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An Application of Intuitionistic Pentagonal Fuzzy Relation in Medical Diagnosis

Research Article*

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Abstract: In this paper, we study Sanchez's method of medical diagnosis by using Intuitionistic Pentagonal Fuzzy Relation. To develop Intuitionistic Pentagonal Fuzzy Relation and using score and accuracy function for to solve medical diagnosis decision making problem. In this paper it is presented the procedures based on Intuitionistic Pentagonal Fuzzy Number for medical diagnosis using a numerical example to verify the proposed approach.

Keywords: Medical Diagnosis, Intuitionistic Pentagonal Fuzzy Relation, Score, Accuracy.

1. Introduction

In this chapter, a system for medical diagnosis based on Pentagonal Valued Instuitionistic Fuzzy Relation is proposed. The Intuitionstic Fuzzy Sets [IFSs] were first introduces Atanassov (1986) which is a generalization of the concept of fuzzy set zadeh (1965). The basic characteristic of the IFS is that the values of its membership function and non membership function are intervals rather then exact number. Shannon et.al were the first to develop an approach using IFS for decision making in medical diagnosis. In this chapter Pentagonal Valued Intuitionistic Fuzzy Relation is used to solve medical diagnosis decision making problem. We study Sanchez's method of medical diagnosis with the notion of PVIFS. Numerical example is provided to illustrate this approaches.

2. Basic Definitions

Definition 2.1 (Fuzzy Number)**.** *A Fuzzy Number $\widetilde{A}$ is a fuzzy set on the real line R must satisfy the following conditions.*

1. *$\mu_{\tilde{A}}(x_0)$ is piecewise continuous.*
2. *There exists at least one $x_0 \in R$ with $\mu_{\tilde{A}}(x_0) = 1$.*
3. *$\tilde{A}$ must be normal and convex.*

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Definition 2.2 (Pentagonal Fuzzy Number). *A Pentagonal Fuzzy Number (PFN) of a fuzzy set* $\widetilde{\tilde{A}}$ *is defined as* $\tilde{A}_P = (a,b,c,d,e)$ *and its membership function is given by,*

$$\mu_{\tilde{A}_P} = \begin{cases} 0, & \text{for } x < a \\ \frac{x-a}{(b-a)}, & \text{for } a \le x \le b \\ \frac{(x-b)}{(c-b)}, & \text{for } b \le x \le c \\ 1, & \text{for } x = c \\ \frac{(d-x)}{(d-c)}, & \text{for } c \le x \le d \\ \frac{(e-x)}{(e-d)}, & \text{for } d \le x \le e \\ 0, & \text{for } x > e \end{cases}$$

Definition 2.3 (Operations on Pentagonal Fuzzy Number). *Let* $A = (a_1, b_1, c_1, d_1, e_1)$ *and* $B = (a_2, b_2, c_2, d_2, e_2)$ *be two PFN (Pentagonal Fuzzy Number) then* min *and* max *operator for any two PFNs are defined as,*

$$\min(A,B) = (\min(a_1,a_2), \min(b_1,b_2), \min(c_1,c_2), \min(d_1,d_2), \min(e_1,e_2))$$
$$\max(A,B) = (\max(a_1,a_2), \max(b_1,b_2), \max(c_1,c_2), \max(d_1,d_2), \max(e_1,e_2))$$

Supremum of PFN: Let $A = (x_1, x_2, x_3, x_4, x_5)$ *be a PFN, then Sup (A) is defined as* $\sup(A) = x_5$.

Definition 2.4 (Intuitionstic Fuzzy Set). *Let* X *denote a universe of discourse, then the intuitionstic fuzzy sett* A *in* X *is given by,* $\tilde{A}_I = \{< x, \mu_{\tilde{A}}(x), \nu_{\tilde{A}}(x) > /x \in C\}$, *where* $\mu_{\tilde{A}} : x \to [0,1]$ *and* $\nu_{\tilde{A}} : x \to [0,1]$ *with the condition* $0 \le \mu_{\tilde{A}}(x) + \nu_{\tilde{A}}(x) \le 1$, $x \in X$. *Here* $\mu_{\tilde{A}}(x)$ *and* $\nu_{\tilde{A}}(x) \in [0,1]$ *denote the membership and the non membership function of the fuzzy set* A.

Definition 2.5 (Intuitionstic Fuzzy Number). *An Intuitionstic Fuzzy Set* $\tilde{A}_I$ *is called an Intuitionstic Fuzzy Number if it satisfies the following conditions,*

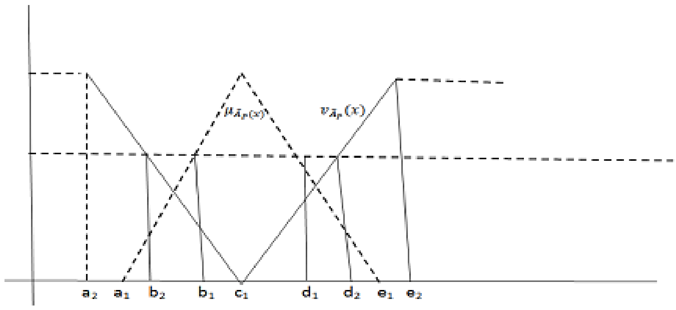
1. $\tilde{A}_I$ *is normal, (i.e) there exists at least two points* x_0, $x_1 \in X$ *such that* $\mu_{\tilde{A}}(x_0) = 1$ *and* $\nu_{\tilde{A}}(x_0) = 1$.
2. $\tilde{A}_I$ *is convex, (i.e) its membership function is fuzzy convex and its non membership function is concave.*
3. *Its membership function is upper semicontinuous and its non membership function is lower semicontinuous and the set* $\tilde{A}_I$ *is bounded.*

Definition 2.6 (Intuitionistic Pentagonal Fuzzy Number). *An Intuitionistic Pentagonal Fuzzy Number of a Intuitionistic Fuzzy Number (IFS) is* $\tilde{A}_I$ *is defined as* $\tilde{A}_{IP} = \{(a_1, b_1, c_1, d_1, e_1)(a_2, b_2, c_2, d_2, e_2)\}$ *where all* $(a_1, b_1, c_1, d_1, e_1)(a_2, b_2, c_2, d_2, e_2)$ *are real number and its membership function* $\mu_{\tilde{A}IP}(x)$, *non-membership function* $\nu_{\tilde{A}IP}(x)$ *are given by*

$$\mu_{\tilde{A}P} = \begin{cases} 0, & \text{for } x < a_1 \\ \frac{(x-a_1)}{(b_1-a_1)}, & \text{for } a_1 \le x \le b_1 \\ \frac{(x-b_1)}{(c_1-b_1)}, & \text{for } b_1 \le x \le c_1 \\ 1, & \text{for } x = c_1 \\ \frac{(d_1-x)}{(d_1-c_1)}, & \text{for } c_1 \le x \le d_1 \\ \frac{(e_1-x)}{(e_1-d_1)}, & \text{for } d_1 \le x \le e_1 \\ 0, & \text{for } x > e_1 \end{cases}$$

$$\mu_{\tilde{A}P} = \begin{cases} 0, & for\ x < a_2 \\ \frac{(x-a_2)}{(b_2-a_2)}, & for\ a_2 \leq x \leq b_2 \\ \frac{(x-b_2)}{(c_2-b_2)}, & for\ b_2 \leq x \leq c_2 \\ 1, & for\ x = c_2 \\ \frac{(d_2-x)}{(d_2-c_2)}, & for\ c_2 \leq x \leq d_2 \\ \frac{(e_2-x)}{(e_2-d_2)}, & for\ d_2 \leq x \leq e_2 \\ 0, & for\ x > e_2 \end{cases}$$

Definition 2.7. *Graphical representation of Intuitionistic Pentagonal Fuzzy Number (IPFN)*



Definition 2.8 (Score function of an Intuitionistic Pentagonal Fuzzy Number)**.** *Score function of an Intuitionistic Pentagonal Fuzzy Number* $\tilde{A}_{IP} = \{(a_1, b_1, c_1, d_1, e_1)(a_2, b_2, c_2, d_2, e_2)\}$ *is defined as,* $S(\tilde{A}_{IP}) = \frac{(a_1-a_2+b_1-b_2+c_1-c_2+d_1-d_2+e_1-e_2)}{5}$ *where* $S(\tilde{A}_{IP}) \in [-1, 1]$.

Definition 2.9 (Accuracy Function of an IPFN)**.** *A accuracy function of an Intuitionistic Pentagonal Fuzzy Number* $\tilde{A}_{IP} = \{(a_1, b_1, c_1, d_1, e_1)(a_2, b_2, c_2, d_2, e_2)\}$ *is defined as,* $S(\tilde{A}_{IP}) = \frac{(a_1+a_2+b_1+b_2+c_1+c_2+d_1+d_2+e_1+e_2)}{5}$ *where* $H(\tilde{A}_{IP}) \in [-1, 1]$*. The Score function S and the Accuracy function H are respectively, defined as the difference and sum of the membership function* $\mu_{\tilde{A}IP}(x)$*, non-membership function* $\nu_{\tilde{A}IP}(x)$*.*

Definition 2.10 (Pentagonal Valued Intuitionstic Fuzzy Relation)**.** *We defined Pentagonal Valued Intuitionstic Fuzzy Relations and Composition of fuzzy relation.*

Definition 2.11. *Let X and Y be two sets. A Pentagonal Valued Intuitionstic Fuzzy Relation (PVIFR) R from X to Y is a PVIFR of* $X \times Y$ *characterized by the membership function* μ_R *and non-membership function* ν_R *where out put value of* μ_R *and* ν_R *is a pentagonal fuzzy number. A PVIFR R from X to Y will be denoted by* $R(X \to Y)$*.*

Definition 2.12. *If A is an PVIFS of X, the Composition of the Pentagonal Valued Intuitionstic Fuzzy Relation* $R(X \to Y)$ *with A is a PVIFS B of Y denoted by* $B = R \circ A$*, and is defined as* $R \circ A(y) = (\mu_{R \circ A}(y), \nu_{R \circ A}(y)) = B(y)$ *where* $\mu_{R \circ A}(y) = \max[\mu_A(x) \ \min \ \mu_R(x, y)]$ *and* $\nu_{R \circ A}(y) = \min[\nu_A(x) \ \max \ \nu_R(x, y]$*,* $y \in Y$*.*

Definition 2.13. *Let* $V(X \to Y)$ *and* $R(X \to Y)$ *be two PVIFRs. The composition R?V is the PVIFR from X to Z defined as,* $R \circ V(x, z) = (\mu_{R \circ V}(x, y), \nu_{R \circ V}(y, z))$*, where* $\mu_{R \circ V}(x, z) = \max[\mu_V(x, y) \min \ \mu_R(y, z)]$ *and* $\nu_{R \circ v}(x, z) = \min[\nu_V(x, y) \ \max \ \nu_R(y, z)]$*,* $(x, z) \in X \times Z$*,* $y \in Y$ *and* $z \in Z$*.*

3. Medical Diagnosis

We present an application of PVIFR in Sanchez's approach for medical diagnosis. Let S be a set of symptoms, D is a set of diseases and P is a set of patients.

Procedure:

Step 1: We define Pentagonal Valued Intuitionstic Fuzzy Relation V between set of patients P and the set of symptoms S ((i.e) on $P \times S$) which reveals the membership and non-membership between patients and symptoms.

Step 2: We define another Pentagonal Valued Intuitionstic Fuzzy Relation R form the set of symptoms S to the set of diseases D ((i.e) on $S \times D$) which reveals the membership and non-membership between symptoms and diseases.

Step 3: Composition of Pentagonal Valued Intuitionstic Fuzzy Relation to get the PVIFR $N[N = R \circ V]$ describes the state of patients in terms of the diseases as a PVIFR from P to D.

Step 4: Score and accuracy function is calculated for every of N to medical diagnosis for the patients. Maximum of score value which helps the decision maker to strongly confirm the disease for the patient.

4. Numerical Example

Consider the five patients: P_1 (Vishnu, P_2 (John), P_3 (Geetha), P_4 (Kala), P_5 (Rose). Their symptoms are S_1 (temperature), S_2 (fever), S_3 (vomiting), S_4 (stomach problem) and S_5 (body pain). Let the possible diseases relating to the above symptoms be d_1 (Viral fever), d_2 (Dengue) and d_3 (Malaria).

Step 1: The Pentagonal Valued Intuitionstic Fuzzy Relation (PVIFR) $V(P \to S)$ is given as in Table 1.

V	P_1	
S_1	(0.5,0.6,0.7,0.75,0.8)	(0.07,0.1,0.15,0.17,0.19)
S_2	(0.32,0.4,0.49,0.5,0.6)	(0.09,0.13,0.17,0.2,0.25)
S_3	(0.05,0.12,0.2,0.28,0.3)	(0.3,0.4,0.45,0.51,0.6)
S_4	(0.7,0.8,0.82,0.85,0.9)	(0.01,0.04,0.05,0.07,0.09)
S_5	(0.4,0.5,0.55,0.61,0.65	(0.1,0.15,0.25,0.29,0.3)

Table 1.

V	P_2	
S_1	(0.2,0.3,0.35 ,0.4,0.43)	(0.06,0.1,0.12,0.18,0.2)
S_2	(0.08,0.11,0.15,0.2,0.25)	(0.3,0.4,0.5,0.66,0.7)
S_3	(0.7,0.75,0.8,0.83,0.86)	(0.02,0.04,0.06,0.08,0.1)
S_4	(0.5,0.54,0.6,0.67,0.71)	(0.09,0.12,0.15,0.17,0.2)
S_5	(0.04,0.09,0.15,0.19,0.22)	(0.2,0.25,0.3,0.4,0.62)

V	P_3	
S_1	(0.7,0.73,0.8,0.87,0.9)	0.01,0.03,0.04,0.06,0.08)
S_2	(0.08,0.09,0.11,0.16,0.18)	(0.4,0.5,0.6,0.7,0.8)
S_3	(0.3,0.42,0.48,0.51,0.55)	(0.18,0.21,0.28,0.31,0.4)
S_4	(0.53,0.62,0.68,0.7,0.75)	(0.04,0.09,0.15,0.18,0.2)
S_5	(0.07,0.09,0.13,0.16,0.22)	(0.3,0.5,0.6,0.7,0.75)

V	P_4	
S_1	(0.2,0.4,0.5,0.55,0.6)	(0.1,0.14,0.17,0.2,0.23)
S_2	(0.06,0.1,0.15,0.27,0.3)	0.2,0.27,0.33,0.4,0.6)
S_3	(0.64,0.68,0.7,0.75,0.82)	(0.01,0.06,0.011,0.15,0.16)
S_4	(0.1,0.2,0.3,0.4,0.5)	(0.07,0.18,0.2,0.25,0.3)
S_5	(0.5,0.55,0.57,0.63,0.68)	(0.06,0.1,0.15,0.19,0.25)

V	P_5	
S_1	(0.1,0.13,0.14,0.2,0.24)	(0.3,0.41,0.48,0.52,0.6)
S_2	(0.45,0.52,0.59,0.62,0.68)	(0.12,0.18,0.21,0.24,0.28)
S_3	(0.2,0.28,0.35,0.4,0.46)	(0.03,0.05,0.1,0.16,0.22)
S_4	(0.3,0.35,0.4,0.45,0.5)	(0.17,0.2,0.25,0.3,0.35)
S_5	(0.2,0.25,0.29,0.3,0.32)	(0.3,0.4,0.53,0.58,0.6)

Step 2: PVIFR R (S→D) is given as in Table 2

R	d_1	
S_1	(0.2,0.26,0.3,0.35,0.5)	(0.07,0.09,0.1,0.13,0.18)
S_2	(0.55,0.61,0.65,0.7,0.75)	(0.08,0.1,0.14,0.18,0.2)
S_3	(0.14,0.18,0.2,0.23,0.26)	(0.6,0.66,0.68,0.7,0.72)
S_4	(0.44,0.49,0.51,0.52,0.58)	(0.3,0.32,0.33,0.38,0.4)
S_5	(0.3,0.4,0.45,0.5,0.55)	(0.03,0.04,0.08,0.1,0.2)

Table 2.

R	d_2	
S_1	(0.2,0.25,0.3,0.35,0.4)	(0.1,0.13,0.14,0.2,0.23)
S_2	(0.03,0.08,0.1,0.18,0.2)	(0.5,0.55,0.6,0.65,0.75)
S_3	(0.25,0.3,0.4,0.5,0.6)	(0.1,0.15,0.19,0.2,0.23)
S_4	(0.6,0.65,0.68,0.7,0.75)	(0.05,0.08,0.1,0.15,0.2)
S_5	(0.44,0.55,0.66,0.68,0.7)	(0.1,0.13,0.15,0.17,0.2)

R	d_3	
S_1	(0.03,0.05,0.1,0.15,0.19)	(0.45,0.5,0.55,0.6,0.67)
S_2	(0.33,0.41,0.48,0.5,0.56)	(0.18,0.2,0.25,0.29,0.3)
S_3	(0.42,0.49,0.53,0.56,0.6)	(0.01,0.05,0.1,0.16,0.2)
S_4	(0.15,0.19,0.2,0.23,0.3)	(0.5,0.52,0.55,0.58,0.6)
S_5	(0.7,0.82,0.85,0.88,0.9)	(0.01,0.03,0.05,0.08,0.09)

Step 3: The composition $N = R \circ V$ is as given in Table 3

N	P_1	
d_1	(0.44,0.49,0.51,0.52,0.58)	(0.07,0.1,0.15,0.17,0.19)
d_2	(0.6,0.65,0.68,0.7,0.75)	(0.05,0.08,0.1,0.15,0.2)
d_3	(0.4,0.5,0.55,0.61,0.65)	(0.1,0.15,0.25,0.29,0.3)

Table 3.

N	P_2	
d_1	(0.44,0.49,0.51,0.52,058	(0.07,0.1,0.12,0.18,0.2)
d_2	(0.5,0.54,0.6,0.67,0.71)	(0.09,0.12,0.15,0.17,0.2)
d_3	(0.42,0.49,0.53,0.56,0.6)	(0.18,0.21,0.28,0.31,0.4)

N	P_3	
d_1	(0.44,0.49,0.51,0.52,0.58)	(0.07,0.09,0.1,0.13,0.18)
d_2	(0.53,0.62,0.68,0.7,0.75)	(0.05,0.09,0.15,0.18,0.2)
d_3	(0.3,0.42,0.48,0.51,0.55)	(0.18,0.21,0.28,0.31,0.4)

N	P_4	
d_1	(0.3,0.4,0.45,0.5,0.55)	(0.06,0.1,0.15,0.19,0.25)
d_2	(0.44,0.55,0.66,0.68,0.7)	(0.07,0.13,0.15,0.17,0.2)
d_3	(0.5,0.55,0.57,0.63,0.68)	(0.01,0.06,0.11,0.16,0.2)

N	P_5	
d_1	(0.45,0.52,0.59,0.62,0.68)	(0.12,0.18,0.21,0.24,0.28)
d_2	(0.3,0.35,0.4,0.45,0.5)	(0.1,0.15,0.19,0.2,0.23)
d_3	(0.33,0.41,0.48,0.5,0.56)	(0.03,0.05,0.1,0.16,0.22)

Step 4: We calculate score and accuracy as given in Table 4

	P_1	P_2	P_3
d_1	0.372,0.644	0.374,0.642	0.406,0.634
d_2	0.56,0.792	0.458,0.75	0.522,0.952
d_3	0.324,0.76	0.244,0.796	0.176,0.728

	P_4	P_5
d_1	0.29,0.59	0.366,0.778
d_2	0.462,0.75	0.226,0.574
d_3	0.478,0.694	0.344,0.568

From table 4, the score values it is shows that the patient P_1 (Vishnu), P_2 (John) and P_3 (Geetha) are suffer from diseases d_2 (Dengue), P_4 (Kala) suffer from d_3 (Malaria) and P_5 (Rose) suffer from d_1 (Viral fever).

5. Conclusion

The procedures are determinating by using Pentagonal Valued Intuitionstic Fuzzy Relation for medical problems. The result of the numerical example for verify to given the best diagnostic conclusions. Hence Sanchez's approach for medical diagnosis has been made with a generalized notion. And then we apply the score and accuracy function to order Pentagonal Valued Intuitionstic Fuzzy Numbers and its application has been used in may different approaches to model of medical diagnosis process.

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