Neutrosophic Sets and Systems, Vol. 73, 2024
University of New Mexico

Improved Method of Interval valued neutrosophic matrix composition and Its Application in Medical Diagnosis

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Abstract. Neutrosophic sets are an important branch of topology that addresses issues with inconsistent, indeterminate, and uncertain situations in everyday life. Interval valued neutrosophic sets, known as subclasses of neutrosophic sets, have been specifically designed to address problems with a set of numbers in the real unit of interval rather than just a single number. Interval valued neutrosophic (IVN) matrix plays an influential role in decision making problems with indeterminant and inconsistent information. The objective of the paper is to discuss the concepts and operations of IVN matrix theory and propose a newly concept of an improved method of IVN matrix composition and apply it in the field of medical diagnosis. Finally, a decision-making algorithm based on IVN matrix composition has been proposed to solve problems with disease diagnosis from the manifestation of different symptoms in individuals and successfully applied in the field of medical diagnosis.

Keywords: Interval valued neutrosophic matrix, Interval valued neutrosophic matrix complement, improved method of Interval valued neutrosophic matrix composition.

1. Introduction

A common problem in various fields, including business, finance, engineering, health care and social sciences is uncertainty. Fuzzy sets[23], intuitionistic fuzzy sets[2] , neutrosophic sets[19], vague soft sets, Interval valued neutrosophic sets [22]are some approaches that can be used as mathematical tools to prevent concerns when handling ambiguous data. To make computations in operations on fuzzy sets easier Fuzzy matrix theory [21] was first introduced by Thomason, who described the convergence of powers of fuzzy matrix.

In 1999, Smarandache introduced a new theory so called the neutrosophic set [19] with three independent membership functions (truth (T), indeterminacy (I), and falsity (F)) to deal with indeterminate and inconsistent data that each range from zero and one. Neutrosophic set is a general framework that encompasses various concepts such as classical, fuzzy, interval valued, and intuitionistic fuzzy sets. In the year 2014, the neutrosophic matrix[8], which is a representation of the neutrosophic set, was firstly given by Kandasamy and Smarandache, and they also discussed the properties of square neutrosophic matrices and super neutrosophic matrices, quasi neutrosophic matrices. In 2004, The subclass of neutrosophic sets, the Interval valued neutrosophic sets[22] introduced and set theoretic operators and various properties of operators of Interval valued neutrosophic sets discussed by Wang, Praveen Madiraju, Yanqing Zhang, Rajshkhar Sunderraman. The relationship between the interval neutrosophic set and other sets is classical set $\subseteq$ Fuzzy set $\subseteq$ Intuitionistic fuzzy set $\subseteq$ Interval valued Intuitionistic fuzzy set $\subseteq$ Interval valued neutrosophic set. Therefore, interval valued neutrosophic sets represent the generalization of other sets. Using these concepts varies authors applied these concepts in decision making problems [1,4,6,9,11,21].

In 2021, Interval valued neutrosphic matrix [8] was first introduced by Faruk Karaaslan, Khizar Hayat, and Chiranjibe Jana. Also, the determinant and adjoint of the interval valued neutrosophic matrix defined and various properties related to the adjoint operator discussed. Based on [20] on improved method of interval valued neutrosophic composition method is proposed and applied in the field of medical diagnosis.

The article is organized as follows section 2 presents basic definitions, algebraic operations of interval valued neutrosophic matrix and section 3 presents the improved method of interval valued neutrosophic matrix composition in decision making problem with real time application. Section 4 gives conclusion of this research paper.

2. Preliminaries

Definition 2.1: Any matrix $\hat{A}$ in $M_{m\times n}$ is called an interval valued neutrosophic matrix (IVN Matrix in short) it can be written in the form $M_{m\times n}(J) = \left\{\left[\langle [T_{ij}^L, T_{ij}^U], [I_{ij}^L, I_{ij}^U], [F_{ij}^L, F_{ij}^U]\rangle\right]_{m\times n} : \langle [T_{ij}^L, T_{ij}^U], [I_{ij}^L, I_{ij}^U], [F_{ij}^L, F_{ij}^U]\rangle \in \mathrm{N(J)}\right\}$ where $\mathrm{J} = \mathrm{I}^2 \times \mathrm{I}^2 \times \mathrm{I}^2$.

Definition 2.2: Consider IVN Matrices $\hat{A} = [\langle [T_{A_{ij}}^L, T_{A_{ij}}^U], [I_{A_{ij}}^L, I_{A_{ij}}^U], [F_{A_{ij}}^L, F_{A_{ij}}^U]\rangle]_{m\times n}$ $\hat{B} = [\langle [T_{B_{ij}}^L, T_{B_{ij}}^U], [I_{B_{ij}}^L, I_{B_{ij}}^U], [F_{B_{ij}}^L, F_{B_{ij}}^U]\rangle]_{m\times n}$ and $\hat{C} = [\langle [T_{C_{ij}}^L, T_{C_{ij}}^U], [I_{C_{ij}}^L, I_{C_{ij}}^U], [F_{C_{ij}}^L, F_{C_{ij}}^U]\rangle]_{m\times n}$.

Then, addition between two IVN matrices $\hat{B}$ and $\hat{C}$ is denoted by $\hat{B} + \hat{C}$, whose truth membership, indeterminacy membership, and false membership functions are related to $\hat{B} + \hat{C}$ is defined as

$$\hat{B} + \hat{C} = \left[\langle \left[T_{B_{ij}}^L + T_{C_{ij}}^L,\ T_{B_{ij}}^U + T_{C_{ij}}^U\right],\ \left[I_{B_{ij}}^L + I_{C_{ij}}^L, I_{B_{ij}}^U + I_{C_{ij}}^U\right], \left[F_{B_{ij}}^L + F_{C_{ij}}^L, F_{B_{ij}}^U + F_{C_{ij}}^U\right]\rangle\right]$$

Where

$$T_{B_{ij}}^L + T_{C_{ij}}^L = T_{B_{ij}}^L \vee T_{C_{ij}}^L,\ T_{B_{ij}}^U + T_{C_{ij}}^U = T_{B_{ij}}^U \vee T_{C_{ij}}^U$$
$$I_{B_{ij}}^L + I_{C_{ij}}^L = I_{B_{ij}}^L \wedge I_{C_{ij}}^L,\quad I_{B_{ij}}^U + I_{C_{ij}}^U = I_{B_{ij}}^U \wedge I_{C_{ij}}^U$$
$$F_{B_{ij}}^L + F_{C_{ij}}^L = F_{B_{ij}}^L \wedge F_{C_{ij}}^L,\ F_{B_{ij}}^U + F_{C_{ij}}^U = F_{B_{ij}}^U \wedge F_{C_{ij}}^U.$$

Example: 2.3

$$\hat{A} = \begin{bmatrix} \langle [0.2,0.6],[0.2,0.3],[0.3,0.6]\rangle & \langle [0.5,0.8],[0.3,0.5],[0.4,0.6]\rangle & \langle [0.2,0.6],[0.4,0.5],[0.1,0.2]\rangle \\ \langle [0.2,0.6],[0.3,0.4],[0.5,0.6]\rangle & \langle [0.5,0.6],[0.1,0.3],[0.5,0.6]\rangle & \langle [0.1,0.4],[0.5,0.9],[0.1,0.5]\rangle \\ \langle [0.3,0.6],[0.3,0.5],[0.5,0.9]\rangle & \langle [0.2,0.7],[0.1,0.3],[0.3,0.5]\rangle & \langle [0.5,0.9],[0.2,0.3],[0.3,0.4]\rangle \end{bmatrix}$$

$$\hat{B} = \begin{bmatrix} \langle [0.2,0.3],[0.2,0.4],[0.4,0.8]\rangle & \langle [0.3,0.6],[0.2,0.4],[0.4,0.6]\rangle & \langle [0.3,0.6],[0.3,0.6],[0.3,0.6]\rangle \\ \langle [0.1,0.7],[0.3,0.5],[0.7,0.8]\rangle & \langle [0.2,0.4],[0.1,0.3],[0.3,0.6]\rangle & \langle [0.2,0.4],[0.4,0.6],[0.2,0.4]\rangle \\ \langle [0.4,0.6],[0.3,0.5],[0.6,0.9]\rangle & \langle [0.2,0.5],[0.1,0.2],[0.3,0.6]\rangle & \langle [0.2,0.3],[0.3,0.4],[0.2,0.3]\rangle \end{bmatrix}$$

$$\hat{A} + \hat{B} = \begin{bmatrix} \langle [0.2,0.6],[0.2,0.3],[0.3,0.6]\rangle & \langle [0.5,0.8],[0.3,0.5],[0.4,0.6]\rangle & \langle [0.2,0.6],[0.3,0.6],[0.1,0.2]\rangle \\ \langle [0.2,0.7],[0.3,0.4],[0.5,0.6]\rangle & \langle [0.5,0.6],[0.1,0.3],[0.3,0.6]\rangle & \langle [0.1,0.4],[0.4,0.6],[0.1,0.4]\rangle \\ \langle [0.4,0.6],[0.3,0.5],[0.5,0.9]\rangle & \langle [0.2,0.7],[0.1,0.2],[0.3,0.5]\rangle & \langle [0.5,0.9],[0.2,0.3],[0.2,0.3]\rangle \end{bmatrix}$$

Definition 2.4: For any two IVN matrices $\hat{A}$ and $\hat{B}$, the product operations between IVN matrices $\hat{A}$ and $\hat{B}$ denoted by $\hat{A}\hat{B}$, whose truth membership, indeterminacy membership, and false membership functions are related to $\hat{A}\hat{B}$ is defined as

$\hat{A}\hat{B} = [\langle [T^L_{AB_{ij}}, T^U_{AB_{ij}}], [I^L_{AB_{ij}}, I^U_{AB_{ij}}], [F^L_{AB_{ij}}, F^U_{AB_{ij}}] \rangle]_{m\times n}$ Where

$$T^L_{AB_{ij}} = \bigvee_{k=1}^{m} (T^L_{A_{ik}} \wedge T^L_{B_{kj}}), \qquad T^U_{AB_{ij}} = \bigvee_{k=1}^{m} (T^U_{A_{ik}} \wedge T^U_{B_{kj}})$$

$$I^L_{AB_{ij}} = \bigvee_{k=1}^{m} (I^L_{A_{ik}} \vee I^L_{B_{kj}}), \qquad I^U_{AB_{ij}} = \bigvee_{k=1}^{m} (I^U_{A_{ik}} \vee I^U_{B_{kj}})$$

$$F^L_{AB_{ij}} = \bigvee_{k=1}^{m} (F^L_{A_{ik}} \vee F^L_{B_{kj}}), \qquad F^U_{AB_{ij}} = \bigvee_{k=1}^{m} (F^U_{A_{ik}} \vee F^U_{B_{kj}}$$

Example: 2.5 For the above example 3.2 , the IVN Matrix $\hat{A}\hat{B}$ is given by

$$\hat{A}\hat{B} = \begin{bmatrix} \langle [0.2,0.6],[0.2,0.3],[0.3,0.6]\rangle & \langle [0.5,0.8],[0.3,0.5],[0.4,0.6]\rangle & \langle [0.2,0.6],[0.3,0.6],[0.1,0.2]\rangle \\ \langle [0.2,0.7],[0.3,0.4],[0.5,0.6]\rangle & \langle [0.5,0.6],[0.1,0.3],[0.3,0.6]\rangle & \langle [0.1,0.4],[0.4,0.6],[0.1,0.4]\rangle \\ \langle [0.4,0.6],[0.3,0.5],[0.5,0.9]\rangle & \langle [0.2,0.7],[0.1,0.2],[0.3,0.5]\rangle & \langle [0.5,0.9],[0.2,0.3],[0.2,0.3]\rangle \end{bmatrix}$$

Definition 2.6: For any two IVN matrices $\hat{A}$, the transpose of the IVN matrix $\hat{A}$ is denoted A^t , whose truth membership, indeterminacy membership, and false membership functions are related to $\hat{B} + \hat{C}$ is defined as $\hat{A}^t = [\langle [T^L_{A_{ji}}, T^U_{A_{ji}}], [I^L_{A_{ji}}, I^U_{A_{ji}}], [F^L_{A_{ji}}, F^U_{A_{ji}}] \rangle]_{m\times n}$.

Example: 2.7: For the above example 3.2, the IVN Matrix $\hat{A}^t$ is given by

$$\hat{A}^t = \begin{bmatrix} \langle [0.2,0.6],[0.2,0.3],[0.3,0.6]\rangle & \langle [0.5,0.8],[0.3,0.5],[0.4,0.6]\rangle & \langle [0.2,0.6],[0.3,0.6],[0.1,0.2]\rangle \\ \langle [0.2,0.7],[0.3,0.4],[0.5,0.6]\rangle & \langle [0.5,0.6],[0.1,0.3],[0.3,0.6]\rangle & \langle [0.1,0.4],[0.4,0.6],[0.1,0.4]\rangle \\ \langle [0.4,0.6],[0.3,0.5],[0.5,0.9]\rangle & \langle [0.2,0.7],[0.1,0.2],[0.3,0.5]\rangle & \langle [0.5,0.9],[0.2,0.3],[0.2,0.3]\rangle \end{bmatrix}$$

Definition 2.8: For any IVN matrix $\hat{A}$, the power of the IVN matrix $\hat{A}$, whose truth membership, indeterminacy membership, and false membership functions are related to $\hat{A}$ are defined as

$$\hat{A}^k = [\langle [T^L_{A_{ij}}{}^{(k)}, T^U_{A_{ij}}{}^{(k)}], [I^L_{A_{ij}}{}^{(k)}, I^U_{A_{ij}}{}^{(k)}], [F^L_{A_{ij}}{}^{(k)}, F^U_{A_{ij}}{}^{(k)}] \rangle] \ .$$

Definition 2.9: IVN-unit matrix is defined as $\hat{A}^0 = I = [\langle [T^L_{I_{ij}}, T^U_{I_{ij}}], [I^L_{I_{ij}}, I^U_{I_{ij}}], [F^L_{I_{ij}}, F^U_{I_{ij}}] \rangle]_{m\times n}$

where

$$\langle [T^L_{I_{ij}}, T^U_{I_{ij}}], [I^L_{I_{ij}}, I^U_{I_{ij}}], [F^L_{I_{ij}}, F^U_{I_{ij}}] \rangle = \begin{cases} \langle [1,1],[0,0],[0,0]\rangle, & i = j \\ \langle [0,0],[1,1],[1,1]\rangle, & i \neq j \end{cases}$$

Definition 2.10: For any two IVN matrices $\hat{A}$ and $\hat{B}$, the IVN matrix $\hat{B}$ is said to smaller than the IVN-matrix $\hat{B}$ denoted by $\hat{A} \leq \hat{B}$ and whose truth membership, indeterminacy membership, and false membership functions are defined as $\langle [T^L_{A_{ij}}, T^U_{A_{ij}}], [I^L_{A_{ij}}, I^U_{A_{ij}}], [F^L_{A_{ij}}, F^U_{A_{ij}}] \rangle \leq \langle [T^L_{B_{ij}}, T^U_{B_{ij}}], [I^L_{B_{ij}}, I^U_{B_{ij}}], [F^L_{B_{ij}}, F^U_{B_{ij}}] \rangle$ for all $1 \leq i \leq m, 1 \leq j \leq n$.

4. Some operations in IVN matrices:

Definition 3.1: Let$\hat{A} = [\langle [T^L_{A_{ij}}, T^U_{A_{ij}}], [I^L_{A_{ij}}, I^U_{A_{ij}}], [F^L_{A_{ij}}, F^U_{A_{ij}}] \rangle]_{m\times n}$

$\hat{B} = [\langle [T^L_{B_{ij}}, T^U_{B_{ij}}], [I^L_{B_{ij}}, I^U_{B_{ij}}], [F^L_{B_{ij}}, F^U_{B_{ij}}] \rangle]_{m\times n}$ and

$\hat{C} = [\langle [T^L_{C_{ij}}, T^U_{C_{ij}}], [I^L_{C_{ij}}, I^U_{C_{ij}}], [F^L_{C_{ij}}, F^U_{C_{ij}}] \rangle]_{m\times n}$ then IVN complement of a matrix $\hat{A}$ denoted by $\hat{A}^c$ whose truth membership, indeterminacy membership, and false membership functions are defined as $\hat{A}^c = [\langle [F^L_{A_{ij}}, F^U_{A_{ij}}], [1 - I^U_{A_{ij}}, 1 - I^L_{A_{ij}}], [T^L_{A_{ij}}, T^U_{A_{ij}}] \rangle]_{m\times n}$.

Example 3.2: Let $\hat{A}$ be a IVN Matrix defined by

$$\hat{A} = \begin{bmatrix} \langle[0.2,0.7],[0.1,0.2],[0.3,0.4]\rangle & \langle[0.3,0.7],[0.2,0.3],[0.4,0.5]\rangle & \langle[0.2,0.6],[0.4,0.5],[0.1,0.2]\rangle \\ \langle[0.1,0.6],[0.2,0.3],[0.4,0.5]\rangle & \langle[0.5,0.9],[0.1,0.2],[0.5,0.6]\rangle & \langle[0.1,0.4],[0.5,0.9],[0.1,0.5]\rangle \\ \langle[0.3,0.9],[0.2,0.6],[0.5,0.9]\rangle & \langle[0.2,0.6],[0.1,0.2],[0.3,0.4]\rangle & \langle[0.5,0.9],[0.2,0.3],[0.3,0.4]\rangle \end{bmatrix}$$

Then the Complement of IVN Matrix $\hat{A}$ is

$$\hat{A}^{C} = \begin{bmatrix} \langle[0.3,0.4],[0.8,0.9],[0.2,0.7]\rangle & \langle[0.4,0.5],[0.7,0.8],[0.3,0.7]\rangle & \langle[0.1,0.2],[0.5,0.6],[0.2,0.6]\rangle \\ \langle[0.4,0.5],[0.7,0.8],[0.1,0.6]\rangle & \langle[0.5,0.6],[0.8,0.9],[0.5,0.9]\rangle & \langle[0.1,0.5],[0.1,0.5],[0.1,0.4]\rangle \\ \langle[0.5,0.9],[0.4,0.8],[0.3,0.9]\rangle & \langle[0.3,0.4],[0.8,0.9],[0.2,0.6]\rangle & \langle[0.3,0.4],[0.7,0.8],[0.5,0.9]\rangle \end{bmatrix}$$

Definition 3.2: The difference of two IVN matrix $\hat{A}$ and $\hat{B}$ denoted by $\widehat{C} = \widehat{A} - \widehat{B}$ whose truth membership, indeterminacy membership, and false membership functions are defined as

$\widehat{C} = [\langle \left[T^L_{C_{ij}}, T^U_{C_{ij}}\right], \left[I^L_{C_{ij}}, I^U_{C_{ij}}\right], \left[F^L_{C_{ij}}, F^U_{C_{ij}}\right] \rangle]_{m\times n}$ where

$T^L_{C_{ij}} = \wedge[T^L_{A_{ij}}, T^L_{B_{ij}}]$, $T^U_{C_{ij}} = \wedge[T^U_{A_{ij}}, T^U_{B_{ij}}]$

$I^L_{C_{ij}} = \vee\,[I^L_{A_{ij}}, 1 - I^U_{B_{ij}}]$, $T^U_{C_{ij}} = \vee\,[I^U_{A_{ij}}, 1 - I^L_{B_{ij}}]$

$F^U_{C_{ij}} = \vee\,[F^L_{A_{ij}}, F^L_{B_{ij}}]$, $T^U_{C_{ij}} = \vee\,[F^U_{A_{ij}}, F^U_{B_{ij}}]$

Example 3.4: Consider the IVN Matrices $\hat{A}$ and $\hat{B}$

$$\hat{A} = \begin{bmatrix} \langle[0.45,0.80],[0.15,0.35],[0.1,0.20]\rangle & \langle[0.45,0.80],[0.15,0.30],[0.20,0.30]\rangle & \langle[0.55,0.85],[0.20,0.30],[0.15,0.25]\rangle \\ \langle[0.50,0.80],[0.2,0.40],[0.25,0.35]\rangle & \langle[0.50,0.80],[0.20,0.35],[0.25,0.45]\rangle & \langle[0.60,0.85],[0.25,0.35],[0.20,0.30]\rangle \\ \langle[0.60,0.80],[0.15,0.30],[0.15,0.30]\rangle & \langle[0.55,0.65],[0.10,0.25],[0.20,0.35]\rangle & \langle[0.60,0.75],[0.15,0.25],[0.15,0.25]\rangle \end{bmatrix}$$

6 exam level matrix B are givenexam level matrix B

$$\hat{B} = \begin{bmatrix} \langle[0.25,0.35],[0.50,0.60],[0.35,0.65]\rangle & \langle[0.30,0.45],[0.55,0.65],[0.35,0.55]\rangle & \langle[0.30,0.40],[0.60,0.70],[0.40,0.65]\rangle \\ \langle[0.30,0.40],[0.50,0.60],[0.40,0.75]\rangle & \langle[0.35,0.50],[0.55,0.65],[0.40,0.60]\rangle & \langle[0.35,0.45],[0.60,0.70],[0.50,0.70]\rangle \\ \langle[0.20,0.35],[0.60,0.70],[0.35,0.70]\rangle & \langle[0.25,0.45],[0.65,0.75],[0.35,0.70]\rangle & \langle[0.20,0.40],[0.70,0.80],[0.45,0.75]\rangle \end{bmatrix}$$

Then the difference $C = \widehat{A} - \widehat{B}$ is given by

$$\widehat{C} = \begin{bmatrix} \langle[0.25,0.35],[0.40,0.50],[0.35,0.65]\rangle & \langle[0.30,0.45],[0.35,0.65],[0.35,0.55]\rangle & \langle[0.30,0.40],[0.30,0.40],[0.40,0.65]\rangle \\ \langle[0.30,0.40],[0.40,0.50],[0.40,0.75]\rangle & \langle[0.35,0.50],[0.35,0.45],[0.40,0.60]\rangle & \langle[0.35,0.45],[0.40,0.30],[0.50,0.70]\rangle \\ \langle[0.20,0.35],[0.30,0.40],[0.35,0.70]\rangle & \langle[0.25,0.45],[0.25,0.35],[0.35,0.70]\rangle & \langle[0.20,0.40],[0.20,0.30],[0.45,0.75]\rangle \end{bmatrix}$$

Definition 3.5: Improved method of IVN matrix composition denoted by $A@B$ and defined as

$$A@B = \begin{cases} \bigvee_{k=1}^{m} \dfrac{T^L_{A_{ij}} + T^L_{B_{jk}}}{2}, \bigvee_{k=1}^{m} \dfrac{T^U_{A_{ij}} + T^U_{B_{jk}}}{2}, \\ \bigwedge_{k=1}^{m} \dfrac{I^L_{A_{ij}} + I^L_{B_{jk}}}{2}, \bigwedge_{k=1}^{m} \dfrac{I^U_{A_{ij}} + I^U_{B_{jk}}}{2}, \\ \bigwedge_{k=1}^{m} \dfrac{F^L_{A_{ij}} + F^L_{B_{jk}}}{2}, \bigwedge_{k=1}^{m} \dfrac{F^U_{A_{ij}} + F^U_{B_{jk}}}{2}, \end{cases}$$

Decision making algorithm using improved method of IVN matrix composition:

In this section, we put forward a decision making algorithm using IVN matrix composition.

Algorithm:

Step:1

Input the IVN matrix A (Patient-symptom Matrix)and B (Symptom –disease Matrix) of order $m \times n$.

Step:2

Write the complement of each of IVN Matrix A^c and B^c.

Step:3

Compute the IVN composition (Patient-symptom disease Matrix) matrix $C = A@B$ and(Patient-symptom non disease Matrix) $D = A^c@B^c$.

Step:4

compute score matrix

$$S(C,D) = \frac{\hat{C}+\hat{D}}{2} = \left[\left\langle \left[\frac{T^L_{B_{ij}}+T^L_{C_{ij}}}{2}, \frac{T^U_{B_{ij}}+T^U_{C_{ij}}}{2}\right] \left[\frac{I^L_{B_{ij}}+I^L_{C_{ij}}}{2}, \frac{I^U_{B_{ij}}+I^U_{C_{ij}}}{2}\right] \left[\frac{F^L_{B_{ij}}+F^L_{C_{ij}}}{2}, \frac{F^U_{B_{ij}}+F^U_{C_{ij}}}{2}\right] \right\rangle\right].$$

Convert Interval valued neutrosophic value into crisp value by using $\frac{4+T^L+T^U-I^L-I^U-F^L-F^U}{6}$-----(i).

Step:5

After calculating the patient P_i's maximum score, it is decided that the patient has the illness D_i.

Example: 3.6: Suppose three patients $P = \{P_1, P_2, P_3\}$ represents persons Arun, Ram, Atul with symptoms $P = \{P_1, P_2, P_3\}$ represents symptoms headache, temperature, body pain. Let the possible disease relate to their symptoms $D = \{D_1, D_2, D_3\}$ be viral fever, typoid, malaria.

Now, consider a collection of an approximate description of patient symptoms in the hospital as follows.

Let Patient-symptom relationship Matrix A is given by

$$A = \begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \end{array} \begin{array}{c} \begin{array}{ccc} S_1 & S_2 & S_3 \end{array} \\ \begin{bmatrix} \langle[0.3,0.7],[0.4,0.5],[0.1,0.2]\rangle & \langle[0.3,0.7],[0.1,0.2],[0.5,0.6]\rangle & \langle[0.2,0.6],[0.3,0.5],[0.3,0.7]\rangle \\ \langle[0.1,0.5],[0.3,0.7],[0.2,0.3]\rangle & \langle[0.6,0.8],[0.1,0.3],[0.1,0.2]\rangle & \langle[0.2,0.5],[0.5,0.6],[0.2,0.5]\rangle \\ \langle[0.5,0.8],[0.2,0.6],[0.3,0.5]\rangle & \langle[0.2,0.6],[0.1,0.5],[0.3,0.6]\rangle & \langle[0.7,0.9],[0.2,0.3],[0.1,0.2]\rangle \end{bmatrix} \end{array}$$

6 exam level matrix B are givenexam level matrix B are giv Symptom –disease Matrix B is given by

$$B = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \end{array} \begin{array}{c} \begin{array}{ccc} D_1 & D_2 & D_3 \end{array} \\ \begin{bmatrix} \langle[0.1,0.5],[0.3,0.5],[0.1,0.2]\rangle & \langle[0.1,0.5],[0.2,0.5],[0.5,0.6]\rangle & \langle[0.5,0.8],[0.1,0.2],[0.2,0.3]\rangle \\ \langle[0.1,0.4],[0.4,0.7],[0.8,0.9]\rangle & \langle[0.5,0.7],[0.1,0.2],[0.2,0.7]\rangle & \langle[0.8,0.9],[0.5,0.6],[0.3,0.8]\rangle \\ \langle[0.5,0.9],[0.1,0.5],[0.2,0.4]\rangle & \langle[0.3,0.8],[0.2,0.6],[0.3,0.4]\rangle & \langle[0.8,0.9],[0.1,0.2],[0.6,0.9]\rangle \end{bmatrix} \end{array}$$

The complement of the given IVN matrix A is given by

$$A^c = \begin{bmatrix} \langle[0.1,0.2],[0.5,0.6],[0.3,0.7]\rangle & \langle[0.5,0.6],[0.8,0.9],[0.3,0.7]\rangle & \langle[0.3,0.7],[0.5,0.7],[0.2,0.6]\rangle \\ \langle[0.2,0.3],[0.3,0.7],[0.1,0.5]\rangle & \langle[0.1,0.2],[0.7,0.9],[0.6,0.8]\rangle & \langle[0.2,0.5],[0.4,0.5],[0.2,0.5]\rangle \\ \langle[0.3,0.5],[0.4,0.8],[0.5,0.8]\rangle & \langle[0.3,0.6],[0.5,0.9],[0.2,0.6]\rangle & \langle[0.1,0.2],[0.7,0.8],[0.7,0.9]\rangle \end{bmatrix}$$

The complement of the given IVN matrix B is given by

$$B^c = \begin{bmatrix} \langle[0.1,0.2],[0.5,0.7],[0.1,0.3]\rangle & \langle[0.5,0.6],[0.5,0.8],[0.1,0.5]\rangle & \langle[0.2,0.3],[0.8,0.9],[0.5,0.8]\rangle \\ \langle[0.8,0.9],[0.3,0.6],[0.1,0.4]\rangle & \langle[0.2,0.7],[0.8,0.9],[0.5,0.7]\rangle & \langle[0.3,0.8],[0.4,0.5],[0.8,0.9]\rangle \\ \langle[0.2,0.4],[0.5,0.9],[0.5,0.9]\rangle & \langle[0.3,0.4],[0.4,0.8],[0.3,0.8]\rangle & \langle[0.6,0.9],[0.8,0.9],[0.8,0.9]\rangle \end{bmatrix}$$

The IVN Matrix $D = A^\circ B$ is Th

$$A^\circ B = \begin{bmatrix} \langle[0.35,0.75],[0.20,0.45],[0.10,0.20]\rangle & \langle[0.40,0.70],[0.10,0.20],[0.30,0.40]\rangle & \langle[0.55,0.80],[0.20,0.35],[0.15,0.25]\rangle \\ \langle[0.35,0.70],[0.25,0.50],[0.15,0.25]\rangle & \langle[0.55,0.75],[0.10,0.25],[0.15,0.40]\rangle & \langle[0.70,0.85],[0.20,0.40],[0.20,0.30]\rangle \\ \langle[0.60,0.90],[0.15,0.40],[0.15,0.30]\rangle & \langle[0.50,0.85],[0.10,0.35],[0.20,0.30]\rangle & \langle[0.75,0.90],[0.15,0.25],[0.25,0.40]\rangle \end{bmatrix}$$

The IVN Matrix $E = A^{c\circ} B^c$ is

$$E=\begin{bmatrix}\langle[0.65,0.75],[0.50,0.65],[0.20,0.55]\rangle & \langle[0.35,0.65],[0.50,0.70],[0.20,0.60]\rangle & \langle[0.45,0.80],[0.60,0.70],[0.40,0.75]\rangle\\ \langle[0.45,0.55],[0.40,0.70],[0.10,0.50]\rangle & \langle[0.35,0.45],[0.40,0.65],[0.10,0.50]\rangle & \langle[0.40,0.70],[0.55,0.70],[0.30,0.65]\rangle\\ \langle[0.55,0.75],[0.40,0.75],[0.15,0.50]\rangle & \langle[0.40,0.65],[0.45,0.80],[0.30,0.65]\rangle & \langle[0.35,0.55],[0.45,0.70],[0.50,0.75]\rangle\end{bmatrix}$$

FThe The

The score matrix $\mathrm{S(C,D)}$ is

$$\mathrm{S}=\begin{bmatrix}\langle[0.35,0.75],[0.50,0.65],[0.20,0.55]\rangle & \langle[0.35,0.65],[0.50,0.70],[0.30,0.60]\rangle & \langle[0.45,0.80],[0.60,0.70],[0.40,0.75]\rangle\\ \langle[0.45,0.55],[0.40,0.70],[0.10,0.50]\rangle & \langle[0.35,0.45],[0.40,0.65],[0.10,0.50]\rangle & \langle[0.40,0.70],[0.55,0.70],[0.30,0.65]\rangle\\ \langle[0.55,0.75],[0.40,0.75],[0.15,0.50]\rangle & \langle[0.40,0.65],[0.45,0.8],[0.30,0.65]\rangle & \langle[0.35,0.55],[0.45,0.7],[0.5,0.75]\rangle\end{bmatrix}$$

Ccccc

The conversion of IVN value into crisp value by using equation (i) gives

$$S(C,D)=\begin{array}{c} \\ P_1\\ P_2\\ P_3\end{array}\begin{array}{c}\begin{array}{ccc} D_1 & D_2 & D_3\end{array}\\ \begin{bmatrix}\mathbf{0.6125} & 0.5917 & 0.6000\\ 0.6 & 0.6083 & \mathbf{0.6125}\\ \mathbf{0.667} & 0.6042 & 0.5958\end{bmatrix}\end{array}$$

The above matrix indicates evident that the patients $\{P_1, P_3\}$ are suffering from the disease $\{D_1\}$ and $\{P_2\}$ is from $\{D_3\}$.

Conclusion

In this paper we have defined an improved IVN matrix composition method and successfully applied it in the field of medical diagnosis. Also, Interval valued neutrosophic matrix provides effective solutions to various decision-making issues and it can be applied to multi criteria decision making methods.

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Received: June 19, 2024. Accepted: August 12, 2024