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Analysis of Genetic Disease by Intuitionistic Fuzzy Sets

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Abstract: *We proposed a comprehensive approach for medical diagnosis for vitamin B disorders by using intuitionistic fuzzy sets. In this article, an example of medical diagnosis will be presented assuming there is a database which contains set of Diseases D and set of symptoms S. Here the patient's state will be described by his/her medical tests. And we use the normalised Hamming distance to calculate the distance between patient and diseases. The Soulin number plays a major role in this paper. And then the results were graphed and analysed using R- programming.*

Keywords: *Cardinality, Normalised hamming distance, Soulin number, R-programming.*

1. INTRODUCTION:

In this paper we will present intuitionistic fuzzy set to diagnose diseases that are hereditary. However it is not an easy and direct task because the information about the patient and about medical relationships to the physician is inherently uncertain [1]. In order to improve the problem, they have introduced fuzzy set theories. In 1969, Zadeh proposed an application of fuzzy set on the medical field. This fuzzy set theory attracted worldwide in the various fields like biological and social science, psychology, linguistic and economics. In some fields, variables are difficult to determine and dependencies between variables so ill-defined that exact characterization in terms of algebraic or differential equations becomes impossible. However in such fields fuzzy set is necessary and advantageous rather than crisp algorithms because dependencies among variables are well defined to arrive at a solution [6].

M. Gupta, R. R. Yager, R. K. Ragade [9] introduced the fuzzy set modelling theory to develop the relationship between symptoms and diseases. Atanassov [4] and [5] introduced the Intuitionistic fuzzy sets. A major idea in the fuzzy set is to study about the uncertain set whose elements have membership and non membership degrees. The element of membership in fuzzy set theory is a single value between zero and one. But in real life it would not be always possible that the non-membership degree element is equal to one minus the membership degree because there might be some hesitation degree. Suppose if the information is not sufficient, intuitionistic fuzzy set is an alternative method to approach and define a fuzzy set. Hence the generalization of fuzzy set was introduced by intuitionistic fuzzy set (IFS). Therefore it is used to show the human decision making processes and any activities requiring human expertise.

Fuzzy set theory had been applied in many fields to model the diagnostic process. By using intuitionistic fuzzy sets Szmit and Karcprzyk [7] and [8] proposed two solution concepts about intuitionistic fuzzy core and the consensus winner for group decision-making. In many studies different techniques had applied to find the disease of the patients the loss of the information if the disease is genetic is not considered.

In this paper normalised Euclidean distance is used to several patients according to the symptoms and diseases due to deficiency of vitamin-B and to analyse a new approach for genetic disorder using souslins number. Excess of vitamin B contribute the skin flushing, blurry vision, vomiting and abdominal cramps. Vitamin B deficiency associated with cell metabolism. Various symptoms and disease occurs as a result of vitamin-B deficiency. Here we have considered four diseases and symptoms for vitamin-B deficiency.

2. INTUITIONISTIC FUZZY SETS:

2.1 Definition

A fuzzy set is a pair (X, m) where X is a set and m: $X \rightarrow [0,1]$ a membership function. The reference set X (sometimes denoted by Ω or X) is called universe of discourse and for each x∈X, the value m(x) is called the grade of membership of x in (X, m). The function m = μ_A is called the membership function of the fuzzy set A = (X, m).

For a finite set X = $\{x_1, x_2, \ldots \ldots x_n\}$, the fuzzy set (X, m) is often denoted by $\{\frac{\mathrm{m}(x_1)}{x_1}, \ldots \ldots, \frac{\mathrm{m}(x_n)}{x_n}\}$.

Let x ∈ X, then x is called as

- Not included in the fuzzy set (X, m) if m(x) = 0 (no member),
- Included fully if m(x) = 1 (full member),
- Partially included if 0 is less than m(x), 1 (fuzzy member).

2.2 Definition

An intuitionistic fuzzy graph (IFG) is in the form G: (V, E) where,

i. V is finite non-empty set of vertices such that $\mu_A: V \rightarrow [0,1]$ and $V_A: V \rightarrow [0,1]$ denotes the degree of membership and non-membership of the elements x ∈ V respectively and 0≤ $\mu_A(x) + V_A(x) \leq 1$for every x ∈ V.
ii. E ⊂ V × v is a finite set of edges such that μ_B(xy) ≤ $\min\{\mu_A(x),\ \mu_A(y)\}$ and V_B(xy) ≤ $\max\{V_A(x),\ V_A(y)\}$ and 0 ≤ μ_B(xy) + V_B(xy) ≤ 1 $for\ every\ (x, y) \in E$

2.3 Definition

We have $\pi_A(x) = 1 - \mu_A(x) - V_A(x)$ is called the intuitionistic fuzzy set index or hesitation margin of x i A. $\pi_A(x)$ is the degree of indeterminacy of x ∈ X to the IFS A and $\pi_A(x)$ ∈ [0.1] that is $\pi_A(x): X \rightarrow [0,1] and\ 0 \leq \pi_A \leq \frac{1}{\mathrm{x} \in X}$. $\pi_A(x)$ expresses the lack of knowledge of whether x belongs to IFS A or not.

$\mu_A(x) + V_A(x) + \pi_A(x) = 1$

3. DISTANCE MEASURES IN INTUITIONISTIC FUZZY SETS

Let X be a nonempty set such that IFS P, Q, R ∈ **X.** Then the distance measure d between IFS P and Q is a mapping d: X × X→ [0, 1]; if d (P, Q) satisfies the following axioms:

P_1 0 ≤ d (P, Q) ≤ 1

P_2 d (P, Q) = 0 if and only if P = Q

P_3 d (P, Q) = d (P, Q)

P_4 d (P, Q) + d (Q, R) ≥ d(P, Q)

P_5 if P ⊂ Q ⊂ R, then d (P, R) ≥ d (P, Q) and d(P, R) ≥ d(Q, R)

Distance measure is defined as difference between intuitionistic fuzzy sets and can be represented as dual concept of similarity measure. Between intuitionistic fuzzy sets we used the normalised hamming distance, which is based on the geometric interpretation of intuitionistic fuzzy sets and have some geometric properties.

Let P = {x, $\mu_A(x_i), \nu_A(x_i), \pi_A(x_i)$/ x ∈ X and Q = {x, $\mu_B(x_i), \nu_B(x_i), \pi_B(x_i)$/ x ∈ X be two IFSs in X = $\{x_1, x_2, x_3 \ldots . x_n\}$ i = 1,2,….. n. Distance between A and B based on the geometric interpretation of IFS [3], [4] is discussed in the following section.

A) The Hamming Distance

$$d_H(A, B) = \frac{1}{2}\sum_{i=1}^{n} |\mu_A(x_i) - \mu_B(x_i)| + |\nu_A(x_i) - \nu_B(x_i)| + |\pi_A(x_i) - \pi_B(x_i)|$$

B) The Euclidean Distance

$$d_E(A,B) = \sqrt{\tfrac{1}{2}\sum_{i=1}^{n}[(\mu_A(x_i) - \mu_B(x_i))^2 + (v_A(x_i) - v(x_i))^2 + (\pi_A(x_i) - \pi_B(x_i))^2\ ]}$$

C) The Normalised Hamming Distance

$$d_{n-H}(A,B) = \tfrac{1}{2}\sum_{i=1}^{n}|\mu_A(x_i) - \mu_B(x_i)| + |v_A(x_i) - v_B(x_i)| + |\pi_A(x_i) - \pi_B(x_i)|$$

D) The Normalised Euclidean Distance

$$d_{n-E}(A,B) = \sqrt{\tfrac{1}{2}\sum_{i=1}^{n}[(\mu_A(x_i) - \mu_B(x_i))^2 + (v_A(x_i) - v(x_i))^2 + (\pi_A(x_i) - \pi_B(x_i))^2\ ]}$$

By considering the below example we have shown that normalised Hamming distance is the best one to measure distance:

Let us assume the intuitionistic fuzzy sets A and B in X = {1, 2, 3, 4, 5, 6, 7}

A = (0.5, 0.2, 0.3) + (0.3, 0.7, 0.0) + (0.2, 0.4, 0.4) + (0.1, 0.2, 0.7)

B = (0.4, 0.3, 0.3) + (0.6, 0.3, 0.1) + (0.7, 0.3, 0.0) + (0.5, 0.2, 0.3)

We have used the above distance formula to calculate the distance between A and B.

The hamming distance for A and B $d_H(A,B) = 0.5$

The normalised hamming distance for A and B $d_{n-H}(A,B)$ = 0.125

The Euclidean distance for A and B $d_E(A,B)$ = 0.89

The normalised Euclidean distance for A and B $is\ d_{n-E}(A,B) = 0.2225$.

From the above results, the normalised hamming distance is the smallest or shortest. Therefore, we concluded that the normalised hamming distance is the best distance measure between A and B. For this particular reason, we can make use of normalised hamming distance in the application for its higher rate of confidence in terms of accuracy.

3.1 Hereditary property:

A fuzzy topological property p is said to be hereditary (hereditary with respect to open subspaces and closed subspaces), if and only if each subspace (open and closed subspace) of a fuzzy topological space with the property p could also has property p.

3.2 Cardinality:

The set A is of cardinality (or size) and it is written as |A|. If cardinality n is in the set A, then it is written as |A| = n and also if there exists any natural numbers n such that the set A = {1, 2,…n}. The cardinality of a finite set is the number of elements that it contains.

3.3 Souslin Number:

We can say that c(X) called as souslins number. The souslins number of a topological space is defined as the least upper bound of the cardinality of disjoint sets of open subsets of the space X. It is known as Toplogical invariant.

Souslins number = sup { : $\alpha = |Y|, Y \subset X, Y -$ discrete.

According to the way of R.W. Hansell, souslins sets inherit topological properties in a stronger way. In the following section we have concluded that if the patient is inherited with particular disorder or not.

3.4 Model of intuitionistic fuzzy set for genetic disorder using Soulin number

Step 1: Patients name with symptoms are collected. The symptoms are assigned by a physician.

Step 2: The disease are diagnosed by using various distance measures.

Step 3: Normalised Euclidian distance gives the best accuracy of all the distance measures.

Step 4: Souslin number concept is the topological hereditary invariants which is a calculated to check if the patient is inherited with the diagnosed disorder.

4. CASE STUDY:

Human reasoning mostly involves the use if variable whose values are uncertain that is fuzzy in nature. This is the basic concept of linguistic variable, that is, a variable with words values rather than numbers. But in medical diagnosis, the description by a linguistic variable in terms of membership function alone is not sufficient because there is a chance if the existing of non-membership function. In such a case, IFS is suitable because it uses membership function, non-membership function and hesitation margin function involved in an uncertain situation.Let the set of patients be $P=\{P_1,P_2,P_3,P_4\}$: D={Beri Beri, Paresthesia, Dermatitis, Pellagra} be the set of diseases and S={paralysis, numbness, swelling, Delusions} be the set of symptoms. The above mentioned symptoms and diseases arise in the case of Vitamin-B deficiency.

	Paralysis	Numbness	Swelling	Delusions
Beri Beri	(0.6, 0.2, 0.2)	(0.5, 0.3, 0.2)	(0.3, 0.6, 0.1)	(0.9, 0.0, 0.1)
Paresthesia	(0.8, 0.1, 0.1)	(0.2, 0.6, 0.2)	(0.4, 0.3, 0.3)	(0.3, 0.4, 0.3)
Dermatitis	(0.5, 0.3, 0.2)	(0.2, 0.7, 0.1)	(0.1, 0.3, 0.6)	(0.2, 0.2, 0.6)
Pellagra	(0.1, 0.7, 0.2)	(0.7, 0.1, 0.2)	(0.7, 0.1, 0.2)	(0.5, 0.1, 0.4)

Table 1: Diseases Vs Symptoms

Based on medical knowledge in intuitionistic fuzzy nature here table 1 is an assumed database of diseases and their symptoms. In table 1, each symptom Si is described by membership μ, non- membership υ and hesitation margin π. The samples are taken from patients and analysed for the diagnosis sake. From the analysis, we get the Table 2.

A	Beri Beri	Paresthesia	Dermatitis	Pellagra
P_1	(0.55, 0.3, 0.15)	(0.35, 0.5, 0.15)	(0.15,0.25,0.25)	(0.5, 0.25, 0.25)
P_2	(0.25, 0.65, 0.1)	(0.65, 0.3, 0.15)	(0.2, 0.65, 0.15)	(0.55, 0.35, 0.1)
P_3	(0.45, 0.35, 0.2)	(0.8, 0.1, 0.1)	(0.65, 0.25, 0.1)	(0.5, 0.45, 0.05)
P_4	(0.35, 0.55, 0.1)	(0.25, 0.3, 0.45)	(0.75, 0.05, 0.2)	(0.7, 0.15, 0.15)

Table 2: Patients Vs Symptoms.

To calculate the distance between each of the patients in Table 2 and each of the diseases in Table 1 we have used the normalized Hamming distance aforementioned,

	Beri Beri	Paresthesia	Dermatitis	Pellagra
P_1	(0.05, 0.1, 0.05)	(0.15, 0.2, 0.05)	(0.15,0.35,0.15)	(0.4, 0.25, 0.15)
P_2	(0.55, 0.55, 0.0)	(0.45, 0.3, 0.05)	(0.2, 0.35, 0.15)	(0.05, 0.1, 0.05)
P_3	(0.05, 0.05, 0.0)	(0.6, 0.6, 0.0)	(0.55, 0.05, 0.5)	(0.3, 0.25, 0.55)
P_4	(0.35, 0.45, 0.1	(0.45, 0.2, 0.25)	(0.65,0.65,0.0)	(0.2, 0.05, 0.25)

Table 3: Distance Between Patients And Diseases.

	Beri Beri	Paresthesia	Dermatitis	Pellagra
P_1	0.1	0.2	0.325	0.4
P_2	0.55	0.4	0.35	0.1
P_3	0.05	0.6	0.55	0.55
P_4	0.45	0.45	0.65	0.25

Table 4: Calculation of Soulin Number for Each Patient.

Now we have plotted the graph by using R programming. In fig.1, the graph is plotted for the BeriBeri disease with the distance (0.1, 0.2, 0.325, 0.4). In fig.2, the graph is plotted for the paresthesia disease with the distance (0.55, 0.4, 0.35, 0.1).

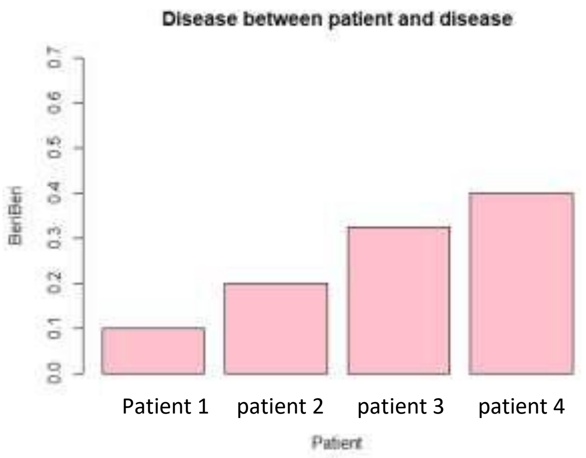

Figure 1

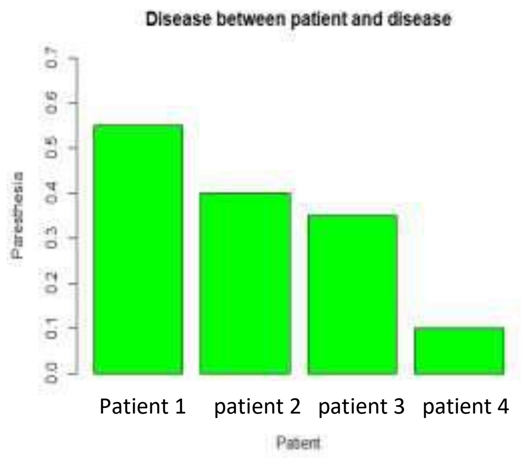

Figure 2

In fig.3, the graph is plotted for the Dermatitis disease with the distance (0.05, 0.6, 0.55, 0.55). In fig.4, the graph is plotted for the paellagra disease with the distance (0.45,0.45,0.65,0.25) .

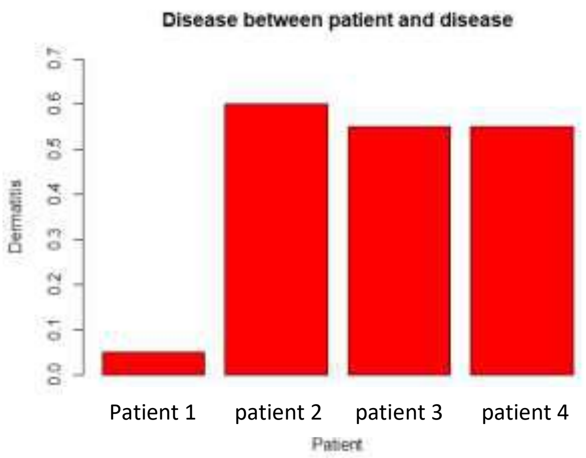

Fig.1

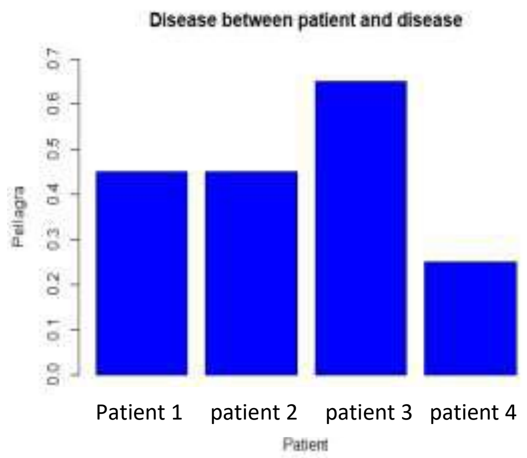

Fig.4

Here Souslin number of

Patient P_1= 0.4

Patient P_2= 0.55

Patient P_3= 0.6

Patient P_4= 0.65

i.e., Patient P_1 is inherited with Pellagra

Patient P_2 is inherited with Beri Beri

Patient P_3 is inherited with Paresthesia

Patient P_4 is inherited with Dermatitis.

5. CONCLUSION:

We can express a hesitation in the concerning examined objects by employing intuitionistic fuzzy sets in database. Clearly, the concept of intuitionistic fuzzy sets is of immense significance in decision mathematics because it produces all the possibilities involve in real life decision problems. The biochemical and genetic in patients has yielded important insights into the structure and function of the receptor in mediating Vitamin- B. Similarly, study of the affected children with vitamin- B deficiency continues to provide a more complete understanding of the biological role of Vitamins- B. These studies have been essential to promote the wellbeing of the families with vitamin- B and in improving the diagnostic and clinical management of this rare genetic disease. This allows us to apply flexible ways to replicate real decision situations, thereby building more realistic scenarios narrating possible future events. We expect that the method will be improved to be an well organized tool for medical diagnosis and the physician's decision.

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