An application of Fuzzy Max-Min composition in Medical Diagnosis using fuzzy operations

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Abstract

We propose a technique named fuzzy Max-Min composition to study the interference method and Sanchez's approach for Medical Diagnosis.

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1Introduction

The field of medicine is one of the most fruitful and interesting areas of applications for fuzzy set theory. In the discrimination analysis, the symptoms are ranked according to the grade of each disease by a particular symptom and is represented in the form of a matrix called frequency distribution $F = (f_{ij})$ where f_{ij} is the ratio of the patients with disease d_i and symptom's s_j to the total number of patients with the diseased_i. This matrix model may not yield more accurate diagnosis in such a case where several diseases affect a single patient or when a single disease manifests quite differently in different patients and at different disease stages. Moreover, with the 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 and determining the appropriate therapeutic actions becomes increasingly difficult. Recently there are verities of models in medical diagnosis under the general frame work of fuzzy set theories involving fuzzy matrices to deal with the different complicating aspects of medical diagnosis.

In real world, we frequently deal with vague of imprecise information. Information available is sometimes vague. Sometimes inexact or sometimes insufficient. Out of several higher order fuzzy sets, intuitionistic fuzzy sets (IFS) 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 upto our satisfaction. Due to the some reason evaluation of non-membership values is not also 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 IFS theory is more suitable. In the present paper we study Sanchez's method for medical diagnosis using IFS.

2 Preliminaries

Here we give some basic definitions, which are used in our next section.

2.1 Definition

Let a set E be fixed. An Intuitionistic fuzzy set or IFS A in E is an object having the same form $A = \{< x, \mu_A(x), \gamma_A(x) > x \epsilon E\}$ where the functions $\mu_A : E \rightarrow [0,1]$ and $\gamma_A : E \rightarrow [0,1]$ define the degree of membership and degree of non-membership respectively of the elements $x \in E, 0 \leq \mu_A(x) + \gamma_A(x) \leq 1$. The amount $\Pi_A(x) = 1 - \left(\mu_A(x) + \gamma_A(x)\right)$ is called the hesitation part, which may cater to either membership value or non-membership value or both.

2.2 Definition

If A and B are two IFS of the set E, then A $\subset B$ if and only if and only if $\forall$

$x \in E, [\mu_A(x) \leq \mu_B(x) and\ \gamma_A(x) \leq \gamma_B(x)]\ A \supset B$ iff $B \subset A$

$$A = B\ iff\ \forall\ x \in E, [\mu_A(x) \leq \mu_B(x) and\ \gamma_A(x) \leq \gamma_B(x)],$$

$$\bar{A} = \{\langle x, \gamma_A(x), \mu_A(x)\rangle / x \in E\}$$

$$A \cap B = \left\{\langle x, \min\left(\mu_A(x), \mu_B(x)\right), \max(\gamma_A(x), \gamma_B(x))\rangle / x \in E\right\}$$

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

Fuzzy max-min composition technique

Obviously every fuzzy set has the form

$\{\langle x, \mu_A(x), \mu_B(x)\rangle / \ x \in E\}$

2.3 Definition

Let $Q(X \rightarrow Y)$ and $R(Y \rightarrow Z)$ be two IFR. The max-min-max composition $R \circ Q$ is the intuitionistic fuzzy relation from X to Z, defined by the membership function

$\mu_{R \circ Q} = \bigvee_y (\mu_Q(x, y) \wedge \mu_R(y, z))$ and the

Non-membership function

$$\gamma_{R \circ Q}(x, z) = \bigwedge_y (\gamma_Q(x, y) \vee \gamma_R(y, z))\ \forall (x, z) \in X \times Z\ and\ y \in Y.$$

3 Medical Diagnosis

In this section we present an application of intuitionistic fuzzy set theory in Sanchez's approach for medical diagnosis. In a given pathology, suppose S is a set of symptoms, D a set of diagnosis, P a set of patients.

Analogous to Sanchez's notion of "Medical Knowledge" we define "Intuitionistic Medical Knowledge" as an intuitionistic fuzzy relation R from the set of symptoms S of the set of diagnoses D(i.e., on S x D) which reveals the degree of association and the degree of non-association between symptoms and diagnosis.

Now let us discuss intuitionistic fuzzy medical diagnosis. The methodology involves mainly the following three jobs:

1. Determination of syptomps.
2. Formulation of medical knowledge based on intuitionistic fuzzy relation.
3. Determination of diagnosis on the basis of composition of intuitionistic fuzzy relation.

An intuitioniistic fuzzy relation Q is given from the set of patients P to the set of symptoms S and another intuitionistic fuzzy relation R is given from a set of symptoms S to the of diagnoses D. The composition T of intuitionistic fuzzy relation R and Q.

3.1Algorithm

[1] Compute $T = R \circ Q$

[2] Find $Min\{\mu_A(p_i,s), \mu_{A^c}(p_i,s)\}$

[3] Find $Max\{Min\{\mu_A(p_i,s), \mu_{A^c}(p_i,s)\}\}$ then we conclude that the patient p_i is suffering from the diseases d_j (i.e., j=1,2,3,4,5,6,7,8,9).

4 Case study

Let there be four patients Gobi, Anirooth, kumaran and gaurav i.e., P={ Gobi, Anirooth, kumaran and gaurav} and the set of symptoms S=$\{S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10}, S_{11}\}$ where the symptoms are S_1 = High Temperature, S_2= Headache, S_3= Nausea, S_4= Vomiting, S_5= Rash S_6=Joint Pain, S_7=Muscle pain, S_8=Runny Nose S_9= Loss of appetite,S_{10}Diarrhea and S_{11}Cough.The fuzzy relation Q, the membership function of symptoms is given as in Table 1. Let the set of diagnosis be $D = \{D_1, D_2, D_3, D_4, D_5, D_6, D_7, D_8, D_9\}$ where D_1= Measles, D_2=Malaria, D_3=Typhoid, D_4=Joundice, D_5=Tuberculosos, D_6= Dengu, D_7= Swineflue, D_8=Chicken Gunia and D_9= Chickenpox. The intuitionistic fuzzy relation $R(S \rightarrow D)$ is given as in Table 2.

Table 1

S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}
0.8	1	1	0.8	0.3	0	0	0	0	0	0

Table 2

	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9
S_1	0.8	0.5	0.6	0.5	0.8	0.9	1	0.9	0.9
S_2	1	0	0	0	0	0	0	0	0.9
S_3	1	0	0	0	0	0	0	0	0
S_4	0.3	1	1	0	0.4	0.4	0.6	0.4	0.6
S_5	0	0.8	0	0	0.7	0	0.8	1	0.8
S_6	0	0.2	1	0	1	0	0	1	0
S_7	0	0.5	0	1	1	1	0	0	0.8
S_8	0	0	0.9	0	0.8	0	0.8	0.5	0
S_9	0	0	0	0	0	0	0	1	0.5
S_{10}	0	0	0	0	0	0	1	0	1
S_{11}	0	0	0.8	0	0	0	0.9	1	1

Table 3

Thus the membership grade of D as follows

D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9
1	0.8	0.8	0.5	0.8	0.8	0.8	0.8	0.9

From the fuzzy data the patients P is most likely suffer from the disease D. From the above fuzzy data by using the max-min composition of fuzzy relation the following result is found. The patients are most likely suffered from the disease Measles.

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