Single-valued Plithogenic entropy measurement

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Abstract

In the last decade many researchers paid attention towards uncertainty measurement in given attributes arises unconsciously. These types of uncertainty measurement become more complex in case of dynamic changes in multi-variable, multi-attributes or Plithogenic attributes. It creates major problem at time of knowledge discovery and processing tasks. To resolve this issue, a method is proposed in this paper for precise measurement of randomness arises unconsciously for single valued Plithogenic attribute. In addition the selection of some important Plithogenic attributes at user defined granulation is discussed with an illustrative example.

Keywords: Knowledge representation; Plithogenic set; Plithogenic probability; Shannon entropy; Granulation; Turiyam

1. Introduction

Recently, Plithogenic set and its properties are introduced to deal with many-valued attributesby Smarandache [1-2]. It is nothing but a generalization of dialectics and Neutrosophic set beyond the three-way fuzzy space [3-4]. It contains multi-attributes which values are either independent or dependent in the given interval. One of the suitable examples is cricket score data set which contains several multi-variable attributes [5-7]. Same way the human thought of country like India towards any party is based on multi-valued attributes which changes in opposite and non-opposite direction several times. In this case, the precise measurement of uncertainty arises in expert opinion or human thought due to Plithogenic attribute is major tasks for knowledge discovery and representation. Same time measuring the importance of Plithogenic attributes and its ordering is another issue [8-11]. To resolve this issue, current paper tried to introduce the Plithogenic entropy in this paper with an illustrative example.

Entropy theory is required to measure the average information beyond the randomness for adequate decision [12]. Due to which this theory is applied for handling data with fuzzy attributes [13-14] as well as vague attributes [15]. Recently, it is applied to measure the randomness in multi-valued attributes like citation and document publication analysis [16]. In this case a problem is addressed while dealing the several opposite, non-opposite and neutral citation or document publications in the given area. It can be considered as one of the suitable example for measuring the randomness in single-valued Plithogenic attributes beyond cricket data sets [5]. Cricket data sets also problem arises when the decision is based on Turiyam consciousness of expert rather than the changes in Plithogenic attribute [17]. It may contain randomness in Plithogenic attributes due to conflict in opinion among two or more expert [17-20]. It requires new dimension for measuring the dynamic changes of ambiguity arises in Plithogenic attributes based on time [21], human Turiyam consciousness [22] or unconsciousness way [23]. However the current paper focused on measuring the randomness in Single valued Plithogenic attributes unconsciously in the event due to ambiguity [23] rather than expert Turiyam consciousness involvement [24]. To resolve this issue, the current paper proposed a method for computing the Entropy of Single-valued Plithogenic attributes and its level of granulation for knowledge processing tasks. The proposed method is explained using the cricket data sets.

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The Plithogenic attributes contains several static or dynamic attributes with many contradictory, neutrals, or non-contradictory opinions [5-7]. It can be easily represented using the algebra of Plithogenic set [1-2]. Many researchers tried to apply this set theory for several applications in distinct fields like Cricket data [5], Olympic data [6], Air Quality Index [7], Medical diagnoses [8] and other multi-decision process [9-11] with extensive properties [18-21] without using human Turiyam consciousness [22-24]. The sports data set can be considered as one of the suitable examples for single-valued Plithogenic attributes in case the expert consciousness is not involved in the data. One of the reasons is these data sets contains many contradiction and changes as everyone has different views on the same game. Same time views of everyone changes just replacement of any player or its turn. It creates an issue while measuring the randomness in expert opinion. To deal with this issue recently Plithogenic probability [17-19] is studied which motivated the author to introduce the Single-valued Plithogenic entropy in [0, 1] for precise analysis of multi-decision process. Recently, Singh [20-21] has paid attention towards this topic and shown its application. However the Plithogenic set and its representation does not depends on human Turiyam cognition [22] while representation of ambiguity [23]. One of the examples is India (or Pakistan) may lose the math consciously with any low team also in case Pakistan (or India) will be out from the tournament due to lose of the particular match. These types of ambiguity arise due to human Turiyam consciousness rather than unconscious uncertainty. These types of lost are considered as Win by Indian Team (or Pakistan Team) in context of Turiyam whereas Plithogenic considers them as lost [22-23]. The social Network analysis is another example where Plithogenic set cannot be useful as it is totally depends on the Human Turiyam consciousness to make someone as friend or not [24]. In this case there is possibility of randomness while representation the dynamicity of Plithogenic attribute. It is totally depends on events and its multi-attributes. Hence the current paper focused on introducing Plithogenic entropy rather than using Human Turiyam awareness. The objective is to investigate some of the important Plithogenic attribute at user defined information granules. To achieve this goal, the current paper tries to introduce the Plithogenic entropy in this paper and its refinement at granulation with an illustrative example. One of the significant outputs of the proposed method is that provides an alternative way to deal with data with Plithogenic attribute without visualization. In case someone is not expert in graph analytics can use the given method.

Other parts of the paper are organized as follows: Section 2 provides basic background about Plithogenic set and its probability. Section 3 provides the proposed method for computing the Plithogenic entropy and its importance based on user required information granulation. Section 4 demonstrates the proposed method with an illustrative example. Section 5 includes conclusions, followed by acknowledgements and references.

2. Background

This section provides basics of Plithogenic attributes and its probability for understanding the uncertainty existence in data with Plithogenic set.

Definition 1.PlithogenicSet[1-2]: Let us suppose,ξbe 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*>). In this case, the set (P, a, V, d, c)can be called as Plithogenic Set (**P**) 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). The contradiction degree function (c) distinct the Plithogenic set from all of the above set. It represents the between the attribute values in form of fuzzy t-norm and fuzzy t-conorm as:

(i)$c: V \times V \rightarrow [0, 1]$represents the contradiction degree function among $v_1$and v_2.

It used be noted as $c(v_1, v_2)$, and satisfies the following axioms:

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

(iii) $c(v_1, v_2) = c(v_2, v_1)$,the contradiction among v_1 and v_2 or v_2 and v_1 used to be Considered as per the commutative properties. In this paper author focuses on single-valued fuzzy membership to handle the Plithogenic set.

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Example 1: Let us suppose, an expert(y_1)wants to write his/her opinion towards the player (x_1)that player (x_1) is 60 percent suitable for the TEST match without any contradiction,20 percent suitable for one day match which is $\frac{1}{2}$ contradicted by other expert. Similarly, the expert (y_1) given an opinion that player (x_1) is 70 percent suitable for T20 match which is by $\frac{2}{3}$ contradicted by other expert. The reason behind it given by expert (y_1) that, the player (x_1) is consistent in80 percent matches due to his/her 50 percent suitable health conditions which is $\frac{1}{2}$ contradiction by others. This type of Plithogenic attribute can be written precisely via Plithogenic set based context as shown in Table 1.

Table 1: The expert (y_1) opinion towards a player (x_1)

Contradiction degree	0	$\frac{1}{3}$	$\frac{2}{3}$	0	$\frac{1}{2}$
Multi-attributes	TEST Player	ODI Player	T20 Player	*Consistent*	*Health*
Fuzzy degree	0.6	0.2	0.7	0.8	0.5

Definition 2.Plithogenic Probability [18]: It provides a chance to occur an event composing the Plithogenic attributes given by an expert or each of the random variables which determines it.The Plithogenic Probability, based on Plithogenic Variate Analysis, is a multi-dimensional probability ("plitho" means "many", synonym with "multi"). We may say that it is a probability of sub-probabilities, where each sub-probability describes the behavior of one the variable. Each variable is represented by a Probability Distribution (Density) Function(PDF). In this case, T represents that the chance of an event to occur, I represents that the chance of indeterminacy or uncertainty and F represents that the chance of event does not occur. In this way, Plithogenic neutrosophic probability give a generalize way to represent chance of occurrence for the given event.

Example 2 : Let us consider the Table 1 to compute the probability that player (x_1) is a test player. In this case, one needs to find the probability for the Plithogenic attribute. Table 1 shows that the player (x_1) that player (x_1) is 60 percent suitable for the TEST match without any contradiction, 20 percent suitable for one day match with $\frac{1}{2}$ contradiction, 70 percent suitable for T20 match with $\frac{2}{3}$ contradiction. In this case the Probability can be find as chance that he/she can be ODI player divided by total number cases for being he/she as a player as: $\frac{\text{Chance that player } x_1 \text{ is Test Player}}{\text{Total chances that player } x_1 \text{ is Player}}$. It means $\frac{0.6}{0.6\times(1-0)+0.2\times(1-\frac{1}{3})+0.7\times(1-\frac{2}{3})}$ which means 0.62. It shows that the x_1 is 62 % chance as an ODI Player. In similar way probability of being he/she as ODI or T20 can be computed.

The problem arises with expert in case they want to select some of the important player for the TEST, ODI or T20. It contains lots of uncertainty and randomness which need to define as a weight to characterize them in the order. To achieve this goal, the current paper proposes a method based on Shannon entropy in the next section.

3. Proposed methods

In this section, a method is proposed for uncertainty measurement of Plithogenic attribute and it's ordering using Entropy theory as shown in Figure 1. The steps of the algorithm are as follows:

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Step 1. Let us consider the data with Plithogenic attributes(P, a, V, d, c), where P is a set,a is the set of attribute values, V *is* the attribute range, d is the degree of appurtenance and c is the degree of contradiction. The degree of appurtenance and the degree of contradiction of the attribute values are determined with respect to a dominant attribute value.

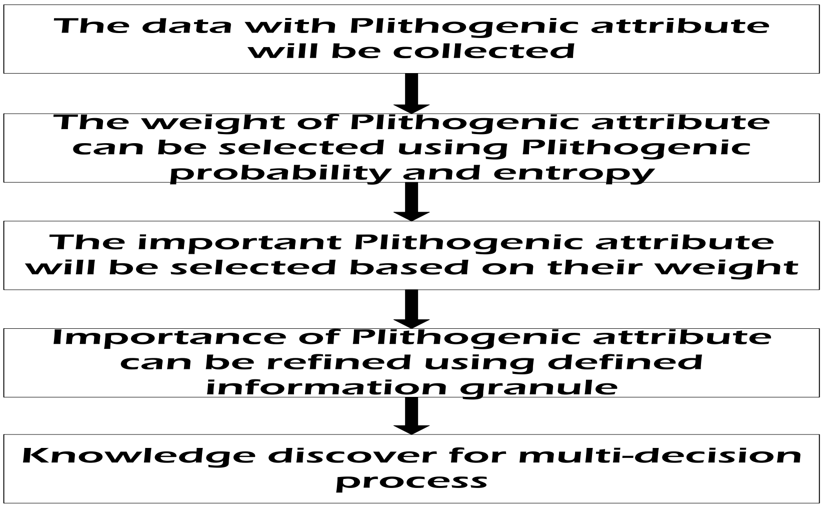

Figure 1: Flow chart of the proposed research methodology

Table 2 :A contextual representation of data with Plithogenic attributes

	A_1	A_2	…	A_m
O_1	$R_{11}(P_{11}, a_{11}, V_{11}, d_{11}, C_{11})$	$R_{12}(P_{12}, a_{12}, V_{12}, d_{12}, C_{12})$	…	$R_{11}(P_{1m}, a_{1m}, V_{1m}, d_{1m}, C_{1m})$
O_2	$R_{21}(P_{21}, a_{21}, V_{21}, d2_{1}, C_{21})$	$R_{22}(P_{21}, a_{21}, V_{21}, d_{21}, C_{21})$	…	$R_{23}(P_{31}, a_{31}, V_{31}, d_{31}, C_{31})$
…				
O_n	$R_{n1}(P_{n1}, a_{n1}, V_{n1}, d_{n1}, C_{n1})$	$R_{n2}(P_{n1}, a_{n1}, V_{n1}, d_{n1}, C_{n1})$	…	$R_{nm}(P_{nm}, a_{nm}, V_{nm}, d_{nm}, C_{nm})$

Step 2. Try to represent them in the contextual format as shown in Table 2.

Step 3. The probability of possessing the object (O) by Plithogenic attribute (A) can be computed as below:

$$P(O/A)=\frac{P(O_i,A_j)}{P(A)}$$

Where $P(A)$ can be computed using the $P(O_i, A_j)$ and its contradiction degrees ($1-c_i$) as shown in Example 2 i.e. $P(O_i, A_j)\times(1-c_i)$. It means the proposed method try to compute the conditional probability of Single-valued Plithogenic attribute using its contradiction.

Step 4. The weight of the Plithogenic attribute to possess the particular object can be computed using entropy theory as given below:

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$$E(O/A) = -\sum \frac{P(O_i, A_j)}{P(A_j)} \log(\frac{P(O_i, A_j)}{P(A_j)})$$

Step 5. The average weight of the Plithogenic attribute can be computed using all the object set:

$$\text{Average weight } (W_i) = \frac{\text{Summation of entropy weight (E(O/A)}}{\text{Total number of obejcts in the Plithogenic context shown in Table 2}} \quad (1)$$

Step 6. The importance of Plithogenic attribute can be considered based on user defined weight as information granules (α).

Step 7. In this way the data with Plithogenic attribute and its importance can be analyzed for various decision making process.

Table 3:A proposed algorithm for computing the Plithogenic entropy

Input: An array of Plithogenic attributes
Output: Important Plithogenic attribute for the chosen threshold
1. **for**i = 1,2,3,…..m, where m is the number of Plithogenic attribute
2. Compute the Plithogenic probability as:

$$P(O/A) = \frac{P(O_i, A_j)}{P(A)}$$

Where P(*A*) can be found using $P(O_i, A_j) \times (1 - c_i)$

3. Compute the entropy of Plithogenic attribute as :

$$E(O/A) = -\sum \frac{P(O_i, A_j)}{P(A_j)} \log(\frac{P(O_i, A_j)}{P(A_j)})$$

4. Average weight can be computed as :

$$\text{Average weight } (W_i) = \frac{\text{Summation of entropy weight (E(O/A)}}{\text{Total number of obejcts in the Plithogenic context}}$$

5. Return the weight value of Plithogenic attribute i.e. (W_i)
end for
6. Decide the information granules (α) for weight (W_i).
7. **if** ($W_i > \alpha$)
Choose as important attribute
8. **else**
Discard them
end if

Step 8. The pseudo code for the proposed method is shown in Table 3.

Time complexity: Let us suppose, there are *m*-Plithogenic attribute and *n*-number of objects, *c* number of contradiction in the given data set. The proposed method shown in Table 3 compute the Plithogenic probability which may take maximum $O(m.c)$ which leads towards entropy computation as $O(m \times c \times \log(m))$ time or $O(n \times c \times \log(n))$. Figure 1 shows the flowchart of the proposed method. The next provides illustration of the proposed method with an example.

4. Illustration

Recently, data with Plithogenic attribute and its uncertainty measurement is considered as one of the major issues [1-2]. Same time deciding some of the important Plithogenic attribute at user defined information granules is another task [4-7]. To deal with this issue, recently entropy theory is utilized for data analysis with fuzzy attributes [13-14] and vague attributes [15-16]. Same time the mathematics of Plithogenic probability is introduced [18-19] which motivated the author to introduce single-valued Plithogenic entropy. The objective is to provide single-value measurement of randomness in Plithogenic attributes within [0, 1] interval for adequate decision making. To achieve this goal, a method is proposed in Section 3 as shown in Table 3. In this section the proposed method is illustrated with an example for decision making process as given below:

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Example 3: Let us suppose an expert gives opinion about three players based on their performance in TEST, ODI, and T20 as shown in Table 4. The problem is finding some of the suitable TEST or ODI player based on their performance of expert opinion. To resolve this problem proposed method can be helpful as given below:

Table 4: An Expert opinion about three players on various format

Contradiction degree	0.5	0.67	0.0	0.0	0.5
Test Players	(x_1, 0.6)	(x_2, 0.5)	(x_3, 0.9)	(*Ball Faced*, 1.0)	(*Strike Rate*, 1.0)
ODI Players	(x_1, 0.8)	(x_2, 0.7)	(x_3, 0.1)	(*Ball Faced*, 1.0)	(*Strike Rate*, 1.0)
T20 Players	(x_1, 0.6)	(x_2, 0.8)	(x_3, 0.0)	(*Ball Faced*, 1.0)	(*Strike Rate*, 1.0)

The problem arises with the selection team that which player is good for TEST (or other format). This problem can be resolved using the proposed method shown in Table 3.

Illustration (i) Compute the chances of players x_1, x_2, and x_3 area TEST player.

a) $x_1 = \frac{0.6\times0.5}{0.6\times0.5+0.8\times0.5+0.6\times0.5} = 0.3$

Plithogenic entropy=-0.3 log(0.3)= 0.36

b) $x_2 = \frac{0.5\times0.67}{0.5\times0.67+0.7\times0.67+0.8\times0.67} = 0.25$

Plithogenic Entropy=0.34

c) x_3=0.9

Plithogenic entropy= 0.1

It shows that, the Player x_1 and $x_2$are almost equal TEST player whereas the player x_3 is distinct and better than them. The Player x_3 generates less randomness while facing the ball or strike rate in case of playing the TEST.

Illustration (ii) Compute the chances of players x_1, x_2, and x_3 are a ODI player.

a) $x_1 = \frac{0.8\times0.5}{0.6\times0.5+0.8\times0.5+0.6\times0.5} = 0.4$

Plithogenic entropy=0.37

b) $x_2 = \frac{0.7\times0.67}{0.5\times0.67+0.7\times0.67+0.8\times0.67} = 0.36$

Plithogenic Entropy=0.36

c) x_3=0.1

Plithogenic entropy= 0.23

It shows that, the Player x_1 is better than others but generated most randomness or uncertainty while facing the ball or strike rate in case of the ODI followed by player x_2. The Player x_3 generates less randomness but the strike rate is slower than given batsman in ODI. In similar way other Plithogenic attributes and its importance can be analyzed. It can be observed that, the proposed method can be helpful in handling data with Plithogenic attributes for multi-decision process. Table 5 represents some comparative study of the proposed method with recent methods.

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It can be observed that, the proposed method provides one of the adequate analyses of single-valued Plithogenic attributes when compared to recent methods.

In this way, the proposed method provides following significant output:

1. It provides a way to compute the importance of Plithogenic attribute.
2. It provides an alternative way to deal with data with Plithogenic attributes.
3. It is helpful in reducing some of the unwanted Plithogenic attributes.

In future the author work will focus on introducing new mathematics for dealing with Plithogenic attributes beyond the single-valued fuzzy appurtenance and contradiction degrees [6-7]. The graphical visualization [20] and its randomness measurement at given phase of time [21] will be another concern. Same time the author will focus on impact of human Turiyam cognition [22] while measurement of ambiguity [23] arises due to consciousness [24].

Table 5: A comparative study of the proposed method

	Plithogenic context [5-7]	Plithogenic probability [18]	Plithogenic entropy [19]	Entropy applications [13-16]	The proposed method
Plithogenic attributes	Yes	Yes	Yes	No	Yes
Randomness measurement	Yes	Yes	Yes	Yes	Yes
Decision making	Yes	Yes	Yes	Yes	Yes
Important attributes	No	No	Yes	Yes	Yes
Information granulation	No	No	No	Yes	Yes
Time complexity	Not given	Not given	Not given	$O(m \times \log(m))$	$O(m \times c \times \log(m))$

4. Conclusions

This paper focuses on dealing with uncertainty and randomness in data with Plithogenic attributes. To achieve this goal, a method is proposed to compute the entropy of Plithogenic attributes. The importance of Plithogenic attribute and its selection is shown based on user defined information granulation with an illustrative example as $O(m \times c \times \log(m))$ time complexity. It is shown that the proposed method will be helpful in various fields for multi-decision process. In near future the author will focus on introducing other metric to deal with data with Plithogenic attribute beyond the unipolar space and the impact of Human Turiyam Consciousness on it.

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