3	0.4,0.2,0.4	0.6,0.3,0.5	0.4,0.1,0.5
	Experts $X_X \vee_P X_Y$	0.76,0.15,0.18	0.48,0.3,0.33	0.4,0.2,0.4	0.45,0.15,0.59		0.8,0.15,0.15	0.52,0.15,0.33	0.55,0.3,0.45	0.24,0.1,0.53
	Experts $X_X \wedge_P X_Y$	0.24,0.15,0.72	0.23,0.3,0.58	0.4,0.2,0.4	0.73,0.15,0.32		0.3,0.15,0.65	0.28,0.15,0.58	0.55,0.3,0.45	0.47,0.1,0.28

The above table calculation is the linear combination of tnorm and tconorm using the equations (e), (f), (I) and (II)

## 6. Conclusion

The objective of this paper is to enhance the accuracy level of decision making, since the decision making level in the existing approaches Fuzzy, Intuitionistic fuzzy set and Neutrosophic set is less accurate. In this paper, it is an attempt to get more accurate value in the Plithogenic set

using aggregative operation  $t_{\text{norm}}$  and  $t_{\text{conorm}}$ . This method can be applied in Multiple Regression to get higher accurate level of evaluation. An example is given in this paper to find the level of accuracy for decision making using Plithogenic set with Fuzzy set, Intuitionistic fuzzy set and Neutrosophic set and it is proved practically how accurate the result is and its effectiveness. Hence from the above example, it is proved that Plithogenic set is a reliable and valuable tool for making decision.

## References

- [1] Zadeh, L. (1965) "Fuzzy sets", Inform and Control 8 338-353.
- [2] Atanassov, K. T. (1983) Intuitionistic fuzzy sets, VII ITKR's Session, Sofia (deposited in CentralSci.-Technical Library of Bulg. Acad. of Sci., 1697/84) (in Bulgarian).
- [3] J. Buckley, "Ranking alternatives using fuzzy numbers," Fuzzy sets and systems, vol. 15, no. 1, pp. 21–31, 1985.
- [4] K. Atanassov, Intuitionistic fuzzy sets. Fuzzy Sets and Systems, 1986, 20: 87-96.
- [5] I.B. Turksen (1986) "Interval valued fuzzy sets based on normal forms" 191- 210. North-Holland
- [6] K. Atanassov, More on intuitionistic fuzzy sets, Fuzzy Sets and Systems 33 (1989) 37– 46
- [7] K. Atanassov. New operations defined over the intuitionistic fuzzy sets. Fuzzy Sets and Systems. 1994, 61: 137-142
- [8] Grabisch M, Orlovski Sergei A, Yager Ronald R. Fuzzy Aggregation of Numerical Preferences. Fuzzy Sets in Decision Analysis, Operations Research and Statistics. The Handbooks of Fuzzy Sets Series 1 (1998) 31-68.
- [9] Atanassov, K. (1999), "Intuitionistic Fuzzy sets", Springer, Heidelberg.
- [10] Supriya Kumar De, Ranjit Biswas, Roy AR (2000) some operations on intuitionistic fuzzy sets. Fuzzy Sets and Systems 114: 477–484.
- [11] M. J. Liberatore, Project Schedule Uncertainty Analysis Using Fuzzy Logic, Project Management Institute, 33(4), (2002), 15-22.
- [12] Florentin Smarandache, Neutrosophic set– A Generalization of the Intuitionistic Fuzzy set, Proceedings of the Third Conference of the European Society for Fuzzy Logic and Technology, EUSFLAT 2003, September 10-12, 2003, Zittau, Germany; University of Applied Sciences at Zittau/Goerlitz, 141-146.
- [13] Glad Deschrijver, Chris Cornelis, and Etienne E. Kerre (2004) "On the Representation of Intuitionistic Fuzzy  $t$ -Norms and  $t$ -Conorms" IEEE TRANSACTIONS ON FUZZY SYSTEMS, VOL. 12, NO. 1, FEBRUARY 2004.
- [14] Monoranjan Bhowmik and Madhumangal Pal, "Intuitionistic Neutrosophic Set," ISSN 1746-7659, England, UK Journal of Information and Computing Science, Vol. 4, No. 2, 2009, pp. 142-15.
- [15] Wang, H.; Smarandache, F.; Zhang, Y.Q.; Sunderraman, R. Single valued neutrosophic sets. Multispace Multistruct. 2010, 4, 410–413.
- [16] Mamoni Dhar (2013) "Cardinality of Fuzzy Sets: An Overview" International Journal of Energy, Information and Communications Vol. 4, Issue 1, February, 2013.

- [17] Said Broumi, Florentin Smarandache: Several Similarity Measures of Neutrosophic Sets, *Neutrosophic Sets and Systems*, vol. 1, 2013, pp. 54-62. doi.org/10.5281/zenodo.571755
- [18] Huchang Liao and Zeshui Xu, "Some new hybrid weighted aggregation operators under hesitant fuzzy multi-criteria decision making environment" *Journal of Intelligent & Fuzzy Systems* 26 (2014) 1601–1617 DOI:10.3233/IFS-130841 IOS Press.
- [19] Hong-yu Zhang, Jian-qiang Wang, and Xiao-hong Chen, "Interval Neutrosophic Sets and Their Application in Multicriteria Decision Making Problems" Hindawi Publishing Corporation © Scientific World Journal Volume 2014, Article ID 645953, 15 pages <http://dx.doi.org/10.1155/2014/645953>.
- [20] R.R. Aliev\*, O.H. Huseynov, K.R. Aliyeva, "Z-valued t-norm and t-conorm operators-based aggregation of partially reliable information" 12th International Conference on Application of Fuzzy Systems and Soft Computing, ICAFS 2016, 29-30 August 2016, Vienna, Austria
- [21] Florentin Smarandache. *Plithogeny, Plithogenic Set, Logic, Probability, and Statistics*. Brussels: Pons Editions, 2017.
- [22] Smarandache, F. (2018). Plithogenic set, an extension of crisp, fuzzy, intuitionistic fuzzy, and neutrosophic sets-revisited. *Infinite Study*.
- [23] D. Preethi, S. Rajareega, J. Vimala, Ganeshsree Selvachandran, Florentin Smarandache, "Single-Valued Neutrosophic Hyperring and Single-Valued Neutrosophic Hyperideals", *Neutrosophic Sets and Systems*, Vol. 29, 2019.
- [24] D. Nagarajan, M. Lathamaheswari, S. Broumi, J. Kavikumar, Blockchain single and interval valued neutrosophic graphs, *Neutrosophic Sets Syst.* 24 (2019) 23–35.
- [25] D. Nagarajan, M. Lathamaheswari, S. Broumi and J. Kavikumar, A new perspective on traffic control management using triangular interval type-2 fuzzy sets and interval neutrosophic sets. *Operations Research perspectives*, Article in Press. <https://doi.org/10.1016/j.orp.2019.100099>
- [26] R. Jansi, K. Mohana and Florentin Smarandache: Correlation Measure for Pythagorean Neutrosophic Fuzzy Sets with T and F as Dependent Neutrosophic Components, *Neutrosophic Sets and Systems*, vol. 30, 2019, pp. 202-212. DOI: 10.5281/zenodo.3569786
- [27] Abdel Nasser H. Zaied, Mahmoud Ismail, Abdullallah Gamal, Nabil Mostafa: An Integrated Neutrosophic and MOORA for Selecting Machine Tool, *Neutrosophic Sets and Systems*, vol. 28, 2019, pp. 23-33. DOI: 10.5281/zenodo.3382505
- [28] Said Broumi, Malayalan Lathamaheswari, Ruipu Tan, Deivanayagampillai Nagarajan, Talea Mohamed, Florentin Smarandache and Assia Bakali, A new distance measure for trapezoidal fuzzy neutrosophic numbers based on the centroids, *Neutrosophic Sets and Systems*, vol. 35, 2020, pp. 478-502. DOI: 10.5281/zenodo.3951706
- [29] Nivetha Martin and Florentin Smarandache, Introduction to Combined Plithogenic Hypersoft Sets, *Neutrosophic Sets and Systems*, vol. 35, 2020, pp. 503-510. DOI: 10.5281/zenodo.3951708



- [30] Abdel-Basst, Mohamed, Rehab Mohamed, and Mohamed Elhoseny. "<? covid19?> A model for the effective COVID-19 identification in uncertainty environment using primary symptoms and CT scans." *Health Informatics Journal* (2020): 146045822095291

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