Multi Interval Valued Fuzzy Soft Matrices And Its Application In Medical Diagnosis

[1]P.Rajarajeswari, [2]J.Vanitha
[1]*Assistant Professor of Mathematics,* [2]*Assistant Professor of Mathematics,*
[1]*Chikkanna Government Arts College, Tirupur, Tamilnadu, India*
[2]*RVS College of Education, Sulur, Coimbatore, Tamilnadu, India*

ABSTRACT: *In this paper, a new type of Matrix called Multi Interval valued Fuzzy Soft Matrix was introduced and studied some of their properties. Also some basic operations on these matrices are also studied. An application of Multi Interval Valued Fuzzy Soft Matrices in Medical diagnosis is illustrated with a numerical example.*

KeyWords: *Soft Set, Fuzzy Soft Set, Multi-Fuzzy Soft Set, Multi-Interval-Valued Fuzzy set*

1. INTRODUCTION

In 1965 Zadeh [13] introduced the concept of Fuzzy sets. As an extension of fuzzy sets, Atanassov ([1],[2]) introduced the concepts namely Interval Valued Fuzzy Sets, Intuitionistic Fuzzy Sets which consists of both the degree of membership and the degree of non membership .The concept of Soft set theory has been introduced by Molodtsor [8] in 1999. Interval Valued Fuzzy Soft sets were introduced by Yang et.al [12]. In 2010, Cagman et.al [5] represented the Soft sets in matrix form namely soft matrix. Interval Valued Fuzzy Soft matrices were studied by Rajarajeswari et.al [9]. Multi sets and Multi Fuzzy Sets were studied in [3,4] and [11]. Multi Interval valued fuzzy soft sets were introduced by Shawkat Alkhazaleh [10].

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2. Preliminaries

In this section we recall some definitions and properties required in this paper

Definition 2.1

An interval valued fuzzy set $\tilde{X}$ on a universe U is a mapping such that $\tilde{X}: U \rightarrow int([0,1])$, where $int([0,1])$ stands for the set of all closed subintervals of [0, 1], the set of all interval valued fuzzy sets on U is denoted by $\tilde{P}(U)$. Suppose that $\tilde{X} \in \tilde{P}(U), \forall x \in U$, $\mu_x(x) = [\mu_x^-(x), \mu_x^+(x)]$ Is called the degree of membership of an element x to X. $\mu_X^-(x)$ and $\mu_X^+(x)$ are referred to as the lower and upper degrees of membership of x to X where $0 \leq \mu_x^-(x) \leq \mu_x^+(x) \leq 1$.

Definition 2.2

Let U be an initial Universe Set and E be the set of parameters. Let A⊆E. A pair (F,A) is called Fuzzy Soft Set over U where F is a mapping given by F:A→ I^U , where I^U denotes the collection of all fuzzy subsets of U. An fuzzy soft set is a parameterized family of fuzzy subsets of Universe U.

Definition 2.3

Let U = $\{c_1, c_2, c_3, c_4, \ldots\ldots c_m\}$ be an Universal set and E be the set of parameters given by E=$\{e_e, e_2, e_3, e_4, \ldots\ldots e_m\}$. Let A⊆ E and (F,A) is a called Interval Valued Fuzzy Soft set over U, where F is a mapping given by F:A→ I^U , where I^U denotes the collection of all intervals valued fuzzy subsets of U. Then the Interval Valued Fuzzy Soft set can be expressed in matrix form as $\tilde{A} = (a_{ij})_{m\times n}$ or $\tilde{A} = (a_{ij})$, i=1,2,3,….m , j=1,2,3,…n.

$$\text{Where } a_{ij} = \begin{cases} [\mu_{jL}(c_i), \mu_{jU}(c_i)] (or) [\mu_{\tilde{A}L_{ij}}, \mu_{\tilde{A}U_{ij}}] & \text{if } e_j \in A \\ [0,0] & e_j \notin A \end{cases}$$

$[\mu_{jL}(c_i), \mu_{jU}(c_i)]$ represents the Interval Valued Fuzzy membership degree of object c_i in the Interval Valued Fuzzy set F(e_j) with the condition $0 \le \mu_{jL}(c_i) + \mu_{jU}(c_i) \le 1$.

If $\mu_{jL}(c_i) = \mu_{jU}(c_i)$ then the Interval Valued Fuzzy Soft Matrix reduces to Fuzzy Soft Matrix.

The set of all m× n Interval Valued Fuzzy Soft Matrices will be denoted by $IVFSM_{m\times n}$.

Definition 2.4

A pair (F, A) is called a Multi Interval valued fuzzy soft set of dimension K over U, where F is a mapping given by F : A → M^K Int(U), where M^K Int(U) denotes the collection of all multi interval valued fuzzy subsets of U with dimension k.

3. Multi-Interval valued Fuzzy soft Matrices

Definition 3.1

Let $U = \{C_1, C_2, \dots, C_m\}$ be an universal set and E be the set of parameters given by $E = \{e_1, e_2, \dots, e_n\}$. Let $A \subseteq E$ and (F,A) be an Multi Interval valued Fuzzy soft set over U where F is a mapping given by $F: A \to M^k Int(U)$ where $M^k Int(U)$ denotes the collection of all Multi Interval valued Fuzzy subsets of U. Then the Multi Interval valued Fuzzy soft set can be expressed in matrix form as $\tilde{A}^{(k)} = \left(a_{ij}^{(k)}\right)_{m\times n}$ (or) $\tilde{A}^{(k)} = (a_{ij}^{(k)}), i = 1,2,3,\dots,m,\ j = 1,2,3,\dots,n$ where each $a_{ij}{}^{(k)}$ is Multi Interval valued Fuzzy soft set with cardinality k. where

$$a_{ij}^{(k)} = \begin{cases} ([\mu_{jL}^k(C_i), \mu_{jU}^k(C_i)]) & ,if\ e_j \in A, \quad k = 1,2,\dots,k \\ ([0,0]) & ,if\ e_j \notin A \end{cases}$$

$[\mu_{jL}^k(C_i), \mu_{jU}^k(C_i)]$ Represents the Multi Interval valued Fuzzy membership degree of object C_i in the Multi Interval valued Fuzzy set $F(e_j)$ with the condition $0 \le \mu_{jL}^k(C_i) + \mu_{jU}^k(C_i) \le 1$, where k=1,2,…,p. The set of $m \times n$ Multi Interval valued Fuzzy soft Matrices will be denoted by $M^{(k)}\,IVFSM_{m\times n}$.

Example 3.2

Suppose that there are four houses under consideration, namely the universe $U = \{h_1, h_2, h_3, h_4\}$ and the parameter set $E = \{e_1, e_2, e_3, e_4\}$ where e_i stands for "beautiful", "large", "cheap" and "green surroundings" for i=1,2,3,4 respectively.

Consider the mapping F from the parameter set $A = \{e_1, e_2\} \subseteq E$ to the set of all Multi Interval valued Fuzzy subsets of power set U with cardinality 3. Let (F, A) be a Multi Interval valued Fuzzy soft set which describes the "attractiveness of houses" that is considering for purchase by the three family members. Therefore, Multi Interval valued Fuzzy soft set (F,A) is

$$(F,A) = F(e_1) = \{\frac{h_1}{([0.6,0.8],[0.5,0.6],[0.5,0.7])}, \frac{h_2}{([0.8,0.9],[0.7,0.8],[0.7,0.9])}, \frac{h_3}{([0.6,0.7],[0.5,0.6],[0.7,0.8])}, \frac{h_4}{([0.5,0.6],[0.4,0.5],[0.6,0.7])}\}$$

$$F(e_2) = \{\frac{h_1}{([0.7,0.8],[0.8,0.9],[0.6,0.7])}, \frac{h_2}{([0.6,0.7],[0.5,0.6],[0.7,0.8])}, \frac{h_3}{([0.5,0.7],[0.5,0.6],[0.6,0.7])}, \frac{h_4}{([0.8,0.9],[0.7,0.9],[0.6,0.8])}\}$$

The above Multi Interval valued Fuzzy soft set in matrix form as

$$\begin{matrix} h_1 \\ h_2 \\ h_3 \\ h_4 \end{matrix} \begin{pmatrix} \overset{e_1}{([0.6,0.8],[0.5,0.6],[0.5,0.7])} & \overset{e_2}{([0.7,0.8],[0.8,0.9],[0.6,0.7])} & \overset{e_3}{([0,0],[0,0],[0,0])} & \overset{e_4}{([0,0],[0,0],[0,0])} \\ ([0.8,0.9],[0.7,0.8],[0.7,0.9]) & ([0.6,0.7],[0.5,0.6],[0.7,0.8]) & ([0,0],[0,0],[0,0]) & ([0,0],[0,0],[0,0]) \\ ([0.6,0.7],[0.5,0.6],[0.7,0.8]) & ([0.5,0.7],[0.5,0.6],[0.6,0.7]) & ([0,0],[0,0],[0,0]) & ([0,0],[0,0],[0,0]) \\ ([0.5,0.6],[0.4,0.5],[0.6,0.7]) & ([0.8,0.9],[0.7,0.9],[0.6,0.8]) & ([0,0],[0,0],[0,0]) & ([0,0],[0,0],[0,0]) \end{pmatrix}$$

Definition 3.3

Let $\tilde{A}_{m\times n}{}^{(k)} = (a_{ij}^{(k)}) \in M^{(k)}IVFSM$, $\tilde{B}_{m\times n}{}^{(k)} = (b_{ij}^{(k)}) \in M^{(k)}IVFSM$ then $\tilde{A}^{(k)}$ is an Multi Interval valued Fuzzy soft sub Matrix of $\tilde{B}^{(k)}$, denoted by $\tilde{A}^{(k)} \subseteq \tilde{B}^{(k)}$ if $\mu_{\tilde{A}L_{ij}}^{(k)} \le \mu_{\tilde{B}L_{ij}}^{(k)}$ and $\mu_{\tilde{A}U_{ij}}^{(k)} \le \mu_{\tilde{B}U_{ij}}^{(k)}$ for all i and j and k.

Definition 3.5

A Multi Interval Valued Fuzzy Soft Matrix of order m ×n with cardinality is called Multi Internal Valued Fuzzy Soft Null (zero) Matrix if all its element are [0, 0]. It is denoted by $\tilde{\Phi}^{(k)}$.

Definition 3.6

An Multi Interval Valued Fuzzy Soft Matrix of order $m \times n$ with cardinality k is called Multi Interval Valued Fuzzy Soft Absolute Matrix if all its elements are [1,1]. It is denoted by $\tilde{I}^{(K)}$.

Definition 3.7

Let $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in MIVFSM$ where $a_{ij}^{(k)} = [\mu_{jL}^{(K)}(c_i), \mu_{jU}^{(k)}(c_i)]$ .Then $\tilde{A}^{(k)}$ is called Multi Interval Valued Fuzzy Soft row matrix if m=1. It means that the Universal set contains only one element (or) object.

Definition 3.8

Let $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in MIVFSM$ where $a_{ij}^{(k)} = [\mu_{jL}^{(K)}(c_i), \mu_{jU}^{(k)}(c_i)]$.Then $\tilde{A}^{(k)}$ is called Multi Interval Valued Fuzzy Soft column matrix if n=1. It means that the parameter set contains only one parameter.

Definition 3.9

Let $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in MIVFSM$ where $a_{ij}^{(k)} = [\mu_{jL}^{(K)}(c_i), \mu_{jU}^{(k)}(c_i)]$ .Then $\tilde{A}^{(k)}$ is called Multi Interval Valued Fuzzy Soft Rectangular matrix if $m \neq n$.

Definition 3.10

Let $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in M^{(k)}IVFSM$ where $a_{ij}^{(k)} = [\mu_{jL}^{(k)}(c_i), \mu_{jU}^{(k)}(c_i)]$. Then $\tilde{A}^{(k)}$ is called Multi Interval Valued Fuzzy Soft Square Matrix if $m = n$.

Definition 3.11

Let $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in MIVSFSM$ Where $a_{ij}^{(k)} = [\mu_{jL}^{(k)}(c_i), \mu_{jU}^{(k)}]$. Then $\tilde{A}^{(k)}$ is called Multi Interval valued Fuzzy Soft Diagonal Matrix if $m = n$ and if all the diagonal element of $\tilde{A}^{(k)}$ only exist all other elements are zero.

If all the diagonal elements of Multi Interval Valued Fuzzy Soft Diagonal Matrix are equal, then the matrix is called Multi Interval Valued Fuzzy Soft Scalar Matrix.

Definition 3.12

Let $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in MIVFSM$ where $a_{ij}^{(k)} = [\mu_{jL}^{(k)}(c_i), \mu_{jU}^{(k)}(c_i)]$. Then $\tilde{A}^{(k)}$ is called Multi Interval Valued Fuzzy Soft Upper Triangular Matrix if $m = n$ and if the all elements in the Diagonal and above the Diagonal only exists and other elements are zero.

Also $\tilde{A}^{(k)}$ is called Multi Interval Valued Fuzzy Soft Lower Triangular Matrix if $m = n$ if all the elements in the Diagonal and below the Diagonal only exists and other elements are zero.

A Multi Interval Valued Fuzzy Soft Matrix is said to be Triangular if it is either Multi Interval Valued Fuzzy Soft Lower Triangular Matrix or Multi Interval Valued Fuzzy Soft Upper Triangular Matrix.

Operation of Multi Interval Valued Fuzzy Soft Matrix:

In this section various operators of Multi Interval Valued Fuzzy Soft Matrix have been defined with examples.

Definition 3.13

If $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in M^{(k)}$ IVFSM where $a_{ij}^{(k)} = \left[\tilde{\mu}_{\tilde{A}L_{ij}}^{(k)}, \mu_{\tilde{A}U_{ij}}^{(k)}\right]$ and $\tilde{B} = (b_{ij}^{(k)})_{m\times n} \in M^{(k)}$ IVFSM where $b_{ij}^{(k)} = \left[\mu_{\tilde{B}L_{ij}}^{(k)}, \mu_{\tilde{B}U_{ij}}^{(k)}\right]$ then it is defined $\tilde{A}^{(k)} + \tilde{B}^{(k)} = (C_{ij}^{(k)})_{m\times n} = \left(\left[\max\left(\mu_{\tilde{A}L_{ij}}^{(k)}, \mu_{\tilde{B}L_{ij}}^{(k)}\right), \max\left(\tilde{\mu}_{\tilde{A}U_{ij}}^{(k)}, \mu_{\tilde{B}U_{ij}}^{(k)}\right)\right]\right)$ *for all i, j and k*

$\tilde{A}^{(k)} - \tilde{B}^{(k)} = (C_{ij}^{(k)})_{m\times n} = \left(\left[\min\left(\mu_{\tilde{A}L_{ij}}^{(k)}, \mu_{\tilde{B}L_{ij}}^{(k)}\right), \min\left(\tilde{\mu}_{\tilde{A}U_{ij}}^{(k)}, \mu_{\tilde{B}U_{ij}}^{(k)}\right)\right]\right)$

Example 3.14

$$\tilde{A}^{(k)} = \begin{pmatrix} ([0.6,0.8],[0.5,0.6]) & ([0.7,0.8],[0.6,0.7]) \\ ([0.8,0.9],[0.7,0.9]) & ([0.6,0.7],[0.5,0.6]) \end{pmatrix} \quad \tilde{B}^{(k)} = \begin{pmatrix} ([0.6,0.7],[0.5,0.8]) & ([0.5,0.7],[0.5,0.7]) \\ ([0.5,0.6],[0.6,0.7]) & ([0.8,0.9],[0.7,0.9]) \end{pmatrix}$$

$$\tilde{A}^{(k)} + \tilde{B}^{(k)} = \begin{pmatrix} ([0.6,0.8],[0.5,0.8]) & ([0.7,0.8],[0.6,0.7]) \\ ([0.8,0.9],[0.7,0.9]) & ([0.8,0.9],[0.7,0.9]) \end{pmatrix}$$

$$\tilde{A}^{(k)} - \tilde{B}^{(k)} = \begin{pmatrix} ([0.6,0.7],[0.5,0.6]) & ([0.5,0.7],[0.5,0.6]) \\ ([0.5,0.6],[0.6,0.7]) & ([0.6,0.7],[0.5,0.6]) \end{pmatrix}$$

Definition 3.15

If $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in M^{(k)}$ IVFSM and $\tilde{B}^{(k)} = (b_{ij}^{(k)})_{m\times n} \in M^{(k)}$ IVFSM then the multiplication of $\tilde{A}^{(k)}$ and $\tilde{B}^{(k)}$ is defined as $\tilde{A}^{(k)} * \tilde{B}^{(k)} = (C_{ij}^{(k)})_{m\times p} = \left(\left[\max\ \min\left(\mu_{\tilde{A}L_{ij}}^{(k)}, \mu_{\tilde{B}L_{ij}}^{(k)}\right), \max\ \min\left(\tilde{\mu}_{\tilde{A}U_{ij}}^{(k)}, \mu_{\tilde{B}U_{ij}}^{(k)}\right)\right]\right)$

for all i, j, k and s.

If the above example

$$\tilde{A}^{(k)} * \tilde{B}^{(k)} = \begin{pmatrix} ([0.6,0.7],[0.6,0.7]) & ([0.7,0.8],[0.6,0.7]) \\ ([0.6,0.7],[0.5,0.8]) & ([0.6,0.7],[0.5,0.6]) \end{pmatrix}$$

Remark 3.16

In general $\tilde{A}^{(k)} * \tilde{B}^{(k)} \neq \tilde{B}^{(k)} * \tilde{A}^{(k)}$

Definition 3.17

If $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in M^{(k)}$ IVFSM then arithmetic mean of Multi Interval Valued Fuzzy Soft Matrix $\tilde{A}^{(k)}$ as

$$\tilde{A}_{AM}^{(k)} = (c_{ij}^{(k)})_{m\times n} = \left(\frac{\sum_{k=1}^{p} (\mu_{\hat{A}L_{ij}}^{(k)} + \mu_{\hat{A}U_{ij}}^{(k)})}{2k} \right)$$

Proposition 3.18

(i). $\tilde{A}^{(k)} \subseteq \tilde{B}^{(k)} \Rightarrow \tilde{A}^{(k)} + \tilde{B}^{(k)} = \tilde{B}^{(k)}$ $\quad (ii)$. $\tilde{A}^{(k)} + \tilde{\phi}^{(k)} = \tilde{A}^{(k)}$ (Identity law)

(iii). $\tilde{A}^{(k)} + \tilde{I}^{(k)} = \tilde{I}^{(k)}$ (Domination law) $\quad (iv)$. $\tilde{A}^{(k)} + \tilde{A}^{(k)} = \tilde{A}^{(k)}$ (Idempotent law)

(v). $\tilde{A}^{(k)} + \tilde{B}^{(k)} = \tilde{B}^{(k)} + \tilde{A}^{(k)}$ (Commutative Law)

(vi). $(\tilde{A}^{(k)} + \tilde{B}^{(k)}) + \tilde{C}^{(k)} = \tilde{A}^{(k)} + (\tilde{B}^{(k)} + \tilde{C}^{(k)})$ (Associative law)

Proof: Can be easily verified.

Definition 3.19

Let $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in M^{(k)}$ *IVFSM* where $a_{ij}^{(k)} = [\mu_{jL}^{(k)}(c_i), \mu_{jU}^{(k)}(c_i)]$ then $\tilde{A}^{T(k)}$ is Multi Interval Valued Fuzzy Soft Transpose Matrix of $\tilde{A}^{(k)}$ if $\tilde{A}^{T(k)} = (a_{ji}^{(k)})$ $i = 1,2,3, \ldots m,\ j = 1,2, \ldots .n$

$\tilde{A}^{T(k)} = (a_{ji}^{(k)})_{n\times m} \in M^{(k)}$ IVFSM.

Example: $\tilde{A}^{(k)} = \begin{pmatrix} ([0.6,0.8],[0.5,0.7]) & ([0.7,0.8],[0.6,0.7]) \\ ([0.8,0.9],[0.7,0.8]) & ([0.6,0.8],[0.8,0.9]) \end{pmatrix}$

Then, $\tilde{A}^{T(k)} = \begin{pmatrix} ([0.6,0.8],[0.5,0.7]) & ([0.8,0.9],[0.7,0.8]) \\ ([0.7,0.8],[0.6,0.7]) & ([0.6,0.8],[0.8,0.9]) \end{pmatrix}$

Definition 3.20

Let $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in M^{(k)} IVFSM$ where $a_{ij}^{(k)} = [\mu_{jL}^{(k)}(c_i), \mu_{jU}^{(k)}(c_i)]$ then $\tilde{A}^{(k)}$ is called an Multi Interval Valued Fuzzy Soft symmetric Matrix if $\tilde{A}^{(k)} = \tilde{A}^{T(k)}$,

If $(a_{ij}^{(k)})_{m\times n} = (a_{ji}^{(k)})_{n\times m}$ *for all i, j.*

Definition 3.21

Let $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in MIVFSM$ where $a_{ij}^{(k)} = \left[\mu_{jL}^{(K)}(c_i), \mu_{jU}^{(k)}(c_i)\right]$ .Then $\tilde{A}^{c(k)}$ is called Multi Interval Valued Fuzzy Soft Complement matrix if $\tilde{A}^{c(k)} = (b_{ij}^{(k)})_{m\times n}$

Where $b_{ij}^{(k)} = \left[1-\mu_{jU}^{(k)}(c_i), 1-\mu_{jL}^{(k)}(c_i)\right]$ *for all i, j and k*

Example 3.22

Let

$\tilde{A}^{(2)} = \begin{pmatrix} ([0.6,0.8],[0.4,0.5]) & ([0.7,0.8],[0.6,0.7]) \\ ([0.5,0.6],[0.6,0.7]) & ([0.7,0.9],[0.7,0.8]) \end{pmatrix}$

$\tilde{A}^{C(2)} = \begin{pmatrix} ([0.2,0.4],[0.5,0.6]) & ([0.2,0.3],[0.3,0.4]) \\ ([0.4,0.5],[0.4,0.7]) & ([0.1,0.3],[0.2,0.3]) \end{pmatrix}$

Proposition 3.23

Let $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in MIVFSM$

Then

(i) $\left(\tilde{A}^{C(k)}\right)^C = \tilde{A}^{(k)}$

(ii) $\tilde{\Phi}^{C(k)} = \tilde{I}^{(k)}$

(iii) $\tilde{I}^{C(k)} = \tilde{\Phi}^{(k)}$

(iv) $\left(\tilde{A}^{(k)} + \tilde{I}^{(k)}\right)^C = \tilde{\Phi}^{(k)}$

(v) $\left(\tilde{A}^{(k)} + \tilde{B}^{(k)}\right)^C = \left(\tilde{B}^{(k)} + \tilde{A}^{(k)}\right)^C$

(vi) $\left(\tilde{A}^{(k)} + \tilde{B}^{(k)} + \tilde{C}^{(k)}\right)^C = \left(\tilde{C}^{(k)} + \tilde{B}^{(k)} + \tilde{A}^{(k)}\right)^C$

(vii) $\left(\tilde{A}^{C(k)}\right)^T = \left(\tilde{A}^{T(k)}\right)^C$

(viii) $\left(\tilde{A}^{C(k)} + \tilde{B}^{C(k)}\right)^T = \left(\tilde{A}^{C(k)}\right)^T + \left(\tilde{B}^{C(k)}\right)^T$

Remark 3.24

Let $\tilde{A}^{(k)} = (a_{ij}^{(k)})_{m\times n} \in$ MIVFSM, $\tilde{B} = (b_{ij}^{(k)})_{m\times n} \in$ MIVFSM and $\tilde{C}^{(k)} = (C_{ij}^{(k)})_{m\times n} \in$ MIVFSM

Then in general

(i) $\left(\tilde{A}^{(k)} + \tilde{B}^{(k)}\right)^C \neq \left(\tilde{A}^{C(k)}\right) + \left(\tilde{B}^{C(k)}\right)$

(ii) $\left(\tilde{A}^{(k)} + \tilde{B}^{(k)} + \tilde{C}^{(k)}\right)^C \neq \left(\tilde{A}^{C(k)}\right) + \left(\tilde{B}^{C(k)}\right) + \left(\tilde{C}^{C(k)}\right)$

4. Application of Multi Interval Valued Fuzzy Soft Matrix in Medical Diagnosis

Multi Interval Valued Fuzzy Soft Matrix can be applied in Medical Diagnosis to identify which patient was affected by which disease which can be illustrated by the following numerical example.

Suppose there are three patients in a hospital with symptoms temperature, headache, couch and stomach problem. Let the possible diseases related to the above symptoms be viral fever and malaria. Now take $P = \{p_1, p_2, p_3\}$ as the universal set where $p_1, p_2, and\ p_3$ represents patients. Let $S = \{s_1, s_2, s_3, s_4\}$ as the set of symptoms where $s_1, s_2, s_3\ and\ s_4$ represents symptoms temperature, headache, couch and stomach problem respectively.

For each patient the data is collected twice within a day. Suppose the Multi Interval Valued Fuzzy Soft set (G, S) over P, gives a collection of approximate described of patient symptoms in the hospital. It is represented in the following Multi Interval Valued Fuzzy Soft Matrix as

$$\widetilde{R}_S^{(2)} = \begin{array}{c} \\ p_1 \\ p_2 \\ p_3 \end{array} \begin{pmatrix} S_1 & S_2 & S_3 & S_4 \\ ([0.6,0.9],[0.6,0.8]) & ([0.3,0.5],[0.3,0.4]) & ([0.8,\ 1],[0.8,0.9]) & ([0.6,0.9],[0.6,0.8]) \\ ([0.3,0.5],[0.3,0.4]) & ([0.3,0.7],[0.3,0.5]) & ([0.2,0.4],[0.2,0.3]) & ([0.3,0.5],[0.3,0.4]) \\ ([0.6,0.8],[0.6,0.7]) & ([0.2,0.6],[0.3,0.5]) & ([0.5,0.7],[0.5,0.6]) & ([0.2,0.5],[0.3,0.4]) \end{pmatrix}$$

Next consider the set $S = \{s_1, s_2, s_3, s_4\}$ as universal set where $s_1, s_2, s_3\ and\ s_4$ represents symptoms temperature, headache, couch and stomach problem respectively and the set

$D = \{d_1, d_2,\}$ where $d_1\ and\ d_2$ represent the disease viral fever and malaria respectively.

Suppose that Multi Interval Valued Fuzzy Soft set (F, D) over S, gives an approximate description of Multi Interval Valued Fuzzy Soft Medical knowledge of the two disease and their symptoms. It can be represented in the following Multi Interval Valued Fuzzy Soft Matrix

$$\widetilde{R}_0^{(2)} = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \end{array} \begin{pmatrix} d_1 & d_2 \\ ([0.7,1],[0.8,1]) & ([0.6,0.9],[0.6,0.8]) \\ ([0.1,0.4],[0.2,0.4]) & ([0.4,0.6],[0.5,0.6]) \\ ([0.5,0.6],[0.4,0.6]) & ([0.3,0.6],[0.4,0.6]) \\ ([0.3,0.4],[0.3,0.4]) & ([0.8,1],[0.8,1]) \end{pmatrix}$$

$$\widetilde{R}_1^{(2)} = \widetilde{R}_S^{(2)} * \widetilde{R}_0^{(2)} = \begin{array}{c} \\ p_1 \\ p_2 \\ p_3 \end{array} \begin{pmatrix} d_1 & d_2 \\ ([0.6,0.9],[0.6,0.8]) & ([0.6,0.9],[0.6,0.8]) \\ ([0.3,0.5],[0.3,0.4]) & ([0.3,0.6],[0.3,0.5]) \\ ([0.6,0.9],[0.6,0.8]) & ([0.6,0.8],[0.6,0.7]) \end{pmatrix}$$

$$\widetilde{R}_S^{C(2)} = \begin{array}{c} \\ p_1 \\ p_2 \\ p_3 \end{array} \begin{pmatrix} S_1 & S_2 & S_3 & S_4 \\ ([0.1,0.4],[0.2,0.4]) & ([0.5,0.7],[0.6,0.7]) & ([0,0.2],[0.1,0.2]) & ([0.1,0.4],[0.2,0.4]) \\ ([0.5,0.7],[0.6,0.7]) & ([0.3,0.7],[0.5,0.7]) & ([0.6,0.8],[0.7,0.8]) & ([0.5,0.7],[0.6,0.7]) \\ ([0.2,0.4],[0.3,0.4]) & ([0.4,0.8],[0.5,0.7]) & ([0.3,0.5],[0.4,0.5]) & ([0.5,0.8],[0.6,0.7]) \end{pmatrix}$$

$$\widetilde{R}_0^{C(2)} = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \end{array} \begin{pmatrix} d_1 & d_2 \\ ([0,0.3],[0,0.2]) & ([0.1,0.4],[0.2,0.4]) \\ ([0.6,0.9],[0.6,0.8]) & ([0.4,0.6],[0.4,0.5]) \\ ([0.4,0.5],[0.4,0.6]) & ([0.4,0.7],[0.4,0.6]) \\ ([0.6,0.8],[0.6,0.7]) & ([0,0.2],[0,0.2]) \end{pmatrix}$$

$$\widetilde{R}_2^{(2)} = \widetilde{R}_S^{(2)} * \widetilde{R}_0^{(2)} = \begin{array}{c} \\ p_1 \\ p_2 \\ p_3 \end{array} \begin{pmatrix} d_1 & d_2 \\ ([0.6,0.8],[0.6,0.7]) & ([0.4,0.7],[0.4,0.6]) \\ ([0.3,0.7],[0.3,0.5]) & ([0.3,0.6],[0.3,0.5]) \\ ([0.4,0.6],[0.4,0.6]) & ([0.4,0.7],[0.4,0.6]) \end{pmatrix}$$

$$\widetilde{R}_3^{(2)} = \widetilde{R}_S^{(2)} * \widetilde{R}_0^{(2)} = \begin{array}{c} \\ p_1 \\ p_2 \\ p_3 \end{array} \begin{pmatrix} d_1 & d_2 \\ ([0.1,0.4],[0.2,0.4]) & ([0.4,0.6],[0.5,0.6]) \\ ([0.5,0.7],[0.6,0.7]) & ([0.5,0.7],[0.6,0.7]) \\ ([0.3,0.5],[0.4,0.5]) & ([0.5,0.8],[0.5,0.7]) \end{pmatrix}$$

$$\widetilde{R}_4^{(2)} = \widetilde{R}_2^{(2)} * \widetilde{R}_3^{(2)} = \begin{array}{c} \\ p_1 \\ p_2 \\ p_3 \end{array} \begin{pmatrix} d_1 & d_2 \\ ([0.6,0.8],[0.6,0.7]) & ([0.4,0.7],[0.5,0.6]) \\ ([0.5,0.7],[0.6,0.7]) & ([0.5,0.7],[0.6,0.7]) \\ ([0.4,0.6],[0.4,0.6]) & ([0.5,0.8],[0.5,0.7]) \end{pmatrix}$$

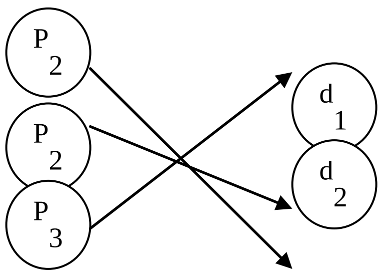
$$\widetilde{R}_{1AM} = \begin{matrix} p_1 \\ p_2 \\ p_3 \end{matrix} \begin{pmatrix} d_1 & d_2 \\ 0.725 & 0.725 \\ 0.375 & 0.475 \\ 0.675 & 0.675 \end{pmatrix}$$

$$\widetilde{R}_{4AM} = \begin{matrix} p_1 \\ p_2 \\ p_3 \end{matrix} \begin{pmatrix} d_1 & d_2 \\ 0.675 & 0.55 \\ 0.625 & 0.625 \\ 0.5 & 0.625 \end{pmatrix}$$

If the matrix $\widetilde{R}_1^{(2)}$ have maximum membership ([1, 1], [1, 1]) Then we can easily confirm the disease d for the patient p. But this is not the case for any of three patients.

Therefore in the illustrative example, acceptable diagnostic hypothesis by using at which (p_j, d_j) $\overset{Max}{\underset{i,j}{}} \widetilde{R}_{1AM}$ with $\overset{Min}{\underset{i,j}{}} \widetilde{R}_{4AM}$ *for all i* occurs.

In $\widetilde{R}_{1AM}$ the first patient has maximum membership both the disease, but $\widetilde{R}_{4AM}$ minimum is for second disease. Therefore P_1 was affected by d_1. Similarly P_2 is also affected by d_2 and p_3 was affected by d_1.
This can be represented in the form of a graph namely network as follows



In this network, the edges denote the strong confirmation of disease to the patient.
i.e., the patients P_1 and P_2 are suffering from the disease d_2 where as P_3 is suffering from d_1 (viral fever).

Conclusion:

In this paper we have defined a new type of Matrix called Multi Interval valued Fuzzy Soft Matrix and studied some of their properties. Also some basic operations on these matrices are also studied. An application of Multi Interval Valued Fuzzy Soft Matrices in Medical diagnosis is illustrated with a numerical example.

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