An application of improved method of fuzzy matrix composition in medical diagnosis

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Abstract. In this paper, the Thangaraj and Mallika's approach for the application of fuzzy matrix is studied. Also, we introduce an improved method of fuzzy matrix composition in medical diagnosis. The validity of the improved method is established in comparison to Thangaraj and Mallika's approach using operation of fuzzy matrices. Finally, an application of the improved method to medical diagnosis is carried out by the operations of fuzzy matrices and the improved method. This improved method could be used to solve other decision making problems.
Keywords: fuzzy set, fuzzy matrix, fuzzy matrix composition, relativity function, comparative matrix.

1. Introduction

Theory of fuzzy set initiated by Zadeh [20] as a generalization of theory of crisp sets plays a vital role in the field of decision making. In classical set, an element a of a subset A of set X has its membership degree 0 or 1, that is; either belongs or does not belong to A. Albeit, a fuzzy subset A of a fuzzy set X has its own membership degree $\mu_A(a)$ in the unit interval $\mathbb{I} = [0, 1]$. In order words, a fuzzy subset A of X is characterized by the membership function $\mu_A(a),\ a \in X$.

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The notion of fuzzy matrices (FMs) proposed by Thomoson [18] is interesting and resourceful. FM is the generalization of classical matrices. In fact, every fuzzy matrix is a classical matrix but classical matrix may not necessarily be a fuzzy matrix [19]. The notion of fuzzy matrix (FM) has been extensively studied (see [3, 5, 9, 10, 15, 16] for details).

Fuzzy matrices have been applied to many fields such as appointment procedure, learning techniques, medical diagnosis, (see [4, 7, 8, 13] for details). The results show that fuzzy matrix theory produces effective solutions to various decision-making problems.

Sanchez [11] developed a technique for medical diagnosis as a fuzzy relation between symptoms and diseases. Elizabeth and Sujath [1] developed the technique of Sanchez for medical diagnosis using the representation of triangular fuzzy membership matrix. Geetha and Usha [2] established the application of fuzzy matrix in yoga on obesity using max-average composition method of fuzzy matrices. Sapre et.al [12] applied fuzzy matrix to study the medical diagnosis of diabetes, anaemia and hypertension. Thangaraji and Mallika [17] established the application of fuzzy matrices in medical diagnosis using comparison matrix.

In this paper, we study Thangaraj and Mallika's approach for the application of fuzzy matrix, and also introduce an improved method of fuzzy matrix composition in medical diagnosis. The same hypothetical medical database studied by Thangaraj and Mallika [17] was considered and we arrived at the same conclusion using our proposed method as was established in [17]. The paper is organized as follows; section 2 presents some preliminaries, basic definitions, some algebraic operations and types of fuzzy matrices. In section 3, the improved method of fuzzy matrix composition in medical diagnosis is presented. Section 4, gives the application of the improved method using the fuzzy matrices in [17]. The paper is concluded in section 5.

2. Preliminaries

This section gives some preliminaries, basic definitions, some algebraic operations and types of FMs.

Definition 2.1 ([17]). *A matrix $A = (a_{ij})_{r\times s}$, $i \in [1, r]$ and $j \in [1, s]$ of size $(r \times s)$ whose entries are closed unit interval $\mathbb{I} = [0, 1]$ is said to be a fuzzy matrix.*

Example 2.1. Let

$$A = \begin{bmatrix} 0.1 & 1.0 \\ 0.5 & 0.4 \\ 1.0 & 0.3 \end{bmatrix}.$$

Then, A is a (3×2)-fuzzy matrix.

Let $\mathbb{M}at_{r,s}(\mathbb{F})$ be the set of all (r, s)-fuzzy matrices.

Definition 2.2 ([6])**.** *Let* $A = \begin{bmatrix} a_1 & a_2 & \cdots & a_s \end{bmatrix} \in \mathbb{M}at_{1,s}(\mathbb{F})$ *be a FM of size* $(1 \times s)$*, then* A *is said to be a fuzzy row matrix.*

Example 2.2. If $A = \begin{pmatrix} 0.1 & 1.0 & 0.6 & 0.2 \end{pmatrix}$, then A is a (1×4)-fuzzy row matrix.

Definition 2.3 ([6])**.** *Let*

$$A = \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_r \end{bmatrix} \in \mathbb{M}_{r,1}(\mathbb{F})$$

be a FM of size $(r \times 1)$*. Then,* A *is called a fuzzy column matrix.*

Example 2.3. If

$$A = \begin{bmatrix} 0.3 \\ 0.1 \\ 0.2 \\ 1.0 \\ 0.0 \end{bmatrix}.$$

Then, A is a (5×1)-fuzzy column matrix.

Definition 2.4 ([17])**.** *Let* $A = (a_{ij}) \in \mathbb{M}at_{r,s}(\mathbb{F})$ *be a fuzzy matrix of order* $(r \times s)$*. Then, the fuzzy complement matrix of* A*, denoted by* A^c *is defined as* $A^c = (a_{ij})^c$*, where* $(a_{ij})^c = 1 - a_{ij}$*, for all* i, j*.*

Example 2.4. If

$$A = \begin{bmatrix} 0.1 & 1.0 \\ 0.5 & 0.4 \\ 1.0 & 0.3 \end{bmatrix}$$

then,

$$A^c = \begin{bmatrix} 0.9 & 0.0 \\ 0.5 & 0.6 \\ 0.0 & 0.7 \end{bmatrix}.$$

Definition 2.5 ([6])**.** *Let*

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1j} & \cdots & a_{1s} \\ a_{21} & a_{22} & \cdots & a_{2j} & \cdots & a_{2s} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{i1} & a_{i2} & \cdots & a_{ij} & \cdots & a_{is} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nj} & \cdots & a_{ss} \end{bmatrix} \in \mathbb{M}_{s,s}(\mathbb{F})$$

be a fuzzy matrix of order $(s \times s)$*. Then,* A *is called fuzzy square matrix.*

Example 2.5. Consider the fuzzy square matrix

$$A = \begin{bmatrix} 0.2 & 0.0 & 1.0 \\ 0.4 & 1.0 & 0.3 \\ 0.0 & 1.0 & 0.5 \end{bmatrix}.$$

Then, A is a fuzzy square matrix of order (3×3).

Definition 2.6 ([6]). *Let $A = (a_{ij}) \in \mathbb{M}at_{s,s}(\mathbb{F})$ be a fuzzy square matrix. Then, A is called a fuzzy diagonal matrix if $a_{ij} = 0$, where $i \neq j, a_{ij} \in [0,1]$.*

Example 2.6. A fuzzy square matrix

$$A = \begin{bmatrix} 0.2 & 0.0 & 0.0 & 0.0 \\ 0.0 & 1.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 0.3 & 0.0 \\ 0.0 & 0.0 & 0.0 & 0.1 \end{bmatrix}$$

is a fuzzy diagonal matrix of order (4×4).

Definition 2.7. *Two fuzzy matrices $A = (a_{ij}) \in \mathbb{M}at_{r,s}(\mathbb{F})$ and $B = (b_{ij}) \in \mathbb{M}at_{r,s}(\mathbb{F})$, of the same order are said to be equal if their corresponding entries are equal.*

Example 2.7. If $A = \begin{bmatrix} 1.0 & 0.2 & 0.4 \\ 0.0 & 0.3 & 1.0 \end{bmatrix}$ and $B = \begin{bmatrix} 1.0 & 0.2 & 0.4 \\ 0.0 & 0.3 & 1.0 \end{bmatrix}$. Then, $A = B$.

Definition 2.8 ([6]). *Let $A = (a_{ij}) \in \mathbb{M}at_{r,s}(\mathbb{F})$ and $B = (b_{ij}) \in \mathbb{M}at_{r,s}(\mathbb{F})$ be fuzzy matrices of order $(r \times s)$. Then, the sum of A and B, denoted by $A + B$ is defined as $A + B = Max(a_{ij}, b_{ij})$, for all $i \in [1,r]$, $j \in [1,s]$.*

Example 2.8. Let $A = \begin{bmatrix} 0.0 & 0.9 & 0.2 & 1.0 \\ 0.4 & 0.2 & 0.3 & 0.0 \\ 1.0 & 0.8 & 0.5 & 0.3 \end{bmatrix}$ and $B = \begin{bmatrix} 0.1 & 0.6 & 0.0 & 1.0 \\ 0.0 & 0.2 & 0.5 & 0.1 \\ 1.0 & 0.7 & 0.4 & 0.2 \end{bmatrix}$.

Then

$$A + B = \begin{bmatrix} 0.1 & 0.9 & 0.2 & 1.0 \\ 0.4 & 0.2 & 0.5 & 0.1 \\ 1.0 & 0.8 & 0.5 & 0.3 \end{bmatrix}.$$

Definition 2.9. *Let $A = (a_{ij}) \in \mathbb{M}at_{r,s}(\mathbb{F})$ and $B = (b_{ij}) \in \mathbb{M}at_{r,s}(\mathbb{F})$ be fuzzy matrices of order $(r \times s)$. Then, the matrix difference of A and B, denoted by $A - B$ is defined as $A - B = Min(a_{ij}, b_{ij})$, for all $[1,r]$, $j \in [1,s]$.*

Example 2.9. If $A = \begin{bmatrix} 0.0 & 0.9 & 0.2 & 1.0 \\ 0.4 & 0.2 & 0.3 & 0.0 \\ 1.0 & 0.8 & 0.5 & 0.3 \end{bmatrix}$ and $B = \begin{bmatrix} 0.1 & 0.6 & 0.0 & 1.0 \\ 0.0 & 0.2 & 0.5 & 0.1 \\ 1.0 & 0.7 & 0.4 & 0.2 \end{bmatrix}$.

Then,

$$A - B = \begin{bmatrix} 0.0 & 0.6 & 0.0 & 1.0 \\ 0.0 & 0.2 & 0.3 & 0.0 \\ 1.0 & 0.7 & 0.4 & 0.2 \end{bmatrix}.$$

Definition 2.10. *Let $A = (a_{ij}) \in \mathbb{M}at_{r,s}(\mathbb{F})$ and $B = (b_{jk}) \in \mathbb{M}_{s,p}(\mathbb{F})$ be FMs of orders $(r \times s)$ and $(s \times p)$, respectively. Then, the product of A and B, denoted by $A * B$ is defined as*

$$A * B = (c_{ik}) \in \mathbb{M}_{r,p}(\mathbb{F}),$$

where $(c_{ik}) = Max(a_{ij}, b_{jk})$, for all $i \in [1, r]$, $j \in [1, p]$.

Example 2.10. If $A = \begin{bmatrix} 0.0 & 0.9 & 0.2 & 1.0 \\ 0.4 & 0.2 & 0.3 & 0.0 \\ 1.0 & 0.8 & 0.5 & 0.3 \end{bmatrix}$ and $B = \begin{bmatrix} 0.1 & 0.6 \\ 0.0 & 1.0 \\ 0.0 & 0.2 \\ 0.5 & 0.1 \end{bmatrix}$.

Then

$$A * B = \begin{bmatrix} 0.50 & 0.90 \\ 0.04 & 0.24 \\ 0.15 & 0.80 \end{bmatrix}.$$

Definition 2.11 ([17])**.** *Let $A = (a_{ij}) \in \mathbb{M}at_{r,s}(\mathbb{F})$ and $B = (b_{jk}) \in \mathbb{M}at_{s,p}(\mathbb{F})$ be FMs of orders $(r \times s)$ and $(s \times p)$, respectively. Then, the fuzzy Max-i composition of A and B, denoted by $A \circ^i B$ is defined as*

$$A \circ^i B = \max -i[A(x, y), B(y, z)],$$

where i is a t-norm.

Example 2.11. Using matrices A and B in example above

$$A \circ^i B = \begin{bmatrix} 0.50 & 0.90 \\ 0.04 & 0.24 \\ 0.15 & 0.80 \end{bmatrix}.$$

Definition 2.12. *Let $A = (a_{ij}) \in \mathbb{M}at_{r,s}(\mathbb{F})$ and $B = (b_{jk}) \in \mathbb{M}at_{s,p}(\mathbb{F})$ be FMs of orders $(r \times s)$ and $(s \times p)$, respectively. Then, the improved method for fuzzy composition of A and B, denoted by $A@B$ is defined as*

$$A@B = \left\{ Max \left(\frac{\mu_A(a_{ij}) + \mu_B(b_{jk})}{2} \right) \right\},$$

for all $1 \leq i \leq r$, $1 \leq k \leq p$.

Example 2.12. Using matrices A and B in the Example (2.10)

$$A@B = \begin{bmatrix} 0.75 & 0.95 \\ 0.25 & 0.60 \\ 0.55 & 0.90 \end{bmatrix}.$$

Definition 2.13 ([17])**.** *Given variables a and b defined on a universal set X. Then, the relativity function, denoted by $f\left(\frac{a}{b}\right)$ is defined as*

$$f\left(\frac{a}{b}\right) = \frac{\mu_b(a) - \mu_a(b)}{\max\{\mu_b(a), \mu_a(b)\}},$$

where $\mu_b(a)$ represents the membership function of a with respect to b.

Definition 2.14 ([17]). *Let $A = \{a_1, \cdots, a_{i-1}, a_i, a_{i+1}, \cdots, a_n\}$ be a set of n variables defined on a universal set X. Form a matrix of relativity values $f(\frac{a_i}{b_i})$ where $a_i's, i = 1, \cdots, n$ are n variables defined on a universal set X. Then, the $R = (r_{ij})$, a square matrix of order n is called the comparison matrix with $f\left(\frac{a_i}{b_i}\right) = \mu_{a_j}(a_i)$.*

3. Improved method for fuzzy matrix composition in medical diagnosis

The concept of max-i composition for FMs was applied in [17]. Notwithstanding, an improved method for fuzzy matrix composition is introduced in this section.

Let $P = \{P_1, \cdots, P_i\}$ be the set of i patients, $S = \{S_1, \cdots, S_j\}$ be the set of j symptoms and $D = \{D_1, \cdots, D_k\}$ be the set of k diseases.

Construct a fuzzy set (σ, D) of order $(m \times n)$ over S, where $\sigma : D \to \mathcal{S}, \mathcal{S}$ is the power set of S. This set represents a matrix A named as symptom-disease fuzzy matrix.

Construct another fuzzy set (τ, S) of order $(m \times n)$ over P, where $\tau : S \to \mathcal{P}, \mathcal{P}$ is the power set of P. This set represents a matrix B named as patient-symptom fuzzy matrix.

Using Definition 2.4, obtain the fuzzy complement matrices A^c and B^c.

Compute $A\Phi B$ and $A'\Phi B'$ using Definition (2.12).

Calculate the relativity value $f\left(\frac{p_i}{d_i}\right)$ and form the comparison matrix $R = (r_{ij})_{m\times n} = \left[f\left(\frac{x_i}{y_i}\right)\right]_{i=1,2,3}$ using Definitions (2.13) and (2.14), respectively.

Then, select the highest number for each patient P_i in R. Hence, the conclusion is that the patient P_i suffers from disease D_j.

Procedure

The procedure are presented as follow:

1. Construct the fuzzy matrices A and B of the same order $(m \times n)$ corresponding to (σ, D) and (τ, S), respectively.

2. Form the complement matrices A^c and B^c of the same order $(m \times n)$ by Definition (2.4).

3. Compute the composition matrices $D = A@B$ and $E = A^c@B^c$ by Definition (2.12).

4. Compute the difference fuzzy matrix $C = D - E$, using Definition (2.9).

5. Calculate the relativity values $f\left(\frac{p_i}{d_i}\right)$ and form the comparison matrix $R = (r_{ij})_{m\times n} = \left[f\left(\frac{p_i}{d_i}\right)\right]_{i=1,2,3}$ using Definitions (2.13) and (2.14), respectively.

6. Identify the highest number for each patient P_i in R. Hence, the patient P_i suffers from disease D_j.

4. Case study

Suppose there are three patients $P = \{P_1, P_2, P_3\}$ where P_1, P_2, P_3 represent Jesse, Faith and Paul in a hospital with symptoms $S = \{S_1, S_2, S_3\}$ where S_1, S_2, S_3 represent high temperature, headache and cough. Let the possible diseases relating to S be $D = \{D_1, D_2, D_3\}$ where D_1, D_2, D_3 represent Dengue, Viral fever and Malaria.

Suppose that fuzzy set (σ, D) over S gives an approximate description of fuzzy medical knowledge of the diseases and their symptoms and fuzzy set (τ, S) over P give a collection of an approximate description of patient-symptoms in the hospital.

Let

$$(\sigma, D) = \begin{cases} \sigma(D_1) = \{(S_1, 0.5), (S_2, 0.6), (S_3, 0.4)\}, \\ \sigma(D_2) = \{(S_1, 0.2), (S_2, 0.7), (S_3, 0.3)\}, \\ \sigma(D_3) = \{(S_1, 0.6), (S_2, 0.4), (S_3, 0.7)\} \end{cases}$$

and

$$(\tau, S) = \begin{cases} \tau(S_1) = \{(P_1, 0.4), (P_2, 0.2), (P_3, 0.7)\}, \\ \tau(S_2) = \{(P_1, 0.3), (P_2, 0.6), (P_3, 0.9)\}, \\ \tau(S_3) = \{(P_1, 0.7), (P_2, 0.5), (P_3, 0.8)\}. \end{cases}$$

The two fuzzy sets (σ, D) and (τ, S) are represented by the following fuzzy matrices A and B, respectively.

$$A = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \end{array} \begin{array}{c} \begin{array}{ccc} D_1 & D_2 & D_3 \end{array} \\ \begin{bmatrix} 0.5 & 0.6 & 0.4 \\ 0.2 & 0.7 & 0.3 \\ 0.6 & 0.4 & 0.7 \end{bmatrix} \end{array}, \qquad B = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \end{array} \begin{array}{c} \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\ \begin{bmatrix} 0.4 & 0.2 & 0.7 \\ 0.3 & 0.6 & 0.9 \\ 0.7 & 0.5 & 0.8 \end{bmatrix} \end{array}$$

Note that the matrices A and B are from [17].

Then, the fuzzy complement matrices A^c and B^c are

$$A^c = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \end{array} \begin{array}{c} \begin{array}{ccc} D_1 & D_2 & D_3 \end{array} \\ \begin{bmatrix} 0.5 & 0.4 & 0.6 \\ 0.8 & 0.3 & 0.7 \\ 0.4 & 0.6 & 0.3 \end{bmatrix} \end{array}, \qquad B^c = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \end{array} \begin{array}{c} \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\ \begin{bmatrix} 0.6 & 0.8 & 0.3 \\ 0.7 & 0.4 & 0.1 \\ 0.3 & 0.5 & 0.2 \end{bmatrix} \end{array}$$

Compute the fuzzy matrices D and E using Definition (2.12)

$$D = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \end{array} \begin{array}{c} \begin{array}{ccc} D_1 & D_2 & D_3 \end{array} \\ \begin{bmatrix} 0.55 & 0.60 & 0.75 \\ 0.50 & 0.65 & 0.80 \\ 0.70 & 0.60 & 0.75 \end{bmatrix} \end{array}$$

$$E = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \end{array} \begin{array}{c} \begin{array}{ccc} D_1 & D_2 & D_3 \end{array} \\ \begin{bmatrix} 0.55 & 0.65 & 0.40 \\ 0.70 & 0.80 & 0.55 \\ 0.65 & 0.60 & 0.35 \end{bmatrix} \end{array}$$

Compute the fuzzy matrix C using Definition (2.9).

$$C = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \end{array} \begin{array}{c} \begin{array}{ccc} D_1 & D_2 & D_3 \end{array} \\ \begin{bmatrix} 0.55 & \mathbf{0.60} & 0.40 \\ 0.50 & \mathbf{0.65} & 0.55 \\ \mathbf{0.65} & 0.60 & 0.35 \end{bmatrix} \end{array}$$

Calculate the relativity values $f\left(\frac{p_i}{d_i}\right)$ and form the comparison matrix $R = (r_{ij})_{m\times n} = \left[f\left(\frac{p_i}{d_i}\right)\right]_{i=1,2,3}$ using Definitions (2.13) and (2.14), respectively

$$f\left(\frac{p_i}{d_i}\right) = \frac{\mu_{d_i}(p_i) - \mu_{p_i}(d_i)}{\max\{\mu_{d_i}(p_i), \mu_{p_i}(d_i)\}},$$

$$f\left(\frac{p_1}{d_1}\right) = \frac{\mu_{d_1}(p_1) - \mu_{p_1}(d_1)}{\max\{\mu_{d_1}(p_1), \mu_{p_1}(d_1)\}} = \frac{0.55 - 0.55}{\max(0.55, 0.55)} = \frac{0.00}{0.55} = 0.00,$$

$$f\left(\frac{p_1}{d_2}\right) = \frac{\mu_{d_2}(p_1) - \mu_{p_1}(d_2)}{\max\{\mu_{d_2}(p_1), \mu_{p_1}(d_2)\}} = \frac{0.60 - 0.50}{\max(0.60, 0.50)} = \frac{0.10}{0.60} = 0.16,$$

$$f\left(\frac{p_1}{d_3}\right) = \frac{\mu_{d_3}(p_1) - \mu_{p_1}(d_3)}{\max\{\mu_{d_3}(p_1), \mu_{p_1}(d_3)\}} = \frac{0.40 - 0.65}{\max(0.40, 0.65)} = \frac{-0.25}{0.65} = -0.38,$$

$$f\left(\frac{p_2}{d_1}\right) = \frac{\mu_{d_1}(p_2) - \mu_{p_2}(d_1)}{\max\{\mu_{d_1}(p_2), \mu_{p_2}(d_1)\}} = \frac{0.50 - 0.60}{\max(0.50, 0.60)} = \frac{-0.10}{0.60} = -0.16,$$

$$f\left(\frac{p_2}{d_2}\right) = \frac{\mu_{d_2}(p_2) - \mu_{p_2}(d_2)}{\max\{\mu_{d_2}(p_2), \mu_{p_2}(d_2)\}} = \frac{0.65 - 0.65}{\max(0.65, 0.65)} = \frac{0.00}{0.65} = 0.00,$$

$$f\left(\frac{p_2}{d_3}\right) = \frac{\mu_{d_3}(p_2) - \mu_{p_2}(d_3)}{\max\{\mu_{d_3}(p_2), \mu_{p_2}(d_3)\}} = \frac{0.55 - 0.60}{\max(0.55, 0.60)} = \frac{-0.05}{0.60} = -0.08,$$

$$f\left(\frac{p_3}{d_1}\right) = \frac{\mu_{d_1}(p_3) - \mu_{p_3}(d_1)}{\max\{\mu_{d_1}(p_3), \mu_{p_3}(d_1)\}} = \frac{0.65 - 0.40}{\max(0.65, 0.40)} = \frac{0.25}{0.65} = 0.38,$$

$$f\left(\frac{p_3}{d_2}\right) = \frac{\mu_{d_2}(p_3) - \mu_{p_3}(d_2)}{\{\max\{\mu_{d_2}(p_3), \mu_{p_3}(d_2)\}} = \frac{0.60 - 0.55}{\max(0.60, 0.55)} = \frac{0.05}{0.60} = 0.08,$$

$$f\left(\frac{p_3}{d_3}\right) = \frac{\mu_{d_3}(p_3) - \mu_{p_3}(d_3)}{\max\{\mu_{d_3}(p_3), \mu_{p_3}(d_3)\}} = \frac{0.35 - 0.35}{\max(0.35, 0.35)} = \frac{0.00}{0.35} = 0.00.$$

Hence, the comparison matrix R is

$$R = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \end{array} \begin{array}{c} \begin{array}{ccc} D_1 & D_2 & D_3 \end{array} \\ \begin{bmatrix} 0.00 & \mathbf{0.16} & -0.38 \\ -0.16 & \mathbf{0.00} & -0.08 \\ \mathbf{0.38} & 0.08 & 0.00 \end{bmatrix} \end{array}$$

We observe from matrices C and R that, patients Jesse and Faith (P_1 and P_2) are suffering from Viral fever (D_2) and patient Paul (P_3) is suffering from Dengue (D_1).

5. Conclusion

The theory of fuzzy matrices are interesting and useful. The studies have shown that, fuzzy matrix yields efficient solutions to various decision-making problems. In this paper, the Thangaraj and Mallika's [17] approach for medical diagnosis was studied and contribution was made to extend the approach. The same hypothetical medical database studied by Thangaraj and Mallika [17] was considered and we arrived at the same conclusion using our proposed method as was established in [17]. Albeit, our improved method of fuzzy matrix composition is more reliable in the sense that matrix C shows a greater relational value when compared to matrix M in [17]. Also, we can deduce from the comparison matrix R that, the potency of the immune systems of the patients were stronger in fighting against the potency of the diseases compare to comparison matrix R in [17]. Hence, the need for its application to other related problems can not be overemphasized since it is an effective tool for decision-making problems. Furthermore, the improved method put forward in this paper together with relativity function and comparison matrix could be adopted in solving other multi-criteria decision-making problems in medicine and other related discipline to get quick output in future work.

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