Data with Intuitionistic Plithogenic attributes and its analysis

Prem Kumar Singh*

Department of Computer Science and Engineering,
Gandhi Institute of Technology and Management-Visakhapatnam, Andhra Pradesh 530045, India
ORCID: 0000-0003-1465-6572
Emails: premsingh.csjm@gmail.com , premsingh.csjm@yahoo.com

Abstract

Recent time a problem is addressed while dealing the data with multi-valued attributes and its dynamicity. The problem is that these types of data set contain lots of opposite, non-opposite and uncertainty unconsciously. One of the suitable examples is handling soil data sets and its pattern for water storage and plant growth. The precise representation of these types of data sets and its multi-veracity is one of the crucial tasks for the data science researchers. To achieve this goal, algebra of Intuitionistic Plithogenic set and its graph is utilized in this paper. The proposed method is explained using the example of Soil pollution.

Keywords: Knowledge representation; Neutrosophic set; Plithogenic set; Plithogenic graph; Intuitionistic fuzzy set

1. Introduction

Recent time the precise analysis of opposite, non-opposite and uncertain side of dark data set (like Air Pollution, Soil pollution and Algae data) is considered as one of the major issue [1]. One of the prominent problem with these types of data sets that these data sets contains uncertainty or vagueness in multi-attribute unconsciously which may change also based on time [2]. Smarandache [3] called them as Plithogenic attributes and introduced its some of the algebra [4] for knowledge processing tasks. The Plithogenic set represents several opposite, non-opposite or indeterminant conditions unconsciously [5]. Recently, it received much attention by researchers of several fields [5-8] for various applications [9-10]. The problem arises while investigation of some pattern in data with Plithogenic attributes and its graphical visualization. To achieve this goal the current paper focused on dealing with data with Plithogenic attributes.

Recently, a problem is addressed while dealing with uncertainty in the known attributes [11]. It is noticed that several data sets where uncertainty may exists beyond the true and false regions of Intuitionistic fuzzy set [12-13].One of the most suitable examples is soil data set [14] which is mixture of several organic, gases, minerals, liquids and other components. These gradients and its uncertainty are included in soil data sets without involvement of Human consciousness as shown in Figure 1 [15]. In this case, the precise representation of soil data sets and measuring its impact on human health is one of the crucial tasks. The reason is that the soil may contain several opposite, non-opposite and uncertain attributes which may affect human health as well as plant growth unconscious manner. The Anthropocene of soil sciences based on expert opinion need to analyze or approximated in the given interval [16-17] at given phase of time [18]. There are several applications of Plithogenic set in case of multi-attribute [19] or multi-objective algorithms [20-23] where uncertainty arises unconsciously [24-26] rather than Human Turiyam consciousness [27]. To deal with these types of data sets the algebra of Intuitionistic Plithogenic set is much adequate.

Doi: https://doi.org/10.54216/GJMSA.070201
Received: March 01, 2023 Revised: June 22, 2023 Accepted: August 09, 2023

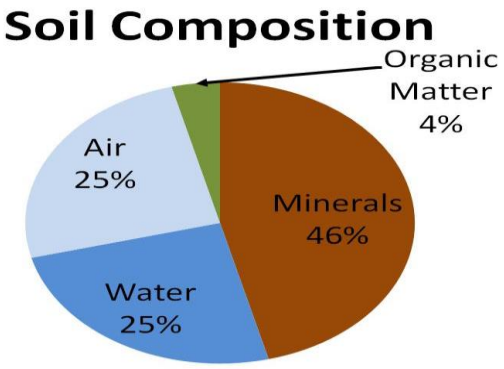

Figure 1: A multi-attribute containment representation of Soil

The motive is to represent the data with Intuitionistic Plithogenic attributes precisely in the given context for various analyses. The objective is to provide a compact graphical representation of data with Intuitionistic Plithogenic attributes for multi-decision process. One of the significant outcomes of the proposed method is its graphical visualization rather than numerical representation of data with Intuitionistic Plithogenic attributes.

Remaining part of the paper is organized as follows: Section 2 provides preliminaries about Plithogenic set. Section 3 includes the proposed method for dealing with data of Intuitionistic Plithogenic attribute with its illustration in Section 4. Section 5 includes conclusions followed by the references.

2. Data with Intuitionistic Plithogenic attributes

This section provides preliminaries about Plithogenic set and its examples for understanding of intuitionistic Plithogenic set:

Definition 1. Plithogenic Set [3-4]: This set contains five parts to represents the multi-valued attributes of the given data sets. Let us suppose, ξ be a universe of discourse, P be a subset of this universe of discourse, "a" a multi-valued attribute, V is the range of the multi-valued attribute, "d" be the known (fuzzy, intuitionistic fuzzy, or neutrosophic) degree of appurtenance with regard to some generic of element x's attribute value to the set P, and c is the (fuzzy, intuitionistic fuzzy, neutrosophic) degree of contradiction (dissimilarity) among the attribute values as (<*A*, Neutral *A*, Anti *A*>; <*B*, Neutral *B*, Anti *B*>; <*C*, Neutral *C*, Anti *C*>). It can be represented as a set (P, a, V, d, c) which named as a Plithogenic Set (**P**). The Plithogenic set is a set **P** (P, a, V, d, c) in which each element $x \in P$ is characterized by all attribute's (a) values in $V = \{v_1, v_2, \ldots, v_n\}$, for $n \geq 1$ for the degree of appurtenance (d). In case of multi-attributes $A = \{\alpha_1, \alpha_2, \ldots, \alpha_m\}$, $m \geq 1$, which has values $V = \{v_1, v_2, \ldots, v_n\}$, for $n \geq 1$. The appurtenance degree function $d(x, v)$ of the element x, with respect to some given criteria, and the contradiction (dissimilarity) degree function $c(v, D)$ which is the one realized between each attribute value and the most important (dominant) one.

Definition 2. ([3]) The *degree of appurtenance* is defined for fuzzy, intuitionistic fuzzy, or neutrosophic degree of appurtenance to the Plithogenic set as: $\forall x \in P, d: P \times V \to \mathcal{P}([0,1]^z)$,

$d(x, v)$is a subset of $[0,1]^z$, $\mathcal{P}([0,1]^z)$ is the power set of $[0,1]^z$, where $z = 1, 2, 3$, for fuzzy, intuitionistic fuzzy, and neutrosophic degrees of appurtenance, respectively. In this paper the degree of appurtenance considered as Intuitionistic fuzzy set for dealing with Plithogenic data.

Definition 3.([3]) The attribute value *contradiction degree functionc*: $V \times V \to [0,1]$represents the dissimilarity between two attribute values v_1 and v_2, as$c(v_1, v_2)$ with following properties:

(i) $c(v_1, v_1) = 0$ *i.e.* the contradiction among v_1 and $v_2$is zero.

(ii) $c(v_1, v_2) = c(v_2, v_1)$, the contradiction among v_1 and v_2 or v_2 and v_1 used to be considered as per the commutativity properties. In this paper author focuses on single-valued fuzzy membership to handle the Plithogenic set. One of the suitable examples of Plithogenic attribute is Soil as shown in Figure 1.

Example 1: Let us suppose, an experts (y_1) given an opinion towards the soil (x_1) of given area that this soil (x_1) contains 60 percent Fluorosis, 20 percent Arsenic with $\frac{1}{3}$ contradiction, 70 percent Bacteria and other organic contaminants with $\frac{2}{3}$ contradiction for 80 percent Water Storage and 50 percent Plant growth with $\frac{1}{2}$ contradiction. It can be represented using Plithogenic context as shown in Table 1.

Doi: https://doi.org/10.54216/GJMSA.070201
Received: March 01, 2023 Revised: June 22, 2023 Accepted: August 09, 2023

Table 1: The expert (y_1) opinion for soil (x_1) of given area

Contradiction degree	0	$\frac{1}{3}$	$\frac{2}{3}$	0	$\frac{1}{2}$
Multi-attributes	Fluorosis	Arsenic Poisoning	Bacteria and other organic contaminants	Water Storage	Plant growth
Fuzzy degree	0.6	0.2	0.7	0.8	0.5

Definition 5: Intuitionistic Fuzzy Set [12-13]: The intuitionistic fuzzy set is a generalization of fuzzy set. It represents the acceptation, rejection part of any attributes simultaneously. The intuitionistic fuzzy set *A* can be defined by $A=\{x,\mu_X(x),\nu_X(x)/x\in X\}$ where $\mu_A(x):E\to[0,1],\nu_A(x):E\to[0,1]$ for each $x\in E$ such that $0\le\mu_A(x)+\nu_A(x)\le 1$. Here $\mu_A(x):E\to[0,1]$ denote degrees of membership and $\nu_A(x):E\to[0,1]$ denotes non-membership of x ∈ A, respectively. In case Intuitionistic Plithogenic set the degree of appurtenance can be represented using intuitionistic fuzzy set whereas the contradiction may be represented by single-valued fuzzy membership.

This paper tried to focus on connecting single-valued Plithogenic set with Intuitionistic set for multi-decision process. To achieve this goal, Intuitionistic Plithogenic context and its graphical visualization is introduced in the next section.

3.A Proposed method

In this section, a method is proposed for dealing with data of Intuitionistic Plithogenic attributes and its graphical visualization for knowledge processing tasks as given below:

Step 1. Let us suppose any data set having Intuitionistic Plithogenic attributes as(*P*, *a*, *V*, *d*, *c*), where *P* is a Plithogenic set, *a* is the set of multi-valued attributes, *V is* the defined range of the multi-valued attributes, *d* is the intuitionistic degree of appurtenance and *c* is the single-valued degree of contradiction.

Step 2. Try to compute the union, intersection and complement among the Plithogenic attribute as follows:

(i) Union of single-valued Plithogenic set as

$$d_{p_1}(a_p,v_p)\vee d_{p_2}(a_p,v_p)=(1-c_p)\times(d_{p_1}(a_p,v_p)\vee_f d_{p_2}(a_p,v_p))+c_p(d_{p_1}(a_p,v_p)\wedge_f d_{p_2}(a_p,v_p))$$

(ii) Intersection of single-valued Plithogenic set as

$$d_{p_1}(a_p,v_p)\wedge d_{p_2}(a_p,v_p)=(1-c_p)\times(d_{p_1}(a_p,v_p)\wedge_f d_{p_2}(a_p,v_p))+c_p(d_{p_1}(a_p,v_p)\vee_f d_{p_2}(a_p,v_p))$$

(iii) Complement can be computed as follows:
$(d_p(a_p,v_p))'=(1-c_p)\times d_p(a_p,v_p)$ where*dp* represents degree of appurtenance, c_p represents contradiction degrees for the multi-valued attributes a_p.

Step 3. Compute the supremum and infimum among Intuitionistic Plithogenic sets based on its intuitionistic degree of appurtenance as: $V_1=\{v_1,\mu_{v_1}(x),\nu_{v_1}(x)/x\in X\}$ and $V_2=\{v_2,\mu_{v_2}(x),\nu_{v_2}(x)/x\in X\}$ then union and intersection can be computed as follows:

Doi: https://doi.org/10.54216/GJMSA.070201
Received: March 01, 2023 Revised: June 22, 2023 Accepted: August 09, 2023

$(i).\ V_1 \vee_p V_2 = \left(\mu_{v_1} \vee_p \mu_{v_2}, \nu_{v_1} \wedge_p \nu_{v2}\right)$

$(ii).\ V_1 \wedge_p V_2 = \left(\mu_{v_1} \wedge_p \mu_{v_2}, \nu_{v_1} \vee_p \nu_{v2}\right)$

Otherwise the Plithogenic relation among them can be computed as follows: $d_{p_1}(a_p, v_p) \wedge d_{p_2}(a_p, v_p) \geq (1 - c_p) \times (d_{p_1}(a_p, v_p) \wedge_f d_{p_2}(a_p, v_p)) + c_p (d_{p_1}(a_p, v_p) \vee_f d_{p_2}(a_p, v_p))$

In this way the supremum and infimum as well as Intuitionistic Plithogenic relation can be computed which will help in its graphical visualization.

Step 4. Try to represent the computed degree of appurtenance in a defined Plithogenic graph G= $\left\{V_p, E_p, a_p, (\mu_{d_p}, \nu_{d_p}), c_p\right\}$ can be called as intuitionistic Plithogenic graph where (*Vp*)represents Intuitionistic Plithogenic attributes as vertex, (*Ep*) represents the intuitionistic Plithogenic set based edges, (a_p) represents the multi-valued i.e. one or more attributes of distinct values. The intuitionistic degree of appurtenance (*dp*) says that at what level the given multi-valued attributes belongs to the set or does not belongs to the set. The (c_p) represents the contradiction degrees as single-valued fuzzy membership.

Step 5. The vertex can be represented as the Intuitionistic Plithogenic set as: $\frac{\left\{a_p, (\mu_{d_p}, \nu_{d_p}), c_p\right\}}{V_p}$ where (a_p)represents multi-valued attributes defines the Intuitionistic Plithogenic vertex(*Vp*). The degree of appurtenance (*dp*) represents the belongingness and non-belongingness of multi-valued attributes via intuitionistic Plithogenic set. The contradiction degree is represented using single-valued fuzzy membership as (c_p).

Step 6. The relationship among vertex can be represented as Intuitionistic Plithogenic set of edges as: $\frac{\left\{a_{pq}, (\mu_{d_{pq}}, \nu_{d_{pq}}), c_{pq}\right\}}{E_{pq}(V_p V_q)}$ where (a_{pq}) represents one or more attributes which defines the Intuitionistic Plithogenic edges (E_{pq}). The degree of appurtenance (d_{pq}) represents the belongingness and non-belongingness of multi-valued edges with its single-valued contradiction degrees (c_{pq}) for the given edge.

Step 7. The contradiction among v_1 and v_2 (or v_2 and v_1) satisfies commutative properties $c(v_1, v_2) = c(v_2, v_1)$. It means the Intuitionistic Plithogenic set based edges (E_{pq}) and (E_{qp}) represents same.

Step 8. The contradiction degrees $c(v_1, v_1) = 0$ due to which the edges can be edges can be represented as $(E_{pq} \subseteq V_p \times V_q - V_p \times V_p - V_q \times V_q)$.

Step 9. Now the data with Intuitionistic Plithogenic attributes considered at Step 1 can be visualized as shown in Figure 2.

Step 10: The Figure 1 can be analyzed based on supremum and infimum among the attributes for knowledge processing tasks.

Doi: https://doi.org/10.54216/GJMSA.070201
Received: March 01, 2023 Revised: June 22, 2023 Accepted: August 09, 2023

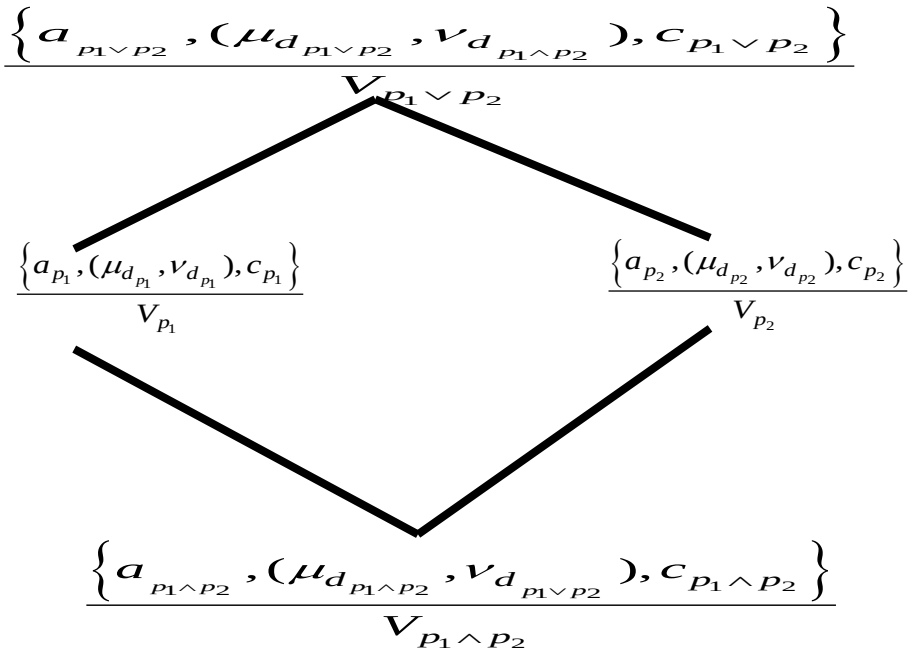

Figure 2: The Intuitionistic Plithogenic graph visualization using supremum and infimum

Time complexity: Let us suppose, there are *n*-number of Intuitionistic Plithogenic attribute with *m*-number of multi-valued appurtenance degree of attributes then it may take O(nm^2) including contradiction degree may take overall O($n.m^3$) time complexity.

4. Illustration

Recently, uncertainty and vagueness exists in dark data set consider as one of the major issues by researchers [1-2]. In this process, a problem is addressed while precise representation of refusal degree [11] and its approximation [16]. The problem arises when the uncertainty in given data sets contains several opposite, non-opposite and indeterminant part as mentioned by Smarandache [3-4]. In this process a problem is addressed while investigation of data with Plithogenic attributes for knowledge processing tasks [5]. To deal with this issue, current paper tried to focus on handling data with Intuitionistic Plithogenic attributes. One of the suitable examples is soil data science where less attention has been paid [15]. The soil data sets contains Plithogenic attributes which contains several opposite, non-opposite, and indeterminant part as shown in Figure 1. The problem is that soil data can be represented beyond single-valued membership and any contradiction arises among the experts. Recently, some researchers tried to approximate the uncertainty in multi-attribute data set via cubic [16] and single-valued Plithogenic set [17-19]. In this process, problem is addressed while dealing with positive and negative opinion of experts in case of conflict for multi-objective problem [20-24] and its uncertainty arises via unconsciously [25] or consciously [26]. This paper focused on dealing the uncertainty arises in multi-attribute unconsciously using the intuition Plithogenic set and its properties motivated from recent work [19]. To achieve this goal a method is proposed in Section 3 and the soil data set is taken for the illustration. One of the reasons that the soil data sets get polluted unconsciously which may impact the human health, plant growth as well as water storage. Hence, this study required a mathematization of the soil pollution and its representation for adequate understanding.

Example 2: Let us extend the Example 1 as the expert provides opinion about a Soil (x_1) in form of for Intuitionistic Plithogenic set as shown in Table 2. Same time another expert with whom contradiction arises given the opinion about Soil (x_1) as shown in Table 3. The problem with selection committee is how to analyze the opinion of both experts for utilization of soil (x_1). To deal with it proposed method in this paper can be

Doi: https://doi.org/10.54216/GJMSA.070201
Received: March 01, 2023 Revised: June 22, 2023 Accepted: August 09, 2023

useful. First compute the union and intersection among the expert opinion as shown in Table 4. The obtained Intuitionistic Plithogenic context visualize based on its supremum and infimum as shown in Figure 2. Now try to extract information from the Figure 3 for knowledge processing tasks.

Table 2: The expert (y_1) opinion about Soil (x_1) of given area

Contradiction degree	0	0.33	0.66	0.0	0.5
Multi-attributes	Fluorosis	Arsenic Poisoning	Bacteria and other organic contaminants	Water Storage	Plant growth
Soil (x_1)	(0.4, 0.5)	(0.1, 0.2)	(0.0, 0.3)	(0.8, 0.2)	(0.4, 0.5)

Table 3: The expert (y_2) opinion about Soil(x_1) of given area

Contradiction degree	0	0.33	0.66	0.0	0.5
Multi-attributes	Fluorosis	Arsenic Poisoning	Bacteria and other organic contaminants	Water Storage	Plant growth
Soil (x_1)	(0.6, 0.3)	(0.4, 0.3)	(0.2, 0.5)	(0.6, 0.1)	(0.5, 0.3)

Doi: https://doi.org/10.54216/GJMSA.070201
Received: March 01, 2023 Revised: June 22, 2023 Accepted: August 09, 2023

Table 4:The Intuitionistic Plithogenic context representation of Table 1 and 2

Contradiction degree	0	0.33	0.66	0.0	0.5
Multi-attributes	Fluorosis	Arsenic Poisoning	Bacteria and other organic contaminants	Water Storage	Plant growth
Expert (y_1)opinion about Soil (x_1)	(0.4, 0.5)	(0.1, 0.2)	(0.0, 0.3)	(0.8, 0.2)	(0.4, 0.5)
Expert (y_2)opinion about Soil (x_1)	(0.6, 0.3)	(0.4, 0.3)	(0.2, 0.5)	(0.6, 0.1)	(0.5, 0.3)
$y_1 \wedge_p y_2$ as per step 7 of Section 3.1	(0.24, 0.65)	(0.18, 0.31)	(0.13, 0.32)	(0.48, 28)	(0.45, 0.40)
$y_1 \vee_p y_2$ as per step 7 of Section 3.1	(0.76, 0.15)	(0.32, 0.19)	(0.07, 0.48)	(0.92, 0.02)	(0.45, 0.40)

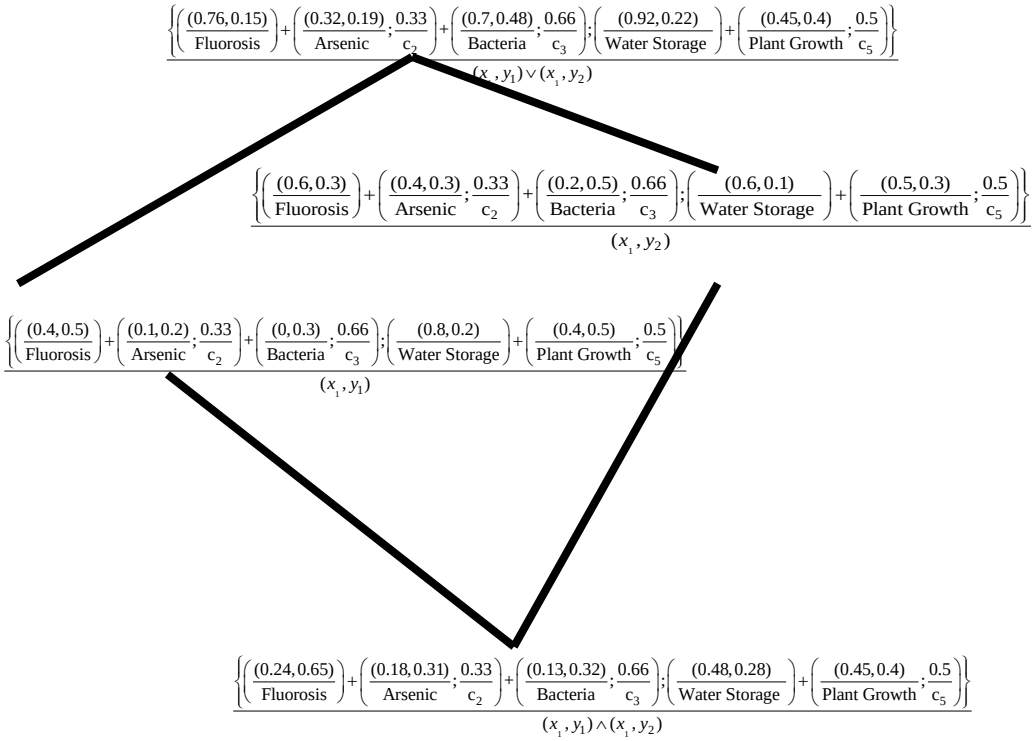

Figure 3: The Intuitionistic Plithogenic graph visualization of Table 4.

Doi: https://doi.org/10.54216/GJMSA.070201
Received: March 01, 2023 Revised: June 22, 2023 Accepted: August 09, 2023

It can be observed that the Figure 3 represents following information:

(i) The expert (y_1) and (y_2) maximally agreed that the soil (x_1) includes 76 percent Fluorosis, 37 percent Arsenic and 70 percent Bacteria which are 92 percent suitable for Water Storage and 45 percent for Plant Growth as per infimum node.

(ii) The supremum node represents that both expert minimally agreed that the soil (x_1) contains 24 percent Fluorosis, 18 percent Arsenic, 13 percent Bacteria for 48 percent Water Storage and 45 percent Plant Growth.

(iii) It means that the conflict happen among the experts for the Water storage capacity of soil (x_1) rather than Plant growth. This information will be useful for various multi-decision processes.

It can be observed that the proposed method able to represent the soil and its containment for various decision making. It will helpful in case some places soil is polluted unconsciously by human or nature which can be characterized as follows:

(i) Soil Polluted: The expert knows that Soil of given area is polluted and harmful for the human can be characterized using the proposed method.

(ii) Anti-Pollution: The expert knows that the Soil of given area is not polluted as per people health standard, plant growth and water storage level.

(iii) Neutro-Pollution: The expert is uncertain about soil pollution due to multi-attribute component of soil. This type of data can be also represented via the proposed method.

(iv) Nothing or Unknown: The problem arises when the expert is unknown about condition of Soil, water storage level, Human Health issues or component of soil. The soil is polluted purposefully by some enemy country which requires super conscious of human cognition. These types of data sets cannot be represented precisely via the proposed method. It requires exploration based on Turiyam consciousness of expert which can be represented as (t, i, f, u) [27-28]. In near future the author will focus on exploring this research area.

It can be observed that the soil pollution is one of the serious concerns for the human health, water storage or plant growth. The proposed method provides an alternative way to deal with data of Intuitionistic Plithogenic attributes when compared to any of the available approaches [14-15]. In near future, the author will on exploring other areas of Plithogenic attributes [16] and its approximation [17-18] for various applications [19-24]. The Plithogenic set unable to deal with unknown attributes, human conscious and its exploration. In case the multi-attribute of soil is unknown Plithogenic set restricted. It requires human Turiyam cognition to understand that soil is polluted or not based on given multi-attribute. In near future the author will focus on dealing the uncertainty arises in dark data sets due to human consciousness [27-28] as well as its exploration for various applications.

5. Conclusions

This paper introduced a method for dealing with data of Intuitionistic Plithogenic attributes and its graphical structure visualization. To achieve this goal the infimum and supremum of Intuitionistic Plithogenic set is discussed with its visualization using the soil data sets. In near future the author will focus on exploring the uncertainty and randomness in Plithogenic attributes and its applications for other knowledge processing tasks.

Acknowledgement: Author thanks the anonymous reviewers for their valuable suggestions and comments.

Funding: Author declares that, there is no funding for this paper.

Conflict of interest: The author declares that there is no conflict of interest.

Doi: https://doi.org/10.54216/GJMSA.070201
Received: March 01, 2023 Revised: June 22, 2023 Accepted: August 09, 2023

Reference

[1] Singh PK, Air Quality Index Analysis Using Single-Valued Neutrosophic Plithogenic Graph for Multi-Decision Process. International Journal of Neutrosophic Sciences, 2021, Volume 16, Issue 1, pp. 28-141, **Doi**: https://doi.org/10.54216/IJNS.160103

[2] Singh PK, Dark data analysis using Intuitionistic Plithogenic Graphs. International Journal of Neutrosophic Sciences, 2021, Volume 16, Issue 2, pp. 80-100, **Doi**: https://doi.org/10.54216/IJNS.160204

[3] Smarandache F, Plithogeny, Plithogenic Set, Logic, Probability, and Statistics. Pons Publishing House, Brussels 2017.

[4] Smarandache F, Extension of Soft Set to hyperSoft Set, and then to Plithogenic Hypersoft set. Neutrosophic Set and System, 2018, Volume 22, pp. 168-170.

[5] Singh PK,Plithogenic set for multi-variable data analysis. International Journal of Neutrosophic Sciences, 2020, Volume 1, Issue 2, pp. 81-89, Feb 2020. DOI: 10.5281/zenodo.3689808.

[6] Gayen S, Samarandache F, Jha S, Singh MK, Broumi S, Kumar R, Introduction of Plithogenic hypersot subgroup. Neutrosophic Sets and Systems, 2020, Volume 33, pp. 208-233

[7] Rana S, Qayuum M, Saeed M, Samarandache F, Khan BA, Plithogenic fuzzy, whole hypersoft set, construction of operators and their application in frequency matrix multi attribute decision making technique, Neutrosophic Sets and Systems, 2019, Volume 28, pp. 34-50

[8] Martin N, Smarandache F, Introduction to Combined Plithogenic Hypersoft Sets, Neutrosophic Sets and Systems, 2020, Volume 35, pp. 503-510. DOI: 10.5281/zenodo.3951708

[9] Gomathy S, Nagarajan D, Broumi S, Lathamaheswari M, Plithogenic sets and their application in decision making, Neutrosophic Sets and Systems, 2021, Volume 83, pp. 453-469

[10] Priyadharsini SP, Nirmala Irudayam F, Smarandache F, Plithogenic Cubic Set. International Journal of Neutrosophic Sciences, 2020, Volume 11, Issue (1), pp. 30-38

[11] Singh PK, Data with Turiyam Set for Fourth Dimension Quantum Information Processing, Journal of Neutrosophic and Fuzzy Systems, 2021, Volume 1, Issue 1, pp. 9-23, ISSN:2771-6430, DOI: https://doi.org/10.54216/JNFS.010101

[12] Atanassov K T, Intuitionistic fuzzy sets. VII ITKR's Session, Sofia (deposited in CentralSci.-Technical Library of Bulg. Acad. of Sci., 1697/84), Year 1983 (in Bulgarian).

[13] Atanassov KT, Intuitionistic fuzzy sets. Fuzzy Sets and Systems, 1986, Volume 20, pp. 87-96.

[14] McBratney AB, Odeh IO. Applications of fuzzy sets in soil sciences: fuzzy logic, fuzzy measurement and fuzzy decision making. Geoderma, 1997, Volume 77, Issue (2-4), vol. 85-113

[15] Pandey LK, Ojha KK, Singh PK, Singh CS, Dwivedi S, Bergey EA, Diatoms image database of India (DIDI): a research tool. Environmental Technology & Innovation, 2016, Volume 5, pp.148-160

[16] Singh PK, Single-valued Plithogenic graph for handling multi-valued attribute data its context. International Journal of Neutrosophic Sciences, 2021, Volume 15, Issue 2, pp. 98-112

[17] Singh, P.K., Cubic graph representation of concept lattice and its decomposition. Evolving Systems, 2022, Volume 13, pp. 551-562.https://doi.org/10.1007/s12530-021-09400-6

[18] Singh, P. K., Complex Plithogenic Set. International Journal of Neutrosophic Sciences, 2022, Volume 18, Issue 1, pp. 57-72, Doi : https://doi.org/10.54216/IJNS.180106

[19] Singh P. K., Intuitionistic Plithogenic graph and it's $\{d_{(\alpha_1,\alpha_2)}, c_\beta\}$-cut for knowledge processing tasks, Neutrosophic Sets and Systems, Vol. 49, April 2022, pp. 70-91

[20] Gupta, S., Haq, A., Ali, I., & Sarkar, B., Significance of multi-objective optimization in logistics problem for multi-product supply chain network under the intuitionistic fuzzy environment. Complex & Intelligent Systems, 2021, Volume 7, pp. 2119-2139. https://doi.org/10.1007/s40747-021-00326-9

[21] Khan, M. F., Haq, A., Ahmed, A., & Ali, I., Multiobjective Multi-Product Production Planning Problem Using Intuitionistic and Neutrosophic Fuzzy Programming. IEEE Access, 2021, Volume 9, pp. 37466-37486. https://doi.org/10.1109/ACCESS.2021.3063725

[22] Haq, A., Kamal, M., Gupta, S., & Ali, I. , Multi-objective production planning problem: a case study for optimal production. International Journal of Operational Research, 2020, Volume 39, Issue 4, pp. 459-493. https://doi.org/10.1504/IJOR.2020.111339

Doi: https://doi.org/10.54216/GJMSA.070201
Received: March 01, 2023 Revised: June 22, 2023 Accepted: August 09, 2023

[23] Haq, A., Gupta, S., & Ahmed, A., A multi-criteria fuzzy neutrosophic decision-making model for solving the supply chain network problem. Neutrosophic Sets and Systems, 2021, Volume 46, pp. 50-66. https://doi.org/10.5281/zenodo.5553476

[24] Quek, S. G., Selvachandran, G., Smarandache, F., Vimala, J., Le, S. H., Bui, Q. T., & Gerogiannis, V. C., Entropy measures for plithogenic sets and applications in multi-attribute decision making. Mathematics, 2020, Volume 8, Issue 6, 965. https://doi.org/10.3390/math8060965

[25] Smarandache, F., "Introduction to the symbolic plithogenic algebraic structures (revisited)". Neutrosophic Set and System, 2023, Volume 53 pp., 653–665.

[26] Singh, P., Ambiguous set theory: A new approach to deal with unconsciousness and ambiguousness of human perception. Journal of Neutrosophic and Fuzzy Systems, 2023, Volume 5, Issue 1, pp. 52-2.

[27] Prem Kumar Singh, Four way Turiyam Set based Human Quantum Cognition Analysis, Journal of Artificial Intelligence and Technology, September 2022, Volume 2, Issue 4, pp. 144-151, DOI: https://doi.org/10.37965/jait.2022.0123

[28] Ganati, G. A., Repalle, V. N., & Ashebo, M. A. , Social network analysis by Turiyam graphs. BMC Research Notes, 2023, Volume 16, Issue 1, pp. 1-9.

[29] Ben Othman, K., Von Shtawzen, O., Khaldi, A., and Ali, R., "On The Concept Of Symbolic 7-Plithogenic Real Matrices", Pure Mathematics For Theoretical Computer Science, Vol.1, 2023.

[30] Ben Othman, K., Von Shtawzen, O., Khaldi, A., and Ali, R., "On The Symbolic 8-Plithogenic Matrices", Pure Mathematics For Theoretical Computer Science, Vol.1, 2023.

Doi: https://doi.org/10.54216/GJMSA.070201
Received: March 01, 2023 Revised: June 22, 2023 Accepted: August 09, 2023