Intuitionistic Fuzzy Sets and its Applications in Medical Diagnosis

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Abstract. In this paper, we propose a new approach for medical diagnosis with the symptoms of disease using intuitionistic fuzzy sets with extended modal operators for negation.

1. 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(IFS)[2,3] have been found to be highly useful to deal with vagueness. There are situations where due to insufficiency in the information available, the evaluation of membership values is not possible to our satisfaction. Due to some reason, evaluation of non-membership values is not also always possible and consequently there remains a part in deterministic on which hesitation survives. Certainly Fuzzy sets theory is not appropriate to deal with such problem, rather IFS theory is more suitable. Out of several generalizations of fuzzy set theory for various objectives, the notion introduced by Atanassov [2] in defining intuitionistic fuzzy sets is interesting and useful. Fuzzy sets are intuitionistic fuzzy sets but the converse is not necessarily true [2]. In fact there are situations where IFS theory is more appropriate to deal with [6]. Besides, it has been cultured in [7] that vague sets [8] are nothing but IFS.

In the present paper we study Sanchez's method [9] for medical diagnosis using the name as extended modal operators for negation [EMON] of IFS theory [4]. The method of intuitionistic medical diagnosis[IMD] involves intuitionistic fuzzy relations[IFR] as defined in [5].

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

Definition 2.1. Let a set E be fixed. An intuitionistic fuzzy set (IFS) A in E is an object having the form. $\breve{A} = \{\langle x, \mu_A(x), \gamma_A(x)\rangle / x \in X\}$ where the function $\mu_A: E \rightarrow$ [0,1] $and\ \gamma_A: E \rightarrow$ [0,1] define the degree of membership and degree of non-membership resepectively of the element $x \in E$ to the set A. which is a subset of E and for every $x \in E, 0 \leq \mu_A(x) + \gamma_A(x) \leq 1$.

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.

3. Methodology
Definition 3.1. If A and B are two IFS of the set E, then
$$A \cap B = \{\langle x, \min(\mu_A(x), \mu_B(x)), \max(\gamma_A(x), \gamma_B(x))\rangle / x \in E\}$$
$$A \cup B = \{\langle x, \max(\mu_A(x), \mu_B(x)), \min(\gamma_A(x), \gamma_B(x))\rangle / x \in E\}$$

Definition 3.2. An operator over an intuitionistic fuzzy set A (IFS A), given the fixed numbers $\alpha, \beta \in$ [0,1], as
$$h_{\alpha,\beta}(A) = \{\langle x, \alpha. \gamma_A(x), \mu_A(x) + \beta. \pi_A(x)\rangle / x \in E\}$$

4. Medical diagnosis
Suppose S is a set of symptoms, D is a set of Disease and P is a set of patient. Let F_1 be an intuitionistic fuzzy relations[IFR] $F_1(P \rightarrow S)$ and F_2 be an intuitionistic fuzzy relations[IFR] $F_2(S \rightarrow D)$.
Then

$$F_1 = A \cap B = \{\langle x, \min(\mu_A(x), \mu_B(x)), \max(\gamma_A(x), \gamma_B(x))\rangle / x \in E\}$$
$$F_2 = A \cup B = \{\langle x, \max(\mu_A(x), \mu_B(x)), \min(\gamma_A(x), \gamma_B(x))\rangle / x \in E\}$$
$$F_3 = (F_1 \circ F_2)$$
$$F_4 = h_{\alpha,\beta}(A) = \{\langle x, \alpha. \gamma_A(x), \mu_A(x) + \beta. \pi_A(x)\rangle / x \in E\}$$
$$\text{Here } \alpha, \beta = 0.5$$
$$F_5 = \mu_A(x) \vee \gamma_A(x) = \max\{\mu_A(x), \gamma_A(x)\}$$

4.1. Algorithm
Step 1:
$F_1(P \rightarrow S)$ and $F_2(S \rightarrow D)$ are applied in Table 1 and Table 2 , we get the results is named Table 3 (ie, compute $F_3 = (F_1 \circ F_2)$)

Step 2:
The Table 3 values are applied in the formula F_4, and get the results is named Table 4.

Step 3:
The Table 4 values applied in F_5 and get the result is named Table 5.

Step 4:

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

4.2. Case study
Let there be four Patients P = $\{P_1, P_2, P_{3,}P_4 \}$ and the set of symptoms
S = {Headache, Acidity, Burning Eyes, Back pain, Depression}
Let the set of Disease be D = {Stress, Ulcer, Vision problem, Spinal problems, Blood pressure}.

Table 1: IFR $F_1(P \rightarrow S)$

	Headache	Acidity	Burning Eyes	Back Pain	Depression
P_1	(0.9, 0.1)	(0.7, 0.2)	(0.2, 0.8)	(0.7, 0.2)	(0.2, 0.7)
P_2	(0.0, 0.7)	(0.4, 0.5)	(0.6, 0.2)	(0.2, 0.7)	(0.1, 0.2)
P_3	(0.7, 0.1)	(0.7, 0.1)	(0.0, 0.5)	(0.1, 0.7)	(0.0, 0.6)
P_4	(0.5, 0.1)	(0.4, 0.3)	(0.4, 0.5)	(0.8, 0.2)	(0.3, 0.4)

Table 2: IFR $F_2(S \rightarrow D)$

	Stress	Ulcer	Vision Problem	Spinal Problems	Blood Pressure
Headache	(0.3, 0.0)	(0.0, 0.6)	(0.2, 0.2)	(0.2, 0.8)	(0.2, 0.8)
Acidity	(0.3, 0.5)	(0.2, 0.6)	(0.5, 0.2)	(0.1, 0.5)	(0.0, 0.7)
Burning Eyes	(0.2, 0.8)	(0.0, 0.8)	(0.1, 0.7)	(0.7, 0.0)	(0.2, 0.8)
Back Pain	(0.7, 0.3)	(0.5, 0.0)	(0.2, 0.6)	(0.1, 0.7)	(0.1, 0.8)
Depression	(0.2, 0.6)	(0.1, 0.8)	(0.2, 0.8)	(0.2, 0.7)	(0.8, 0.1)

Table 3: Using Step 1 (i.e., compute $F_3 = (F_1 \circ F_2)$

	Stress	Ulcer	Vision Problem	Spinal Problems	Blood Pressure
P_1	(0.7, 0.1)	(0.5, 0.2)	(0.5, 0.2)	(0.2, 0.5)	(0.2, 0.7)
P_2	(0.3, 0.5)	(0.2, 0.6)	(0.4, 0.5)	(0.6, 0.2)	(0.2, 0.2)
P_3	(0.3, 0.1)	(0.2, 0.6)	(0.5, 0.2)	(0.2, 0.5)	(0.2, 0.6)
P_4	(0.7, 0.1)	(0.5, 0.2)	(0.4, 0.2)	(0.4, 0.5)	(0.3, 0.4)

Table 4: Using Step 2

	Stress	**Ulcer**	**Vision Problem**	**Spinal Problems**	**Blood Pressure**
P_1	(0.05, 0.80)	(0.10, 0.65)	(0.10, 0.65)	(0.25, 0.35)	(0.35, 0.35)
P_2	(0.25, 0.40)	(0.30, 0.30)	(0.25, 0.45)	(0.10, 0.70)	(0.30, 0.50)
P_3	(0.05, 0.60)	(0.30, 0.30)	(0.40, 0.65)	(0.25, 0.35)	(0.30, 0.30)
P_4	(0.05, 0.80)	(0.10, 0.65)	(0.10, 0.60)	(0.25, 0.45)	(0.20, 0.45)

Table 5: Using Step 3 and Step 4

	Stress	**Ulcer**	**Vision Problem**	**Spinal Problems**	**Blood Pressure**
P_1	**0.80**	0.65	0.65	0.35	0.35
P_2	0.40	0.30	0.45	**0.70**	0.50
P_3	0.60	0.30	**0.65**	0.35	0.30
P_4	**0.80**	0.65	0.60	0.45	0.45

From the results of the disease from Table 5, we see that the max value of P_1 and P_4 is 0.80 and therefore both of them suffer from Stress. The max value of P_2 is 0.70 This concludes that P_2 faces Spinal Problem. Whereas the max value of P_3 is 0.65 and therefore P_3 faces Vision Problem.

5. Conclusion

In this paper, a 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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