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AN APPLICATION OF EXTENDED NOTION OF SIMILARITY OF GENERALIZED FUZZY SOFT SETS IN MEDICAL DIAGNOSIS

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ABSTRACT

The purpose of this paper is to apply the extended notion of similarity between two generalized fuzzy soft sets in a decision problem. A comparative study has been done with the earlier works of Majumder and Samanta.

Keywords: *Soft set, Fuzzy soft set, Generalized Fuzzy Soft Set, Similarity between two generalized fuzzy soft sets.*

1. INTRODUCTION

Zadeh [**13**] initiated the concept of fuzzy sets in 1965 which is considered as generalization of classical or crisp sets. In the Zadehian definition, it has been accepted that the classical set theoretic axioms of exclusion and contradiction are not satisfied. In this regard, Baruah [**2, 3**] proposed that two functions, namely fuzzy membership function and fuzzy reference function are necessary to represent a fuzzy set. Accordingly, Baruah [**2, 3**] reintroduced the notion of complement of a fuzzy set in a way that the set theoretic axioms of exclusion and contradiction can be seen valid for fuzzy sets also.

In 1999, Molodtsov [**6**] introduced the novel concept of soft sets, which is a new mathematical approach to vagueness. In recent years the researchers have contributed a lot towards fuzzification of soft set theory. Maji et al. **[4]** put forward the concept of fuzzy soft sets, which is a hybrid model of fuzzy sets and soft sets. Recently, Neog et al. [**10**] have studied the theory of fuzzy soft sets from a new perspective and put forward a new notion regarding complement of a fuzzy soft set. While doing so, fuzzy sets have been replaced by extended fuzzy sets initiated by Baruah [**2**, **3**]. In 2010, Majumder and Samanta [**5**] gave a more generalized form of fuzzy soft sets, known as generalized fuzzy soft sets, by attaching a degree with the parameterization of fuzzy sets. These results were further studied by Yang [**12**] and some modifications were forwarded. In 2012, Neog et al. [**9**] put forward an extended notion of generalized fuzzy soft sets in the light of the extended definition of fuzzy sets initiated by Baruah [**3**]. They put forward an extended notion of similarity between two generalized fuzzy soft sets and some related properties.

In this article, an attempt has been made to apply the extended notion of similarity between two generalized fuzzy soft sets in the context of detecting the disease of an ill person.

2. PRELIMINARIES

In this section, we first recall some concepts and definitions which would be needed in the sequel.

In [**3**], Baruah put forward an extended definition of fuzzy sets and with the help of this extended definition, he put forward the notion of union and intersection of two fuzzy sets in the following way -

2.1. Extended Definition of Union and Intersection of Fuzzy Sets

Let $A(\mu_1, \mu_2) = \{x, \mu_1(x), \mu_2(x); x \in U\}$ and $B(\mu_3, \mu_4) = \{x, \mu_3(x), \mu_4(x); x \in U\}$ be two fuzzy sets defined over

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the same universe U. Then the operations intersection and union are defined as

$$A(\mu_1,\mu_2)\cap B(\mu_3,\mu_4)=\{x,\min(\mu_1(x),\mu_3(x)),\max(\mu_2(x),\mu_4(x));x\in U\}$$

and $A(\mu_1,\mu_2)\cup B(\mu_3,\mu_4)=\{x,\max(\mu_1(x),\mu_3(x)),\min(\mu_2(x),\mu_4(x));x\in U\}$.

Neog et al. [**11**] showed by an example that this definition sometimes gives degenerate cases and revised the above definition as follows -

2.2. Extended Definition of Union and Intersection of Fuzzy Sets Revised

Let $A(\mu_1,\mu_2)=\{x,\mu_1(x),\mu_2(x);x\in U\}$ and $B(\mu_3,\mu_4)=\{x,\mu_3(x),\mu_4(x);x\in U\}$ be two fuzzy sets defined over the same universe U. To avoid degenerate cases we assume that

$$\min(\mu_1(x),\mu_3(x))\geq\max(\mu_2(x),\mu_4(x))\forall x\in U .$$

Then the operations intersection and union are defined as

$$A(\mu_1,\mu_2)\cap B(\mu_3,\mu_4)=\{x,\min(\mu_1(x),\mu_3(x)),\max(\mu_2(x),\mu_4(x));x\in U\}$$

and $A(\mu_1,\mu_2)\cup B(\mu_3,\mu_4)=\{x,\max(\mu_1(x),\mu_3(x)),\min(\mu_2(x),\mu_4(x));x\in U\}$.

In [**3**], Baruah put forward the notion of complement of usual fuzzy sets with fuzzy reference function 0 in the following way -

2.3. Complement of a Fuzzy Set Using Extended Definition

For usual fuzzy sets $A(\mu,0)=\{x,\mu(x),0;x\in U\}$ and $B(1,\mu)=\{x,1,\mu(x);x\in U\}$ defined over the same universe U, we have

$$A(\mu,0)\cap B(1,\mu)=\{x,\min(\mu(x),1),\max(0,\mu(x));x\in U\}$$

$=\{x,\mu(x),\mu(x);x\in U\}$, which is nothing but the null set φ.

and $A(\mu,0)\cup B(1,\mu)=\{x,\max(\mu(x),1),\min(0,\mu(x));x\in U\}$

$=\{x,1,0;x\in U\}$, which is nothing but the universal set U.

This means if we define a fuzzy set $(A(\mu,0))^c=\{x,1,\mu(x);x\in U\}$, it is nothing but the complement of $A(\mu,0)=\{x,\mu(x),0;x\in U\}$.

Molodtsov [**6**] defined soft set in the following way -

2.5. Soft Set

A pair (F, E) is called a soft set (over U) if and only if F is a mapping of E into the set of all subsets of the set U.

In other words, the soft set is a parameterized family of subsets of the set U. Every set $F(\varepsilon),\varepsilon\in E$, from this family may be considered as the set of ε - elements of the soft set (F, E), or as the set of ε - approximate elements of the soft set.

The following definition of fuzzy soft set is due to Maji et al. [**4**]

2.6. Fuzzy Soft Set

A pair (F, A) is called a fuzzy soft set over U where $F:A\to\tilde{P}(U)$ is a mapping from A into $\tilde{P}(U)$.

The following definitions regarding matrix representation of a fuzzy soft set are due to Neog and Sut [**7**].

2.7. Matrix Representation of a Fuzzy Soft Set

Let $U=\{c_1,c_2,c_3,..................c_m\}$ be the universal set and E be the set of parameters given by $E=\{e_1,e_2,e_3,....................e_n\}$. Then the fuzzy soft set (F,E) can be expressed in matrix form as $A=[a_{ij}]_{m\times n}$

or simply by $[a_{ij}]$, i = 1,2,3…………..m ; j = 1,2,3……………..n and $a_{ij} = \left(\mu_{j1}(c_i), \mu_{j2}(c_i)\right)$; where $\mu_{j1}(c_i)$ and $\mu_{j2}(c_i)$ represent the fuzzy membership function and fuzzy reference function respectively of c_i in the fuzzy set $F(e_j)$ so that $\delta_{ij}(c_i) = \mu_{j1}(c_i) - \mu_{j2}(c_i)$ gives the fuzzy membership value of c_i. We shall identify a fuzzy soft set with its fuzzy soft matrix and use these two concepts interchangeable. The set of all $m \times n$ fuzzy soft matrices over U will be denoted by $FSM_{m\times n}$. For usual fuzzy sets with fuzzy reference function 0, it is obvious to see that $a_{ij} = \left(\mu_{j1}(c_i), 0\right) \forall i, j$.

2.8. Membership Value Matrix

We define the membership value matrix corresponding to the matrix A as $MV(A) = [\delta_{(A)ij}]_{m\times n}$, where $\delta_{(A)ij} = \mu_{j1}(c_i) - \mu_{j2}(c_i) \quad \forall i = 1,2,3......,m$ and $j = 1,2,3......,n$, where $\mu_{j1}(c_i)$ and $\mu_{j2}(c_i)$ represent the fuzzy membership function and fuzzy reference function respectively of c_i in the fuzzy set $F(e_j)$.

Majumder and Samanta [**5**] put forward the notion of generalized fuzzy soft sets in the following manner :

2.9. Generalized Fuzzy Soft Set

Let $U = \{x_1, x_2, x_3, ..., x_n\}$ be the universal set of elements and $E = \{e_1, e_2, e_3, ...e_m\}$ be the universal set of parameters. The pair (U, E) will be called a soft universe. Let $F : E \to I^U$ and μ be a fuzzy subset of E, *i.e.* $\mu : E \to I = [0,1]$, where I^U is the collection of all fuzzy subsets of U. Let F_μ be the mapping $F_\mu : E \to I^U \times I$ defined as follows: $F_\mu(e) = \left(F(e), \mu(e)\right)$, where $F(e) \in I^U$. Then F_μ is called generalized fuzzy soft sets over the soft universe (U, E). Here for each parameter e_i, $F_\mu(e_i) = \left(F(e_i), \mu(e_i)\right)$ indicates not only the degree of belongingness of the elements of U in $F(e_i)$ but also the degree of possibility of such belongingness which is represented by $\mu(e_i)$.

The following definitions related to extended notion of generalized fuzzy soft set are due to Neog and Sut [**9**].

2.10. Extended Definition of Generalized Fuzzy Soft Set

Let $U = \{x_1, x_2, x_3, ..., x_m\}$ be the universal set of elements and $E = \{e_1, e_2, e_3, ...e_n\}$ be the universal set of parameters. The pair (U, E) will be called a soft universe. Let $F : E \to I^U$ and μ be a fuzzy subset of E, *i.e.* $\mu = \{(e, \mu_1(e), \mu_2(e)) : e \in E\}$, where I^U is the collection of all fuzzy subsets of U. Let F_μ be the mapping $F_\mu : E \to I^U \times \mu$ defined as follows:

$F_\mu(e) = \left(F(e), \mu(e)\right)$, where $F(e) \in I^U$. Then F_μ is called generalized fuzzy soft sets over the soft universe (U, E) . Here for each parameter e_i, $F_\mu(e_i) = \left(F(e_i), \mu(e_i)\right)$ indicates not only the degree of belongingness of the elements of U in $F(e_i)$ but also the degree of possibility of such belongingness.

Similarity measures have extensive application in pattern recognition, region extraction, coding theory, image processing and in many other areas. Application of similarity measurement of two generalized fuzzy soft sets has been studied by Majumder and Samanta in [**5**]. In [**9**], Neog and Sut gave an extended notion of similarity between two fuzzy soft sets and between two generalized fuzzy soft sets. In their work, the matrix representation of a fuzzy soft set discussed in their earlier works [**7**, **8**] have been used. Thus the following definitions regarding similarity between two fuzzy soft sets and that between two generalized fuzzy soft sets are due to Neog and Sut [**9**].

2.11. Similarity Between Two Fuzzy Soft Sets

Let (F, E) and (G, E) be two fuzzy soft sets over (U, E), where $U = \{c_1, c_2, c_3, ...c_m\}$ and

$E = \{e_1, e_2, e_3, ...e_n\}$. Let $(F,E)\tilde{\cup}(G,E) = (P,E)$ and $(F,E)\tilde{\cap}(G,E) = (Q,E)$. We assume that $A = [a_{ij}]$ and $B = [b_{ij}]$ are the fuzzy soft matrices corresponding to the fuzzy soft sets (P,E) and (Q,E) respectively, where $a_{ij} = (\mu_{j1}(c_i), \mu_{j2}(c_i))$ and $b_{ij} = (\chi_{j1}(c_i), \chi_{j2}(c_i))$. The membership value matrices corresponding to the fuzzy soft matrices A and B are respectively, $MV(A) = [\delta_{(A)ij}]$, where $\delta_{(A)ij} = \mu_{j1}(c_i) - \mu_{j2}(c_i)$ and $MV(B) = [\delta_{(B)ij}]$, where $\delta_{(B)ij} = \chi_{j1}(c_i) - \chi_{j2}(c_i)$. Let $M((F,E),(G,E))$ denote the similarity between the fuzzy soft sets (F, E) and (G, E). Let $M_j((F,E),(G,E))$ represent the similarity between the e_j approximations $F(e_j)$ and $G(e_j)$ $\forall e_j$. Then we define

$$M_j((F,E),(G,E)) = \frac{\sum_{i=1}^{m}\left(\delta_{(A)ij} \wedge \delta_{(B)ij}\right)}{\sum_{i=1}^{m}\left(\delta_{(A)ij} \vee \delta_{(B)ij}\right)} \text{ and } M((F,E),(G,E)) = \max_j \{M_j((F,E),(G,E))\},\ j = 1,2,3........n$$

2.12. Similarity Between Two Generalized Fuzzy Soft Sets

Let F_μ and G_ν be two GFSS over (U, E). Using the method discussed in **Section 2.11**, we first find out the similarity between the e_j approximations $F(e_j)$ and $G(e_j)$ $\forall j$, which is given by

$$M_j((F,E),(G,E)) = \frac{\sum_{i=1}^{m}\left(\delta_{(A)ij} \wedge \delta_{(B)ij}\right)}{\sum_{i=1}^{m}\left(\delta_{(A)ij} \vee \delta_{(B)ij}\right)},$$

Where (F, E) and (G, E) are the constituent fuzzy soft sets in F_μ and G_ν. Let $M((F,E),(G,E))$ denote the similarity between the fuzzy soft sets (F, E) and (G, E). Then according to our definition,
$M((F,E),(G,E)) = \max_j \{M_j((F,E),(G,E))\}$

Let $m(\mu,\nu)$ be the similarity between μ and ν. We find the fuzzy membership values ($f.m.v.$) for each e_j in μ and ν respectively. Now, $f.m.v.$ of e_j in μ , $f.m.v(\mu(e_j)) = \mu_{j1}(e_j) - \mu_{j2}(e_j)$ and $f.m.v.$ of e_j in ν, $f.m.v(\nu(e_j)) = \nu_{j1}(e_j) - \nu_{j2}(e_j)$. We find the similarity between the fuzzy sets μ and ν in the following manner:

$$m(\mu,\nu) = \frac{\sum_j f.m.v.(\mu(e_j)) \wedge f.m.v.(\nu(e_j))}{\sum_j f.m.v.(\mu(e_j)) \vee f.m.v.(\nu(e_j))}$$

Let $M(F_\mu, G_\nu)$ denote the similarity between the generalized fuzzy soft sets F_μ and G_ν. The similarity between the generalized fuzzy soft sets F_μ and G_ν is defined as, $M(F_\mu, G_\nu) = M((F,E),(G,E)) \times m(\mu,\nu)$

3. SIMILARITY BETWEEN TWO GENERALIZED FUZZY SOFT SETS AND ITS APPLICATION TO MEDICAL DIAGNOSIS

Majumder and Samanta [**5**] successfully applied their technique of similarity measure between two GFSS to detect whether an ill person is suffering from a certain disease or not. We first recall the following definition put forward by Majumder and Samanta [**5**].

3.1. Significantly Similar GFSS

Let F_μ and G_ν be two generalized fuzzy soft sets over the same soft universe (U, E). We call the two generalized fuzzy soft sets to be significantly similar if $M(F_\mu, G_\nu) > \frac{1}{2}$

In our discussion, we are taking the same example given by Majumder and Samanta in [**5**] and proceeding in our way of finding out similarity between two generalized fuzzy soft sets given in [**9**], finally we obtain the same result as was obtained by Majumder and Samanta in [**5**].

We first construct a model generalized fuzzy soft set for pneumonia and the generalized fuzzy soft set of symptoms for the ill persons. Next we find the similarity of these two sets. If they are significantly similar then we conclude that the person is possibly suffering from pneumonia.

Let our universal set contain only two elements 'yes (y)' and 'no (n)', i.e. $U = \{y, n\}$. Here the set of parameters E is the set of certain visible symptoms. Let $E = \{e_1, e_2, e_3, e_4, e_5, e_6, e_7, e_8\}$, where e_1 = body temperature, e_2 = cough with chest Congestion, e_3 = cough with no chest congestion, e_4 = body ache, e_5 = headache, e_6 = loose motion, e_7 = breathing trouble. Our model generalized fuzzy soft set for pneumonia F_μ is given in **Table 1** and this can be prepared with the help of a physician. In a similar fashion, we construct the generalized fuzzy soft sets corresponding to the three ill persons under consideration as given in **Table 2, 3** and **4** respectively.

TABLE 1:

MODEL GFSS FOR PNEUMONIA

F_μ	e_1	e_2	e_3	e_4	e_5	e_6	e_7
y	(1,0)	(1,0)	(0,0)	(1,0)	(0,0)	(0,0)	(1,0)
n	(0,0)	(0,0)	(1,0)	(0,0)	(1,0)	(1,0)	(0,0)
μ	(1,0)	(1,0)	(1,0)	(1,0)	(1,0)	(1,0)	(1,0)

TABLE 2:

GFSS FOR FIRST ILL PERSON

${F^1}_{\mu_1}$	e_1	e_2	e_3	e_4	e_5	e_6	e_7
y	(0.7,0)	(0,0)	(0.6,0)	(0.6,0)	(0.5,0)	(0.1,0)	(0.1,0)
n	(0.1,0)	(0.3,0)	(0.2,0)	(0.1,0)	(0.3,0)	(0.7,0)	(0.6,0)
μ_1	(0.2,0)	(0.8,0)	(0.7,0)	(0.4,0)	(0.3,0)	(0.8,0)	(0.9,0)

TABLE 3:

GFSS FOR SECOND ILL PERSON

${F^2}_{\mu_2}$	e_1	e_2	e_3	e_4	e_5	e_6	e_7
y	(0.8,0)	(0.9,0)	(0.2,0)	(0.6,0)	(0.5,0)	(0.1,0)	(0.8,0)
n	(0.1,0)	(0.1,0)	(0.2,0)	(0.1,0)	(0.3,0)	(0.7,0)	(0.1,0)
μ_2	(0.9,0)	(0.8,0)	(0.7,0)	(0.8,0)	(0.7,0)	(0.8,0)	(0.9,0)

TABLE 4:

GFSS FOR THIRD ILL PERSON

${F^3}_{\mu_3}$	e_1	e_2	e_3	e_4	e_5	e_6	e_7
y	(0.8,0)	(0.9,0)	(0.2,0)	(0.6,0)	(0.5,0)	(0.1,0)	(0.8,0)
n	(0.1,0)	(0.1,0)	(0.2,0)	(0.1,0)	(0.3,0)	(0.7,0)	(0.1,0)
μ_3	(0.2,0)	(0.3,0)	(0.2,0)	(0.6,0)	(0.3,0)	(0.2,0)	(0.4,0)

Case I:

$(F, E) \tilde{\cup} (F^1, E) = (P^1, E)$

(P^1, E)	e_1	e_2	e_3	e_4	e_5	e_6	e_7
y	(1,0)	(1,0)	(0.6,0)	(1,0)	(0.5,0)	(0.1,0)	(1,0)
n	(0.1,0)	(0.3,0)	(1,0)	(0.1,0)	(1,0)	(1,0)	(0.6,0)

$(F,E)\tilde{\cap}(F^1,E)=(Q^1,E)$

(Q^1,E)	e_1	e_2	e_3	e_4	e_5	e_6	e_7
y	(0.7,0)	(0,0)	(0,0)	(0.6,0)	(0,0)	(0,0)	(0.1,0)
n	(0,0)	(0,0)	(0.2,0)	(0,0)	(0.3,0)	(0.7,0)	(0,0)

The fuzzy soft matrices corresponding to these two fuzzy soft sets (P^1,E) and $(Q^1,E)$are given by,

$$A^1 = \begin{bmatrix} (1,0) & (1,0) & (0.6,0) & (1,0) & (0.5,0) & (0.1,0) & (1,0) \\ (0.1,0) & (0.3,0) & (1,0) & (0.1,0) & (1,0) & (1,0) & (0.6,0) \end{bmatrix}$$

$$B^1 = \begin{bmatrix} (0.7,0) & (0,0) & (0,0) & (0.6,0) & (0,0) & (0,0) & (0.1,0) \\ (0,0) & (0,0) & (0.2,0) & (0,0) & (0.3,0) & (0.7,0) & (0,0) \end{bmatrix}$$

The corresponding membership value matrices are given by,

$$MV(A^1) = \begin{bmatrix} 1 & 1 & 0.6 & 1 & 0.5 & 0.1 & 1 \\ 0.1 & 0.3 & 1 & 0.1 & 1 & 1 & 0.6 \end{bmatrix}$$

$$MV(B^1) = \begin{bmatrix} 0.7 & 0 & 0 & 0.6 & 0 & 0 & 0.1 \\ 0 & 0 & 0.2 & 0 & 0.3 & 0.7 & 0 \end{bmatrix}$$

We have,

$$M_1((F,E),(F^1,E)) = \frac{\sum_{i=1}^{m}\left(\delta_{(A^1)i1} \wedge \delta_{(B^1)i1}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^1)i1} \vee \delta_{(B^1)i1}\right)} = \frac{0.7+0}{1+0.1} = \frac{0.7}{1.1} = 0.64$$

$$M_2((F,E),(F^1,E)) = \frac{\sum_{i=1}^{m}\left(\delta_{(A^1)i2} \wedge \delta_{(B^1)i2}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^1)i2} \vee \delta_{(B^1)i2}\right)} = \frac{0+0}{1+0.3} = \frac{0}{1.3} = 0$$

$$M_3((F,E),(F^1,E)) = \frac{\sum_{i=1}^{m}\left(\delta_{(A^1)i3} \wedge \delta_{(B^1)i3}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^1)i3} \vee \delta_{(B^1)i3}\right)} = \frac{0+0.2}{0.6+1} = \frac{0.2}{1.6} = 0.13$$

$$M_4((F,E),(F^1,E)) = \frac{\sum_{i=1}^{m}\left(\delta_{(A^1)i4} \wedge \delta_{(B^1)i4}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^1)i4} \vee \delta_{(B^1)i4}\right)} = \frac{0.6+0}{1+0.1} = \frac{0.6}{1.1} = 0.55$$

$$M_5((F,E),(F^1,E)) = \frac{\sum_{i=1}^{m}\left(\delta_{(A^1)i5} \wedge \delta_{(B^1)i5}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^1)i5} \vee \delta_{(B^1)i5}\right)} = \frac{0+0.3}{0.5+1} = \frac{0.3}{1.5} = 0.20$$

$$M_6((F,E),(F^1,E)) = \frac{\sum_{i=1}^{m}\left(\delta_{(A^1)i6} \wedge \delta_{(B^1)i6}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^1)i6} \vee \delta_{(B^1)i6}\right)} = \frac{0+0.7}{0.1+1} = \frac{0.7}{1.1} = 0.64$$

$$M_7\big((F,E),(F^1,E)\big)=\frac{\sum_{i=1}^{m}\left(\delta_{(A^1)i7}\wedge\delta_{(B^1)i7}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^1)i7}\vee\delta_{(B^1)i7}\right)}\quad=\frac{0.1+0}{1+0.6}\quad=\frac{0.1}{1.6}\quad=0.06$$

Thus $M\big((F,E),(F^1,E)\big)=\max_j\left\{M_j\big((F,E),(F^1,E)\big)\right\},\ j=1,2,3,4,5,6,7.\quad =0.64$

Also, $\mu=\{(e_1,1,0),(e_2,1,0),(e_3,1,0),(e_4,1,0),(e_5,1,0),(e_6,1,0),(e_7,1,0)\}$ and

$\mu_1=\{(e_1,0.2,0),(e_2,0.8,0),(e_3,0.7,0),(e_4,0.4,0),(e_5,0.3,0),(e_6,0.8,0),(e_7,0.9,0)\}$

$f.m.v\,(\mu(e_1))=1,\ f.m.v\,(\mu(e_2))=1,\ f.m.v\,(\mu(e_3))=1,\ f.m.v\,(\mu(e_4))=1,\ f.m.v\,(\mu(e_5))=1,\ f.m.v\,(\mu(e_6))=1$

$f.m.v\,(\mu(e_7))=1$

$f.m.v\,(\mu_1(e_1))=0.2,\ f.m.v\,(\mu_1(e_2))=0.8,\ f.m.v\,(\mu_1(e_3))=0.7,\ f.m.v\,(\mu_1(e_4))=0.4,\ f.m.v\,(\mu_1(e_5))=0.3,$

$f.m.v\,(\mu_1(e_6))=0.8,\ f.m.v\,(\mu_1(e_7))=0.9$

$$m(\mu,\mu_1)=\frac{\sum_j f.m.v.\big(\mu(e_j)\big)\wedge f.m.v.\big(\mu_1(e_j)\big)}{\sum_j f.m.v.\big(\mu(e_j)\big)\vee f.m.v.\big(\mu_1(e_j)\big)}\quad=\frac{0.2+0.8+0.7+0.4+0.3+0.8+0.9}{7}\quad=\frac{4.1}{7}\quad=0.59$$

Thus $M(F_\mu,F^1{}_{\mu_1})\quad=0.64\times0.59\quad=0.38\quad<0.5$

Case II:

$(F,E)\tilde{\cup}(F^2,E)=(P^2,E)$

(P^2,E)	e_1	e_2	e_3	e_4	e_5	e_6	e_7
y	(1,0)	(1,0)	(0.2,0)	(1,0)	(0.5,0)	(0.1,0)	(1,0)
n	(0.1,0)	(0.1,0)	(1,0)	(0.1,0)	(1,0)	(1,0)	(0.1,0)

$(F,E)\tilde{\cap}(F^2,E)=(Q^2,E)$

(Q^2,E)	e_1	e_2	e_3	e_4	e_5	e_6	e_7
y	(0.8,0)	(0.9,0)	(0,0)	(0.6,0)	(0,0)	(0,0)	(0.8,0)
n	(0,0)	(0,0)	(0.2,0)	(0,0)	(0.3,0)	(0.7,0)	(0,0)

The fuzzy soft matrices corresponding to these two fuzzy soft sets (P^1,E) and (Q^2,E) are given by,

$$A^2=\begin{bmatrix}(1,0)&(1,0)&(0.2,0)&(1,0)&(0.5,0)&(0.1,0)&(1,0)\\(0.1,0)&(0.1,0)&(1,0)&(0.1,0)&(1,0)&(1,0)&(0.1,0)\end{bmatrix}$$

$$B^2=\begin{bmatrix}(0.8,0)&(0.9,0)&(0,0)&(0.6,0)&(0,0)&(0,0)&(0.8,0)\\(0,0)&(0,0)&(0.2,0)&(0,0)&(0.3,0)&(0.7,0)&(0,0)\end{bmatrix}$$

The corresponding membership value matrices are given by,

$$MV(A^2)=\begin{bmatrix}1&1&0.2&1&0.5&0.1&1\\0.1&0.1&1&0.1&1&1&0.1\end{bmatrix}$$

$$MV\left(B^2\right)=\begin{bmatrix} 0.8 & 0.9 & 0 & 0.6 & 0 & 0 & 0.8 \\ 0 & 0 & 0.2 & 0 & 0.3 & 0.7 & 0 \end{bmatrix}$$

We have,

$$M_1\left((F,E),\left(F^2,E\right)\right)=\frac{\sum_{i=1}^{m}\left(\delta_{(A^2)i1}\wedge\delta_{(B^2)i1}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^2)i1}\vee\delta_{(B^2)i1}\right)}=\frac{0.8+0}{1+0.1}=\frac{0.8}{1.1}=0.73$$

$$M_2\left((F,E),\left(F^2,E\right)\right)=\frac{\sum_{i=1}^{m}\left(\delta_{(A^2)i2}\wedge\delta_{(B^2)i2}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^2)i2}\vee\delta_{(B^2)i2}\right)}=\frac{0.9+0}{1+0.1}=\frac{0.9}{1.1}=0.82$$

$$M_3\left((F,E),\left(F^2,E\right)\right)=\frac{\sum_{i=1}^{m}\left(\delta_{(A^2)i3}\wedge\delta_{(B^2)i3}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^2)i3}\vee\delta_{(B^2)i3}\right)}=\frac{0+0.2}{0.2+1}=\frac{0.2}{1.2}=0.17$$

$$M_4\left((F,E),\left(F^2,E\right)\right)=\frac{\sum_{i=1}^{m}\left(\delta_{(A^2)i4}\wedge\delta_{(B^2)i4}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^2)i4}\vee\delta_{(B^2)i4}\right)}=\frac{0.6+0}{1+0.1}=\frac{0.6}{1.1}=0.55$$

$$M_5\left((F,E),\left(F^2,E\right)\right)=\frac{\sum_{i=1}^{m}\left(\delta_{(A^2)i5}\wedge\delta_{(B^2)i5}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^2)i5}\vee\delta_{(B^2)i5}\right)}=\frac{0+0.3}{0.5+1}=\frac{0.3}{1.5}=0.20$$

$$M_6\left((F,E),\left(F^2,E\right)\right)=\frac{\sum_{i=1}^{m}\left(\delta_{(A^2)i6}\wedge\delta_{(B^2)i6}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^2)i6}\vee\delta_{(B^2)i6}\right)}=\frac{0+0.7}{0.1+1}=\frac{0.7}{1.1}=0.64$$

$$M_7\left((F,E),\left(F^2,E\right)\right)=\frac{\sum_{i=1}^{m}\left(\delta_{(A^2)i7}\wedge\delta_{(B^2)i7}\right)}{\sum_{i=1}^{m}\left(\delta_{(A^2)i7}\vee\delta_{(B^2)i7}\right)}=\frac{0.8+0}{1+0.1}=\frac{0.8}{1.1}=0.06$$

Thus $M\left((F,E),\left(F^2,E\right)\right)=\max_j\left\{M_j\left((F,E),\left(F^2,E\right)\right)\right\},\ j=1,2,3,4,5,6,7. \quad =0.82$

Also, $\mu=\{(e_1,1,0),(e_2,1,0),(e_3,1,0),(e_4,1,0),(e_5,1,0),(e_6,1,0),(e_7,1,0)\}$ and

$\mu_2=\{(e_1,0.9,0),(e_2,0.8,0),(e_3,0.7,0),(e_4,0.8,0),(e_5,0.7,0),(e_6,0.8,0),(e_7,0.9,0)\}$

$f.m.v\left(\mu(e_1)\right)=1,\ f.m.v\left(\mu(e_2)\right)=1,\ f.m.v\left(\mu(e_3)\right)=1,\ f.m.v\left(\mu(e_4)\right)=1,\ f.m.v\left(\mu(e_5)\right)=1,\ f.m.v\left(\mu(e_6)\right)=1$

$f.m.v\left(\mu(e_7)\right)=1$

$f.m.v\left(\mu_2(e_1)\right)=0.9,\ f.m.v\left(\mu_2(e_2)\right)=0.8,\ f.m.v\left(\mu_2(e_3)\right)=0.7,\ f.m.v\left(\mu_2(e_4)\right)=0.8,\ f.m.v\left(\mu_2(e_5)\right)=0.7,$

$f.m.v\left(\mu_2(e_6)\right)=0.8,\ f.m.v\left(\mu_2(e_7)\right)=0.9$

$$m(\mu,\mu_2) = \frac{\sum_j f.m.v.\left(\mu(e_j)\right) \wedge f.m.v.\left(\mu_2(e_j)\right)}{\sum_j f.m.v.\left(\mu(e_j)\right) \vee f.m.v.\left(\mu_2(e_j)\right)} = \frac{0.9+0.8+0.7+0.8+0.7+0.8+0.9}{7} = \frac{5.6}{7} = 0.80$$

Thus $M(F_\mu, F^2{}_{\mu_2}) = 0.82 \times 0.80 = 0.66 > 0.5$

Hence the two GFSS are significantly similar. So we conclude that this person is suffering from pneumonia.

Case III:

What has been found out by **Case II** is that,

Thus $M\left((F,E),(F^3,E)\right) = \max_j \left\{M_j\left((F,E),(F^3,E)\right)\right\}, j = 1,2,3,4,5,6,7. = 0.82$

Also, $\mu = \{(e_1,1,0),(e_2,1,0),(e_3,1,0),(e_4,1,0),(e_5,1,0),(e_6,1,0),(e_7,1,0)\}$ and

$\mu_3 = \{(e_1,0.2,0),(e_2,0.3,0),(e_3,0.2,0),(e_4,0.6,0),(e_5,0.3,0),(e_6,0.2,0),(e_7,0.4,0)\}$

$f.m.v\left(\mu(e_1)\right)=1,\ f.m.v\left(\mu(e_2)\right)=1,\ f.m.v\left(\mu(e_3)\right)=1,\ f.m.v\left(\mu(e_4)\right)=1,\ f.m.v\left(\mu(e_5)\right)=1,\ f.m.v\left(\mu(e_6)\right)=1$

$f.m.v\left(\mu(e_7)\right)=1$

$f.m.v\left(\mu_3(e_1)\right)=0.2,\ f.m.v\left(\mu_3(e_2)\right)=0.3,\ f.m.v\left(\mu_3(e_3)\right)=0.2,\ f.m.v\left(\mu_3(e_4)\right)=0.6,\ f.m.v\left(\mu_3(e_5)\right)=0.3,$

$f.m.v\left(\mu_3(e_6)\right)=0.2,\ f.m.v\left(\mu_3(e_7)\right)=0.4$

$$m(\mu,\mu_3) = \frac{\sum_j f.m.v.\left(\mu(e_j)\right) \wedge f.m.v.\left(\mu_3(e_j)\right)}{\sum_j f.m.v.\left(\mu(e_j)\right) \vee f.m.v.\left(\mu_3(e_j)\right)} = \frac{0.2+0.3+0.2+0.6+0.3+0.2+0.4}{7} = \frac{2.2}{7} = 0.31$$

Thus $M(F_\mu, F_{\mu_3}) = 0.82 \times 0.31 = 0.25 < 0.5$

4. CONCLUSION

We have applied the extended notion of similarity between two generalized fuzzy soft sets in a decision problem. We have taken the same example as was taken by Majumder and Samanta in [**5**] and proceeding in our way, we have finally arrived at the same conclusion. It is clear that our method uses the extended notion of fuzzy sets initiated by Baruah [**3**]. We hope that our extended notion would be helpful in dealing with several problems related to uncertainty.

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