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IFS with Extended Modal Operators in Medical Diagnosis

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Abstract- In this paper a new technique named as Intuitionistic fuzzy set with Extended Modal Operators. This operator applies to identify the disease of the patient with symptoms in the decision method for Medical Diagnosis.

Keywords — Intuitionistic Fuzzy set(IFS), Intuitionistic Fuzzy Relation (IFR), Intuitionistic Fuzzy Extended Modal Operators [IFEMO], Intuitionistic Medical Diagnosis(IMD).

I. INTRODUCTION

The field of medicine is one of the best areas of application of fuzzy set theory. In the discrimination analysis, the symptoms are ranked according to the grade of discrimination of each disease by a particular symptom. In real world, we frequently deal with vague or imprecise information. Information available is sometimes vague, sometimes inexact or sometimes insufficient. Out of several higher order fuzzy sets, intuitionistic fuzzy sets[1,2] have been found to be highly useful to deal with vagueness. There are situations where due to insuffiency in the information available, the evaluation of membership values is not possible up to our satisfaction.Due to the some reason, evaluation of non-membership values is not always possible and consequently there remains a part indeterministic on which hesitation survives.

Certainly fuzzy set theory is not appropriate to deal with such problem, rather intuitionistic fuzzy set theory is more suitable.Out of several generalizations of fuzzy set theory for various objectives ,the notion introduced by Atanassov[1] in defining intuitionistic fuzzy sets is interesting and useful.Fuzzy sets are intuitionistic fuzzy sets but the converse is not necessarily true[1].In fact, there are situations where intuitionistic fuzzy set theory is more appropriate to deal with [7].Besides, it has been cultured in [8] that vague sets [10] are nothing but intuitionistic fuzzy sets.

In the present paper we study Sanchez's method[11] for medical diagnosis using intuitionistic fuzzy extended modal operators [IFEMO] in [3,4,5]. The method of intuitionistic medical diagnosis[IMD] involves intuitionistic fuzzy relations[IFR] as defined in [6].

II. PRELIMINARIES

We give here some basic definitions, which are used in our next section.

A. Definition

Let a set E be fixed. An intuitionistic fuzzy set (IFS) A in E is an object having the form. $\check{A} = \{\langle x, \mu_A(x), \gamma_A(x)\rangle / x \in X\}$where the function $\mu_A: E \to [0,1]$ *and* $\gamma_A: E \to [0,1]$ define the degree of membership and degree of non-membership respectively of the element $x \in E$ to the set A. which is a subset of E and for every $x \in E, 0 \le \mu_A(x) + \gamma_A(x) \le 1$.

The amount $\pi_A(x) = 1 - (\mu_A(x) + \gamma_A(x))$ is called the hesitation part which may cater to either membership value or non-membership value or both.

III. METHODOLOGY

A. Definition

If A and B are two IFS of the set E, then let
$A = \{\langle x, \mu_A(x), \gamma_A(x)\rangle / x \in E\}$ and
$B = \{\langle x, \mu_B(x), \gamma_B(x)\rangle / x \in E\}$
be two intuitionistic fuzzy set the Cartesian product of these two intuitionistic fuzzy sets the set
$A \times B = \{\langle \mu_A(x) \times \mu_B(x), \gamma_A(x) \times \gamma_B(x)\rangle / x \in E\}$

B. Definition

If A and B are two IFS of the set E, then
$A \cup B = \{\langle x, \max(\mu_A(x), \mu_B(x)), \min(\gamma_A(x), \gamma_B(x))\rangle / x \in E\}$

C. Definition

An operator over an intuitionistic fuzzy set A (IFS A), given the fixed numbers $\alpha, \alpha \in [0,1]$, as
$D_\alpha(A) = \{\langle x, \mu_A(x) + \alpha \cdot \pi_A(x), \gamma_A(x) + (1-\alpha) \cdot \pi_A(x)\rangle / x \in E\}$.

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D. Definition

An operator over an intuitionistic fuzzy set A (IFS A), given the fixed numbers α, β

$\alpha, \beta \in [0,1]$ and $\alpha + \beta \leq 1$, as

$$F_{\alpha,\beta}(A) = \{(x, \mu_A(x) + \alpha \cdot \pi_A(x), \gamma_A(x) + \beta \cdot \pi_A(x))/x \in E\}.$$

IV. MEDICAL DIAGNOSIS

Suppose S is a set of symptoms, D is a set of Disease and P is a set of patient. Let C_1 be an intuitionistic fuzzy relations [IFR] $C_1(P \to S)$ and C_2 be an intuitionistic fuzzy relations [IFR] $C_2(S \to D)$.

Then

$$C_3 = A \times B = \{(\mu_A(x) \times \mu_B(x), \gamma_A(x) \times \gamma_B(x))/\ x \in E\}$$

$$C_4 = A \cup B = \{(x, \max(\mu_A(x), \mu_B(x)), \min(\gamma_A(x), \gamma_B(x)))/x \in E\}$$

$$C_5 = D_\alpha(A) = \{(x, \mu_A(x) + \alpha \cdot \pi_A(x), \gamma_A(x) + (1-\alpha) \cdot \pi_A(x))/x \in E\}.$$

Here $\alpha = 0.5$

$$C_6 = F_{\alpha,\beta}(A) = \{(x, \mu_A(x) + \alpha \cdot \pi_A(x), \gamma_A(x) + \beta \cdot \pi_A(x))/x \in E\}.$$

Here $\alpha, \beta = 0.5$

$$C_7 = \mu_A(x) \wedge \gamma_A(x) = \min\{\mu_A(x), \gamma_A(x)\}$$

A. Algorithm

Step1:

The formula $C_3$and C_4 are applied in Table 1 and Table 2 , and get the results is named Table 3,Table 4 Table 5 & Table 6

Step2:

The Table 7 values are applied in the formula C_5 and C_6 individually, we get the results is named Table 8.

Step3:

The Table 8 values applied in C_7 and get the result is named Table 9.

Step4:

Finally, we select the minimum value from (Table 9)each row, and then we conclude that the Patients $P_i(i = 1,2,3,4)$ is suffering from the Disease $D_j(j = 1,2,3,4,5)$

B. Case Study [9]

Let there be four Patients $P = \{P_1, P_2, P_3, P_4\}$

and the set of Symptoms S = {Temperature, Headache, Stomach-pain, Cough, Chest-pain} and the set of Disease = {Viral fever, Malaria, Typhoid, Stomach-problem, Chest-problem}.

Table 1: IFR $C_1(P \to S)$

C_1	Temperature	Headache	Stomach - pain	Cough	Chest-pain
P_1	(0.8,0.1)	(0.6,0.1)	(0.2,0.8)	(0.6,0.1)	(0.1,0.6)
P_2	(0.0,0.8)	(0.4,0.4)	(0.6,0.1)	(0.1,0.7)	(0.1,0.8)
P_3	(0.8,0.1)	(0.8,0.1)	(0.0,0.6)	(0.2,0.7)	(0.0,0.5)
P_4	(0.6,0.1)	(0.5,0.4)	(0.3,0.4)	(0.7,0.2)	(0.3,0.4)

Table 2: IFR $C_2(S \to D)$

C_2	Viral fever	Malaria	Typhoid	Stomachp -problem	Chest-problem
Temperature	(0.4,0.0)	(0.7,0.0)	(0.3,0.3)	(0.1,0.7)	(0.1,0.8)
Headache	(0.3,0.5)	(0.2,0.6)	(0.6,0.1)	(0.2,0.4)	(0.0,0.8)
Stomach-pain	(0.1,0.7)	(0.0,0.9)	(0.2,0.7)	(0.8,0.0)	(0.2,0.8)
Cough	(0.4,0.3)	(0.7,0.0)	(0.2,0.6)	(0.2,0.7)	(0.2,0.8)
Chest-pain	(0.1,0.7)	(0.1,0.8)	(0.1,0.9)	(0.2,0.7)	(0.8,0.1)

Using step 1

Find **P_1** from the following method for Table 1.

To find the product of membership function in (R_1, C_1) from Table 1&Table 2, and also the product of non-membership function in (R_1, C_1) from Table 1&Table 2.

(0.32, 0.00), (0.18, 0.05), (0.02, 0.56), (0.24, 0.03), (0.01, 0.42)

Now we have to find the maximum of membership function and minimum of non-membership function from above value is **(0.32, 0.00)**

To find the product of membership function in (R_1, C_2) from Table 1&Table 2, and also the product of non-membership function in (R_1, C_2) from Table 1&Table 2.

(0.56, 0.00), (0.12, 0.06), (0.00, 0.72), (0.42, 0.00), (0.01, 0.48)

Now we have to find the maximum of membership function and minimum of non-membership function from above value is **(0.56, 0.00)**

To find the product of membership function in (R_1, C_3) from Table 1&Table 2, and also the product of non-membership function in (R_1, C_3) from Table 1&Table 2.

(0.24, 0.03), (0.12, 0.06), (0.00, 0.72), (0.42, 0.00), (0.01, 0.48)

Now we have to find the maximum of membership function and minimum of non-membership function from above value is **(0.42, 0.00)**

To find the product of membership function in (R_1, C_4) from Table 1&Table 2, and also the product of non-membership function in (R_1, C_4) from Table 1&Table 2.

(0.08, 0.07), (0.12, 0.04), (0.16, 0.00), (0.12, 0.07), (0.02, 0.42)

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Now we have to find the maximum of membership function and minimum of non-membership function from above value is **(0.16, 0.00)**

To find the product of membership function in (R_1, C_5) from Table 1&Table 2, and also the product of non-membership function in (R_1, C_5) from Table 1&Table 2.

(0.08, 0.08), (0.00, 0.08), (0.04, 0.64), (0.12, 0.08), (0.08, 0.06)

Now we have to find the maximum of membership function and minimum of non-membership function from above value is **(0.12, 0.06)**

P_1	Temp.	Headache	Stomach-pain	Cough	Chest-pain
V	(0.32, 0.00)	(0.18, 0.05)	(0.02, 0.56)	(0.24, 0.03)	(0.01, 0.42)
M	(0.56, 0.00)	(0.12, 0.06)	(0.00, 0.72)	(0.42, 0.00)	(0.01, 0.48)
T	(0.24, 0.03)	(0.12, 0.06)	(0.00, 0.72)	(0.42, 0.00)	(0.01, 0.48)
S	(0.08, 0.07)	(0.12, 0.04)	(0.16, 0.00)	(0.12, 0.07)	(0.02, 0.42)
C	(0.08, 0.08)	(0.00, 0.08)	(0.04, 0.64)	(0.12, 0.08)	(0.08, 0.06)

Table 3

V - Viral fever**, M** - Malaria**, T** - Typhoid**, S**-Stomach-problem**, C** – Chest-problem

Using the above method to follow the patients of P_2, P_3, and P_4, then we get the Table 4, Table 5 and Table 6 is given below.

Table 4

P_2	Temp.	Headache	Stomach-pain	Cough	Chest-pain
V	(0.00, 0.00)	(0.13, 0.20)	(0.06, 0.07)	(0.04, 0.21)	(0.01, 0.56)
M	(0.00, 0.00)	(0.08, 0.24)	(0.00, 0.09)	(0.42, 0.00)	(0.01, 0.64)
T	(0.00, 0.24)	(0.24, 0.04)	(0.12, 0.07)	(0.02, 0.42)	(0.01, 0.72)
S	(0.00, 0.56)	(0.08, 0.16)	(0.48, 0.00)	(0.02, 0.48)	(0.02, 0.56)
C	(0.00, 0.64)	(0.00, 0.32)	(0.12, 0.08)	(0.02, 0.56)	(0.08, 0.08)

V - Viral fever**, M** - Malaria**, T** - Typhoid**, S**-Stomach-problem**, C** – Chest-problem

Table 5

P_3	Temp.	Headache	Stomach-pain	Cough	Chest-pain
V	(0.32, 0.00)	(0.24, 0.05)	(0.00, 0.42)	(0.08, 0.21)	(0.00, 0.35)
M	(0.56, 0.00)	(0.16, 0.06)	(0.00, 0.54)	(0.14, 0.00)	(0.00, 0.40)
T	(0.24, 0.03)	(0.48, 0.01)	(0.00, 0.42)	(0.04, 0.42)	(0.00, 0.45)
S	(0.08, 0.07)	(0.16, 0.04)	(0.00, 0.00)	(0.04, 0.49)	(0.00, 0.35)
C	(0.08, 0.08)	(0.00, 0.08)	(0.00, 0.48)	(0.04, 0.56)	(0.00, 0.05)

V - Viral fever**, M** - Malaria**, T** - Typhoid**, S**-Stomach-problem**, C** – Chest-problem

Table 6

P_4	Temp.	Headache	Stomach-pain	Cough	Chest-pain
V	(0.24, 0.00)	(0.15, 0.20)	(0.03, 0.28)	(0.28, 0.06)	(0.03, 0.28)
M	(0.42, 0.00)	(0.10, 0.24)	(0.00, 0.36)	(0.49, 0.00)	(0.03, 0.32)
T	(0.18, 0.03)	(0.30, 0.04)	(0.06, 0.28)	(0.14, 0.12)	(0.03, 0.36)
S	(0.06, 0.07)	(0.10, 0.16)	(0.24, 0.00)	(0.14, 0.14)	(0.12, 0.28)
C	(0.06, 0.08)	(0.00, 0.32)	(0.24, 0.00)	(0.14, 0.16)	(0.24, 0.04)

V - Viral fever**, M** - Malaria**, T** - Typhoid**, S**-Stomach-problem**, C** – Chest-problem

Table 7

	Viral fever	Malaria	Typhoid	Stomach-problem	Chest-problem
P_1	(0.32,0.00)	(0.56,0.00)	(0.42,0.00)	(0.16,0.00)	(0.12,0.06)
P_2	(0.12,0.00)	(0.42,0.00)	(0.24,0.04)	(0.48,0.00)	(0.12,0.08)
P_3	(0.32,0.00)	(0.56,0.00)	(0.48,0.00)	(0.16,0.00)	(0.08,0.05)
P_4	(0.28,0.00)	(0.49,0.00)	(0.30,0.03)	(0.24,0.00)	(0.24,0.00)

Table 8

	Viral fever	Malaria	Typhoid	Stomach-problem	Chest-problem
P_1	(0.34,0.66)	(0.22,0.78)	(0.29,0.71)	(0.42,0.58)	(0.47,0.53)
P_2	(0.44,0.56)	(0.29,0.71)	(0.40,0.60)	(0.26,0.74)	(0.48,0.52)
P_3	(0.34,0.66)	(0.22,0.78)	(0.26,0.73)	(0.26,0.74)	(0.48,0.51)
P_4	(0.36,0.64)	(0.25,0.74)	(0.36,0.63)	(0.38,0.62)	(0.38,0.62)

Table 9

	Viral fever	Malaria	Typhoid	Stomach-problem	Chest-problem
P_1	0.34	**0.22**	0.29	0.42	0.47
P_2	0.44	0.29	0.40	**0.26**	0.48
P_3	0.34	**0.22**	0.26	0.26	0.48
P_4	0.36	**0.25**	0.36	0.38	0.38

V. CONCLUSION

From Table 9, We see that the minimum value of P_1 , P_3& P_4 is 0.22 and 0.25 respectively, therefore they suffer from Malaria. Whereas the minimum value of P_2 is 0.26 and therefore she faces Stomach problem. In this paper, a

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new technique to diagnose the symptom of the disease using intuitionistic fuzzy set is proposed and it is successful and effective to solve many problems faced by patients.

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