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Research paper

Decision Making Problem for Medical Diagnosis Using Hexagonal Fuzzy Number Matrix

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Abstract

Fuzzy set theory plays a vital role in medical fields. There are varieties of models involving fuzzy matrices to deal with different complicated aspects of medical diagnosis. Fuzzy set theory is highly suitable and applicable for developing knowledge based system in medicine for the tasks of medical findings. The field of medicine and decision making are the most fruitful and interesting area of applications of fuzzy set theory. In this paper, we have applied the notion of Hexagonal fuzzy membership matrix in a medical diagnostic model. The advantage of this model is, if the patient-matrices are known, then it is possible to find which patient is suffering from what kind of disease. Most probably the fuzzy decision model in which overall ranking or ordering of different fuzzy sets are determined by using comparison matrix.

Keywords: *Decision making, Hexagonal fuzzy number, Hexagonal fuzzy number matrix,Comparison matrix*

1. Introduction

Fuzzy set theory introduced by professor Zadeh [12] in 1965 acts as a qualitative computational approach which describes uncertainty. As fuzzy decision making is a most important scientific, social and economic endeavour, there exist several major approaches within the theories of fuzzy decision making. The field of medicine and decision making are the most fruitful and interesting area of applications of fuzzy set theory. In real life situations, the imprecise nature of medical documentation and uncertain information gathered for decision making requires the use of fuzzy. Sánchez [10] formulated the diagnostic models involving fuzzy matrices representing the medical knowledge between the symptoms and diseases. Meenakshi and Kaliraja [7] have extended Sanchez's approach for medical diagnosis using the representation of interval valued fuzzy matrix. Elizabeth and Sujatha [2] have extended Sanchez's approach of medical diagnosis using the representation of triangular fuzzy membership matrix. In this paper, we have applied the notion of Hexagonal fuzzy membership matrix in a medical diagnostic model. The advantage of this model is, if the patient-matrices are known, then it is possible to find which patient is suffering from what kind of disease. Most probably the fuzzy decision model in which overall ranking or ordering of different fuzzy sets are determined by using comparison matrix.

2. Preliminaries

2.1 Definition (Fuzzy Set)

Let X be a set. A fuzzy set A on X is defined to be a function A:X→[0,1] or μ_A: X→[0,1] Equivalently, a fuzzy set A is defined to be the class of objects having the following representation A={$(x,\mu_A x)$:$x\epsilon X$} where μ_A:X→[0,1],is a function called the membership function of A.

2.2 Definition (Fuzzy Number)

The fuzzy number A is a fuzzy set whose membership function $\mu_A(x)$ satisfies the following conditions:

1. $\mu_A(x)$ is piecewise continuous;
2. A fuzzy set A of the universe of discourse X is convex;
3. A fuzzy set of the universe of discourse X is called a normal fuzzy set if $\exists\, x_i \in X, \mu_A(x_i) = 1$.

3. Hexagonal Fuzzy Number

A fuzzy number is the normal Hexagonal fuzzy number is denoted by $(a_1, a_2, a_3, a_4, a_5, a_6)$
where $a_1 \le a_2 \le a_3 \le a_4 \le a_5 \le a_6$ are real numbers and its membership function $\mu_{\tilde{A}}$(x) is given below

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 & for\ x < a_1 \\ \frac{1}{2}\left(\frac{x-a_2}{a_2-a_1}\right) & for\ a_1 \le x \le a_2 \\ \frac{1}{2}+\frac{1}{2}\left(\frac{x-a_2}{a_3-a_2}\right) & for\ a_2 \le x \le a_3 \\ 1 & for\ a_3 \le x \le a_4 \\ 1-\frac{1}{2}\left(\frac{x-a_4}{a_5-a_4}\right) & for\ a_4 \le x \le a_5 \\ \frac{1}{2}\left(\frac{a_6-x}{a_6-a_5}\right) & for\ a_5 \le x \le a_6 \\ 0 & for\ x \ge a_6 \end{cases}$$

3.1 Definition (Hexagonal Fuzzy Number Matrix).

The elements of Hexagonal fuzzy number matrix are defined as A = $(a_{ij})_{m\times n}$, where $a_{ij} = (a_{ijL}, a_{ijM}, ,a_{ijM}, a_{ijN}, a_{ijN}, ,a_{ijU}))$ is the ij[th] element of fuzzy number matrix of A.
Then$0 \le a_{ijL} \le a_{ijM} \le \le a_{ijM} \le a_{ijN} \le \le a_{ijN} \le a_{ijU} \le 30$, where a_{ijL} is the lower bound, a_{ijM}, a_{ijN} is the moderate value, and a_{ijU} is the upper bound.

3.2 Definition (Hexagonal Fuzzy Number Matrix into Membership Function).

Let $\tilde{A}=(a_1, a_2, a_3, a_4, a_5, a_6)$ be a Hexagonal fuzzy number. Then $\mu_{\tilde{A}} = (a_1/30,\ a_2/30,\ a_3/30, a_4/30, a_5/30, a_6/30)$, where $0 \le a_1 < a_2 < a_3 < a_4 < a_5 < a_6 < 30$. Thus $0 \le a_1/30 < a_2/30 < a_3/30 < a_4/30 < a_5/30 < a_6/30 \le 1$.
Let Membership function of $a_{ij} = (a_{ijL}, a_{ijM}, a_{ijM}, ,a_{ijN}, a_{ijN}, a_{ijU})$ is defined as
$(a_{ijL}/30, a_{ijM}/30, a_{ijM}/30, a_{ijN}/30, a_{ijN}/30, a_{ijU}/30)$ where $0 \le a_{ijL} \le a_{ijM} \le a_{ijM} \le \le a_{ijN} \le a_{ijN} \le a_{ijU} \le 30$
$0 \le a_{ijL}/30 \le a_{ijM}/30 \le a_{ijM}/30 \le \le a_{ijN}/30 \le a_{ijN}/30 \le a_{ijU}/30 \le 1$ is called a Hexagonal fuzzy number matrix into its membership function.

3.3Arithmetic Mean of a Hexagonal Fuzzy Membership Number

Let $\mu_{\tilde{A}} = (a_1/30, a_2/30, a_3/30, a_4/30, a_5/30, a_6/30)$ be a Hexagonal fuzzy membership number, Then $AM(\mu_{\tilde{A}}) = \frac{a_1+a_2+a_3+a_4+a_5+a_6}{180}$

3.4 Definition (Relativity Function).

Let x and y be variables defined on a universal set$\times$. The relativity function is denoted as $f(x/y)$ and is defined as

$$f(x/y) = \frac{\mu_y(x)\,(-)\,\mu_x(y)}{\max\{\mu_y(x), \mu_x(y)\}}$$

Where$\mu_y(x)$ is the membership function of x with respect to y, $\mu_x(y)$ is the membership function of y with respect to x and max $\{\mu_y(x) - \mu_x(y)\}$ is maximum operation on Octagonal fuzzy number.

3.5 Definition (Comparison Matrix).

Let A = $\{x_1, x_2, x_3, \ldots, x_{i-1}, x_i, x_{i+1}, \ldots, x_n\}$ be a set of n variables defined on $\times$. Then form a matrix of relativity values $f\left(\frac{x_i}{x_j}\right)$,
where x_i's for i = 1 to n, are n variables defined on an universe$\times$.

The matrix C = (C_{ij}) is a square matrix of order n is called the comparison matrix

$$AM\,(f\,(xi/yj)) = \frac{AM\,(\mu_{xj}(x_i)\,(-)\,\mu_{xi}(x_j))}{AM\,(\max\{\mu_{xj}(x_i), \mu_{xi}(x_j)\})}$$

4. Working Rule

Step 1: We can find membership function for Hexagonal fuzzy number matrix by using relativity
function.
Step 2: We shall calculate all the relative values of the function.
Step 3: In the comparison matrix, the upper triangular part and lower triangular part are same
With opposite sign.
Step 4: In comparison matrix the maximum value in each row of the matrix will have the
maximum possibility for ranking purpose.

5. Numerical Examples

Suppose there are 3 patients P_1, P_2, P_3 in a hospital with possible symptoms relating to the diseases like cancer, jaundice and dengue which are represented by D_1, D_2, D_3. Here patient – disease fuzzy matrix can be represented as hexagonal fuzzy number matrix and a scale from 0 – 30.
The hexagonal fuzzy number matrix represents a patient-disease matrix form is given below

$$A = \begin{matrix} & D_1 & D_2 & D_3 \\ P_1 \\ P_2 \\ P_3 \end{matrix}$$

$$\begin{bmatrix} (20,16,10,4,18,30) & (4,6,12,16,20,26) \\ (2,6,12,16,22,26) \\ (8,10,16,20,26,30) & (6,8,14,20,28,30) \\ (4,8,14,18,24,28) \\ (2,8,12,18,24,26) & (8,10,16,22,26,28) \\ (0,0,2,4,16,16) \end{bmatrix}$$

Step 1:-

$(A)_{mem}$ =

$$\begin{bmatrix} (0.6,0.5,0.3,0.1,0.6,1) & (0.1,0.2,0.4,0.5,0.6,0.8) \\ (0.06,0.2,0.4,0.5,0.7,0.8) \\ (0.26,0.3,0.5,0.6,0.8,1) & (0.2,0.26,0.4,0.6,0.9,1) \\ (0.1,0.26,0.4,0.6,0.8,0.9) \\ (0.06,0.26,0.4,0.6,0.8,0.86) & (0.26,0.3,0.53,0.73,0.86,0.9) \\ (0,0,0.06,0.1,0.5,0.5) \end{bmatrix}$$

$$\mu_{P_1}(D_1) = (0.6,0.5,0.3,0.1,0.6,1)$$
$$\mu_{P_1}(D_2) = (0.1,0.2,0.4,0.5,0.6,0.8)$$

$\mu_{P_1}(D_3)$ = (0.06,0.2,0.4,0.5,0.7,0.8)
$\mu_{P_2}(D_1)$ = (0.26,0.3,0.5,0.6,0.8,1)
$\mu_{P_2}(D_2)$ = (0.2,0.26,0.4,0.6,0.9,1)
$\mu_{p_2}(D_3)$ = (0.1,0.26,0.4,0.6,0.8,0.9)
$\mu_{P_3}(D_1)$ = (0.06,0.26,0.4,0.6,0.8,0.86)
$\mu_{P_3}(D_2)$ = (0.26,0.3,0.53,0.73,0.86,0.9)
$\mu_{P_3}(D_3)$ = (0,0,0.06,0.1,0.5,0.5)

Step 2:-

$$f\left(\frac{P_1}{D_1}\right) = \frac{\mu_{D_1}(P_1)\,(-)\,\mu_{P_1}(D_1)}{\max\{\mu_{D_1}(P_1),\mu_{P_1}(D_1)\}}$$

=

$$\frac{(0.6,0.5,0.3,0.1,0.6,1)(-)(0.6,0.5,0.3,0.1,0.6,1)}{\max\{(0.6,0.5,0.3,0.1,0.6,1),(0.6,0.5,0.3,0.1,0.6,1)\}}$$

AM $(f(\frac{P_1}{D_1}))$ = 0
AM $(f(\frac{P_1}{D_2}))$ = 0.244
AM $(f(\frac{P_1}{D_3}))$ = 0.107
AM $(f(\frac{P_2}{D_1}))$ = -0.244
AM $(f(\frac{P_2}{D_2}))$ = 0
AM $(f(\frac{P_2}{D_3}))$ = 0.141
AM $(f(\frac{P_3}{D_1}))$ = -0.107
AM $(f(\frac{P_3}{D_2}))$ = -0.141
AM $(f(\frac{P_3}{D_3}))$ = 0

Step 3:-

The comparison matrix = AM $\left(f\left(\frac{P_i}{D_j}\right)\right)$ is given by

$$A = \begin{bmatrix} 0 & 0.244 & 0.107 \\ -0.244 & 0 & 0.141 \\ -0.107 & -0.141 & 0 \end{bmatrix}$$

Step 4:-
In Comparison matrix, Maximum of I^{st} row =0.244
Maximum of II^{nd} row =0.141
Maximum of III^{rd} row = 0
Here P_1 is affected by jaundice, P_2 is affected by dengue and P_3 is affected by jaundice

6. Conclusion

Fuzzy set framework has been utilized in several different approaches to model the medical diagnostic process and decision making process. From the above analysis it is obvious that, the patient P_1 is affected by jaundice, P_2 is affected by dengue and P_3 is affected by jaundice.. In this paper, we have applied the notion of Hexagonal fuzzy membership matrix in a medical diagnostic model. The advantage of this model is, if the patient-disease matrices are known, then it is possible to find which patient is suffering from what kind of disease.

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