Intern. J. Fuzzy Mathematical Archive
Vol. 16, No. 1, 2018, 13-19
ISSN: 2320 –3242 (P), 2320 –3250 (online)
Published on 21 August 2018
www.researchmathsci.org
DOI: http://dx.doi.org/10.22457/ijfma.v16n1a3

International Journal of
Fuzzy Mathematical
Archive

Intuitionistic Fuzzy Multisets in Medical Diagnosis

***A. Edward Samuel*[1] and *R.Narmadhagnanam*[2]**

[1]PG and Research Department of Mathematics
Government Arts College (Autonomous)
Kumbakonam-612002, Tamilnadu, India.
E-mail: aedward74_thrc@yahoo.co.in
[2]PG and Research Department of Mathematics
Government Arts College (Autonomous)
Kumbakonam-612002, Tamilnadu, India.
Corresponding author. E-mail: narmadhagnanam03@gmail.com

Received 1 July 2018; accepted 17 August 2018

Abstract. In this paper, sine inverse distance among intuitionistic fuzzy multi sets is proposed and some of its properties are discussed herein. The concept of the above method is an essential tool for dealing with uncertainties and shortcomings that affect the existing methods. Implementation of medical diagnosis is presented to find out the disease impacting the patient.

Keywords: Intuitionistic fuzzy set, intuitionistic fuzzy multi set, sine inverse distance, medical diagnosis

AMS Mathematics Subject Classification (2010): 03E72, 03F55, 62P10, 92C50

1. Introduction

Kumbakonam being a temple city with lots of temples and mutts attracts thousands of pilgrims and tourists every day. The dumped wastes left out by them are causing diseases. Further, Kumbakonam is surrounded by a lot of ponds and tanks. These water bodies get their water from several inlets. But in the absence of proper outlets to drain the water, the water gets contaminated and it becomes stagnated too. And it is crystal clear that the stagnated water becomes the breeding ground for mosquitoes to spread diseases like malaria, dengue and elephantiasis and so on and so forth. In many areas of Kumbakonam the prime cause of disease and decease is mosquito. This created an urge to carry out research in the medical field. By introducing innovative methods in the research, the diseases can be diagnosed instantly and infallibly.

A number of real life problems in engineering, medical sciences, social sciences, economics etc., involve imprecise data and their solution involves the use of mathematical principles based on uncertainty and imprecision. Such uncertainties are being dealt with the help of topics like probability theory, fuzzy set theory [20], rough set theory [12] etc., Healthcare industry has been trying to complement the services offered by conventional clinical decision making systems with the integration of fuzzy logic techniques in them. As it is not an easy task for a clinician to derive a fool proof diagnosis it is advantageous to automate few initial steps of diagnosis which would not require intervention from an expert doctor. Intuitionistic fuzzy set possesses all attributes necessary to encode medical knowledge base and capture medical inputs.

As medical diagnosis demands large amount of information processing, large portion of which is quantifiable, also intuitive thought process involve rapid unconscious data processing and combines available information by law of average, the whole process offers low intra and inter personal consistency. So contradictions, inconsistency and fuzziness should be accepted as unavoidable as they are integrated in the behavior of biological systems as well as in their characterization. To model an expert doctor it is imperative that it should not disallow uncertainty as it would be then inapt to capture fuzzy or incomplete knowledge that might lead to the danger of fallacies due to misplaced precision.

As medical diagnosis contains lots of uncertainties and increased volume of information available to physicians from new medical technologies, the process of classifying different sets of symptoms under a single name of disease becomes difficult. In some practical situations, there is the possibility of each element having different truth membership and false membership functions. So, intuitionistic fuzzy sets play a vital role in medical diagnosis.

In 1965, Fuzzy set theory was firstly given by Zadeh [20] which is applied in many real applications to handle uncertainty. Sometimes membership function itself is uncertain and hard to be defined by a crisp value. So, the concept of interval valued fuzzy sets was proposed to capture the uncertainty of grade of membership. In 1986, Atanassov [1] introduced the intuitionistic fuzzy sets which consider both truth-membership and falsity-membership. Hung and Yang [5] proposed the similarity measures of intuitionistic fuzzy sets based on Hausdorff distance. Hung and Yang [6] examined the j-divergence of intuitionistic fuzzy sets. Similarity measures for the intuitionistic fuzzy sets were proposed by Hung and Yang [7], Intarapaiboon [8], Liang and Shi [11]. Khatibi and Montazer [10] examined the intuitionistic fuzzy set vs. fuzzy set application in medical pattern recognition. Pramanik and Mondal [13] introduced the weighted fuzzy similarity measure based on tangent function. Samuel and Narmadhagnanam [3] proposed the tangent inverse distance and sine similarity measure between intuitionistic fuzzy sets. Jemal et al. [4] proposed the enhanced decision support systems in intensive care unit based on intuitionistic fuzzy sets. Xu [18] examined the intuitionistic preference relations and their application in group decision making. Ye [19] introduced the cosine similarity measures for intuitionistic fuzzy sets. Sebastian and Ramakrishnan [16] studied a new concept called fuzzy multi sets (FMS), which is the generalization of multi sets. Shinoj and John [17] extended the concept of fuzzy multi sets by introducing intuitionistic fuzzy multi sets (IFMS). Rajarajeswari and Uma [14,15] proposed various methods among intuitionistic fuzzy multisets.

In this paper, by using the notion of intuitionistic fuzzy multi set, it was provided an exemplary for medical diagnosis. In order to make this, a novel method was executed.

Rest of the article is structured as follows. In Section 2, the basic definitions are briefly presented. Section 3 deals with proposed definitions and some of its properties. Sections 4, 5 and 6 contain methodology, algorithm and case study related to medical diagnosis respectively. Conclusion is given in Section 7.

2. Basic definitions

Definition 2.1. [20] Let X be a non-empty set. A fuzzy set A drawn from X is defined as $A=\{(x,\mu_A(x)): x\in X\}$ where $\mu_A(x): X\rightarrow[0,1]$ is the membership function for the fuzzy set A.

Definition 2.2. [2] Let X be a non-empty set. An intuitionistic fuzzy set A in X is an object having the form $A=\{(x,\mu_A(x),\nu_A(x)): x\in X\}$ where the functions $\mu_A(x)$: $X\rightarrow[0,1], \nu_A(x): X\rightarrow[0,1]$ define the degree of membership and degree of non-membership respectively of the element $x\in X$ to the set A, which is a subset of X, and every element $x\in X$, $0\le\mu_A(x)+\nu_A(x)\le 1$. The value $\pi_A(x)=1-(\mu_A(x)+\nu_A(x))$ is called the intuitionistic fuzzy index or hesitation margin of x in A. $\pi_A(x)$ is the degree of indeterminacy of $x\in X$ to the intuitionistic fuzzy set A and $\pi_A(x)\in[0,1]$ .i.e., $\pi_A(x): X\rightarrow[0,1]$ and $0\le\pi_A(x)\le 1$ for every $x\in X$. $\pi_A(x)$ expresses the lack of knowledge of whether x belongs to intuitionistic fuzzy set A or not.

Definition 2.3. [14] Let X be a nonempty set. An Intuitionistic Fuzzy Multi set (IFMS) A in X is characterized by two function namely count membership function Mc and count non membership function NMc such that $Mc: X\rightarrow Q$ and $NMc: X\rightarrow Q$ where Q is the set of all crisp multi sets in $[0,1]$. Hence, for any $x\in X$, $Mc(X)$ is the crisp multi set from $[0,1]$ whose membership sequence is defined as $(\mu_A^1(x),\mu_A^2(x),\ldots\mu_A^p(x))$ where $\mu_A^1(x)\ge\mu_A^2(x)\ge\ldots\ge\mu_A^p(x)$ and the corresponding non membership sequence $NMc(X)$ is defined as $(\nu_A^1(x),\nu_A^2(x),\ldots\nu_A^p(x))$ where the non membership can be either decreasing or increasing function. Such that $0\le\mu_A^j(x)+\nu_A^j(x)\le 1, \forall x\in X$ and $i=1,2,\ldots p$. Therefore, an IFMS A is given by

$$A=\left\{\left\langle x,(\mu_A^1(x),\mu_A^2(x),\ldots\mu_A^p(x)),(\nu_A^1(x),\nu_A^2(x),\ldots\nu_A^p(x))\right\rangle / x\in X\right\}$$

where $\mu_A^1(x)\ge\mu_A^2(x)\ge\ldots\ge\mu_A^p(x)$

3. Proposed definition

Definition 3.1. Let $A=\left\{\left\langle x,(\mu_A^1(x),\mu_A^2(x),\ldots\mu_A^p(x)),(\nu_A^1(x),\nu_A^2(x),\ldots\nu_A^p(x))\right\rangle / x\in X\right\}$ and $B=\left\{\left\langle x,(\mu_B^1(x),\mu_B^2(x),\ldots\mu_B^p(x)),(\nu_B^1(x),\nu_B^2(x),\ldots\nu_B^p(x))\right\rangle / x\in X\right\}$ be two intuitionistic fuzzy multi sets. Then the sine inverse distance is defined as

$$SID_{IFMS}(A,B)=2p\sum_{j=1}^{p}\left[\sum_{i=1}^{n}\sin^{-1}\left[\frac{\pi}{4}\left[\frac{\left|\mu_A^j(x_i)-\mu_B^j(x_i)\right|+\left|\nu_A^j(x_i)-\nu_B^j(x_i)\right|}{5pn}\right]\right]\right]$$

Proposition 1.

(i) $SID_{IFMS}(A,B)\ge 0$

(ii) $SID_{IFMS}(A,B)=SID_{IFMS}(B,A)$

(iii) If $A \subseteq B \subseteq C$ then $SID_{IFMS}(A,C) \geq SID_{IFMS}(A,B)$ and $SID_{IFMS}(A,C) \geq SID_{IFMS}(B,C)$

Proof:

(i) The proof is straightforward

(ii) The proof is straightforward

(iii) It was well known that,

$$\mu_A^j(x_i) \leq \mu_B^j(x_i) \leq \mu_C^j(x_i)$$

$$\nu_A^j(x_i) \geq \nu_B^j(x_i) \geq \nu_C^j(x_i).$$

$$(\because A \subseteq B \subseteq C)$$

Hence,

$$\left|\mu_A^j(x_i) - \mu_B^j(x_i)\right| \leq \left|\mu_A^j(x_i) - \mu_C^j(x_i)\right|$$

$$\left|\mu_B^j(x_i) - \mu_C^j(x_i)\right| \leq \left|\mu_A^j(x_i) - \mu_C^j(x_i)\right|$$

$$\left|\nu_A^j(x_i) - \nu_B^j(x_i)\right| \leq \left|\nu_A^j(x_i) - \nu_C^j(x_i)\right|$$

$$\left|\nu_B^j(x_i) - \nu_C^j(x_i)\right| \leq \left|\nu_A^j(x_i) - \nu_C^j(x_i)\right|.$$

Here, the sine inverse distance is an increasing function.

$\therefore SID_{IFMS}(A,C) \geq SID_{IFMS}(A,B)$ and $SID_{IFMS}(A,C) \geq SID_{IFMS}(B,C)$

4. Methodology

In this section, it was presented an application of intuitionistic fuzzy multi set in medical diagnosis. In a given pathology, suppose S is a set of symptoms, D is a set of diseases and P is a set of patients and let Q be an intuitionistic fuzzy multi relation from the set of patients to the symptoms .i.e., $Q(P \to S)$ and R be an intuitionistic fuzzy relation from the set of symptoms to the diseases i.e., $R(S \to D)$ and then the methodology involves three main jobs:

1. Determination of symptoms
2. Formulation of medical knowledge based on intuitionistic fuzzy sets
3. Determination of diagnosis on the basis of new method in intuitionistic fuzzy multi sets

5. Algorithm

Step 1: The Symptoms of the patients are given to obtain the patient-symptom relation Q and are noted in Table 1

Step 2: The medical knowledge relating the symptoms with the set of disease under consideration are given to obtain the symptom-disease relation R and are noted in Table 2.

Step3: The computation T of the relation of patients and diseases is found using (1) and are noted in Table 3.

Step 4: Finally, the minimum value from Table 3 of each row was selected to find the possibility of the patient affected with the respective disease and then it was concluded that the patient $P_k(k=1,2,3,4)$ was suffering from the disease $D_r(r=1,2,3,4)$

6. Case study [14]

Let there be four patients $P=\{P_1, P_2, P_3, P_4\}$ and the set of symptoms $S=$ {Temperature, Cough, Throat pain, Headache, Body pain}.The intuitionistic fuzzy multi relation $Q(P \to S)$ is given as in Table 1.Let the set of diseases D ={Viral fever, Tuberculosis, Typhoid, Throat disease}.The intuitionistic fuzzy relation $R(S \to D)$ is given as in Table 2.

Table 1: The Relation between Patients and Symptoms (using step 1)

Q	Temperature	Cough	Throat pain	Headache	Body pain
P_1	(0.6, 0.2) (0.7, 0.1) (0.5, 0.4)	(0.4, 0.3) (0.3, 0.6) (0.4, 0.4)	(0.1, 0.7) (0.2, 0.7) (0.0, 0.8)	(0.5, 0.4) (0.6, 0.3) (0.7, 0.2)	(0.2, 0.6) (0.3, 0.4) (0.4, 0.4)
P_2	(0.4, 0.5) (0.3, 0.4) (0.5, 0.4)	(0.7, 0.2) (0.6, 0.2) (0.8, 0.1)	(0.6, 0.3) (0.5, 0.3) (0.4, 0.4)	(0.3, 0.7) (0.6, 0.3) (0.2, 0.7)	(0.8, 0.1) (0.7, 0.2) (0.5, 0.3)
P_3	(0.1, 0.7) (0.2, 0.6) (0.1, 0.9)	(0.3, 0.6) (0.2, 0.0) (0.1, 0.7)	(0.8, 0.0) (0.7, 0.1) (0.8, 0.1)	(0.3, 0.6) (0.2, 0.7) (0.2, 0.6)	(0.4, 0.4) (0.3, 0.7) (0.2, 0.7)
P_4	(0.5, 0.4) (0.4, 0.4) (0.5, 0.3)	(0.4, 0.5) (0.3, 0.3) (0.1, 0.7)	(0.2, 0.7) (0.1, 0.6) (0.0, 0.7)	(0.5, 0.4) (0.6, 0.3) (0.3, 0.6)	(0.4, 0.6) (0.5, 0.4) (0.4, 0.3)

Table 2: The relation among symptoms and diseases (using step 2)

R	Viral Fever	Tuberculosis	Typhoid	Throat disease
Temperature	(0.8, 0.1)	(0.2, 0.7)	(0.5, 0.3)	(0.1, 0.7)
Cough	(0.2, 0.7)	(0.9, 0.0)	(0.3, 0.5)	(0.3, 0.6)
Throat pain	(0.3, 0.5)	(0.7, 0.2)	(0.2, 0.7)	(0.8, 0.1)
Headache	(0.5, 0.3)	(0.6, 0.3)	(0.2, 0.6)	(0.1, 0.8)
Body ache	(0.5, 0.4)	(0.7, 0.2)	(0.4, 0.4)	(0.1, 0.8)

Table 3: Sine inverse distance (using step 3 and step4)

T	Viral Fever	Tuberculosis	Typhoid	Throat disease
P_1	0.3066	0.7086	**0.2682**	0.7656
P_2	0.5580	**0.3444**	0.4572	0.6774
P_3	0.6768	0.5640	0.5142	**0.2304**
P_4	0.3192	0.6714	**0.1932**	0.7146

From Table 3, it is obvious that, if the doctor agrees, then P_1 and P_4 suffers from Typhoid, P_2 suffers from Tuberculosis and P_3 suffers from Throat disease.

7. Conclusion

In this paper, it was analyzed the relationship between the set of symptoms found with the patients and the set of diseases and employed a novel method (sine inverse distance) to find out the disease possibly affected the patient. The technique considered in this study was more reliable to handle medical diagnosis problems quiet comfortably. In future, these methods can be enhanced to other types of intuitionistic fuzzy sets also.

REFERENCES

1. K.Atanassov, Intuitionistic fuzzy sets, *Fuzzy Sets and Systems*, 20 (1986) 87-96.
2. K.Atanassov, *Intuitionistic Fuzzy Sets: Theory and application*, Springer, 1999.
3. A.Edward Samuel and R.Narmadhagnanam, Intuitionistic fuzzy sets in medical diagnosis, *International Journal of Mathematical Archive*, 9(1) (2018) 1-5.
4. H.Jemal, Z.Kechaou and M.B.Ayed, Enhanced decision support systems in intensive care unit based on intuitionistic fuzzy sets, *Advances in Fuzzy Systems*, 2017 (2017) 1-8.
5. W.L.Hung and M.S.Yang, Similarity measures of intuitionistic fuzzy sets based on Hausdorff distance, *Pattern Recognition Letters*, 25 (2001) 1603-1611.
6. W.L. Hung and M.S.Yang, On the j-divergence of intuitionistic fuzzy sets with its application to pattern recognition, *Information Sciences*, 178 (2008) 1641-1650.
7. W.L.Hung and M.S.Yang, On similarity measures between intuitionistic fuzzy sets, *International Journal of Intelligent Systems*, 23 (2008) 364-383.
8. P.Intarapaiboon, New similarity measures for intuitionistic fuzzy sets, *Applied Mathematical Sciences*, 8(45) (2014) 2239-2250.
9. K.Mondal and S.Pramanik, Intuitionistic fuzzy similarity measure based on tangent function and its application to multi-attribute decision making, *Global Journal of Advanced Research*, 2(2) (2015) 464-471.
10. V.Khatibi and G.A.Montazer, Intuitionistic fuzzy set vs. fuzzy set application in medical pattern recognition, *Artificial Intelligence in Medicine*, 47 (2009) 43-52.
11. Z.Liang and P.Shi, Similarity measures on intuitionistic fuzzy sets, *Pattern Recognition Letters*, 24 (2003) 2687-2693.
12. Z.Pawlak, Rough sets, I*nternational Journal of Information and Computer Sciences*, 11(1982) 341-356.
13. S.Pramanik and K.Mondal, Weighted fuzzy similarity measure based on tangent function and its application to medical diagnosis, *International Journal of Innovative Research in Science, Engineering and Technology*, 4(2) (2015) 158-164.
14. P.Rajarajeswari and N.Uma, Hausdroff similarity measures for intuitionistic fuzzy multi sets and its application in medical diagnosis, *International Journal of Mathematical Archive*, 4(9) (2013) 106-111.
15. P.Rajarajeswari and N.Uma, Normalized hamming similarity measure for intuitionistic fuzzy multi sets and its application in medical diagnosis, *International Journal of Mathematics, Trends and Technology*, 5(3) (2014) 219-225.
16. S.Sebastian and T.V.Ramakrishnan, Multi fuzzy sets, *International Mathematical Forum*, 5(50) (2010) 2471-2476.
17. T.K. Shinoj and Sunil Jacob John, Intuitionistic fuzzy multi sets and its application in medical diagnosis, *World Academy of Science, Engineering and Technology*, 6 (2012) 1418-1421.

18. Z.Xu, Intuitionistic preference relations and their application in group decision making, *Information Sciences*, 177 (2007) 2363-2379.
19. J.Ye, Cosine similarity measures for intuitionistic fuzzy sets and their applications, *Mathematical and computer Modeling*, 53 (2011) 91-97.
20. L.A.Zadeh, Fuzzy sets, *Information and Control*, 8 (1965) 338-353.