INTERVAL VALUED FUZZY SOFT SETs SIMILARITY MEASURE FOR DETERMINING COVID--19 PATIENTS

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Abstract— The continued spread of corona virus disease 2019(COVID-19)has prompted widespread concern around the world. The world Health Organization (WHO), on 11th March 2020, declared COVID-19 a pandemic. COVID-19 affects different people in different ways. Most infected people will develop mild to moderate illness and recover without hospitalization. This article explores knowledge discovering in COVID-19 pandemic. In particular it discusses about the people who affected severely in COVID-19 . We use interval valued fuzzy soft sets(IVFS sets) similarity measure for determining COVID-19 patients.. In introduction we give the major signs and symptoms of COVID-19... We present some examples in medical science which aims to find patients with high COVID-19 disease.

Index Terms—IVFS sets, Similarity Measure, Raw Data, corona virus, Surge.

1 Introduction

Recently Mukherjee and Mukherjee [4] explored knowledge discovering in COVID-19 pandemic. In particular it discussed the age group of the people who affected severely in COVID-19. Most of our real life problems in engineering, social and medical science, economics, environment etc involve imprecise data. Their solutions involve the use of mathematical principles based on uncertainty and imprecision. To handle such uncertainties, a number of theories have been proposed. Some of these are fuzzy sets, interval-valued fuzzy sets, intuitionistic fuzzy sets, interval valued intuitionistic fuzzy sets, soft sets, fuzzy soft sets, neutrosophic sets, interval neutrosophic sets, neutrosophic soft sets and interval value neutrosophicsoft sets etc. People of all ages can be affected by the new corona virus . Older people and people with preexisting medical conditions (such as Asthma, Diabetes, Heart disease, Cancer) appear to be more vulnerable to becoming severely ill with the virus. Most common symptoms are (1) fever (2)dry cough (3)tiredness.Less common symptoms are (a) aches and pains (b)sore throat (c)diarrhea (d) conjunctivitis (e) headache (f)loss of taste or smell (g)a rash on skin or coloration of fingers or toes. Lastly serious symptoms are (i)difficulty breathing or shortness of breath (ii)loss of speech or movement. People seek immediate medical attention if they have serious symptoms. COVID-19 surge is a spread -sheet based tool that hospital administrators and public health officials can use to estimate the surge in demand for hospital based services during the COVID-19 pandemic. A user of COVID-19 surge can produce estimate of the number of COVID-19 patients that need to be hospitalized the number requiring ICU care and the number requiring ventilator support. In this paper we discuss about the people who affected severely in COVID-19 . We use IVFS sets similarity measure for determining COVID-19 patients. We present some examples in medical science which aims to find the patients with high COVID-19 risk.. Here we have shown different types of similarity measure between two IVFS sets . We propose similarity measures of two IVFS sets. Then we construct a decision making method based on similarity measures. Finally we give two simple examples to show the possibilities of determining COVID-19 patients.

The major problem of COVID-19 disease which is affected many people in India . The following are the common symptoms found in the state.

e_1= Fever , e_2= Dry cough, . e_3 =Tiredness, e_4= Headache, , e_5 =Loss of taste or smell, e_6= difficulty breathing or shortness of breath.

2.Preliminaries: We recall some definitions and results relvant to our future discussion.**:**

Definition 2.1:(a)[6] Let U be a non empty set.

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Then a *fuzzy set* α is a set having the form

$\alpha = \{(x, \mu_\alpha(x)) : x \in X\}$

where the function $\mu_\alpha : U \to [0,1]$ is called the membership function and $\mu_\alpha(x)$ is called the degree of membership of each element $x \in U$. The class of all fuzzy sets on is denoted U by FS^U.

(b)[7] An interval valued fuzzy set α over U is of the form

$\alpha = \{(x, \mu_\alpha(x)) : x \in X\}$

where $\mu_\alpha : X \to Int([0,1])$. The set of all subintervals of the unit interval i.e. for every $x \in U$, $\mu_\alpha(x)$ is an interval within $[0,1]$. We denote the class of all interval-valued fuzzy sets on U by *IVFS*^{U}.

(c)[2] Let U be an universe set and E be a set of parameters. Let $P(U)$ denotes the power set of U and $A \subseteq E$. Then the pair (f, A) is called a soft set over U. Here f is a mapping given by $f : A \to P(U)$.

In other words, the soft set is not a kind of set, but a parameterized family of subsets of U. For $e \in A$, $f(e) \subseteq U$ may be considered as the set of e-approximate elements of the soft set (f, A).

2 Suppose there are six houses in the universe set given by $U = \{h_1, h_2, h_3, h_4, h_5, h_6\}$. $A = \{e_1, e_2, e_3, e_4, e_5\}$ is the set of parameters. Where e_1 stands for the parameter 'expensive', e_2 stands for the parameter 'beautiful', e_3 stands for the parameter 'wooden', e_4 stands for the parameter 'cheap' and e_5 stands for the parameter 'in green surroundings'.

In this case to define soft set means to point out expensive houses, beautiful houses and so on. The soft set (f, A) may describe the 'attractiveness of the houses' which Mr. X is going to buy. Suppose that $f(e_1) = \{h_2, h_4\}$, $f(e_2) = \{h_1, h_3\}$, $f(e_3) = \{h_3, h_4, h_5\}$, $f(e_4) = \{h_1, h_3, h_5\}$, $f(e_5) = \{h_1\}$. Then the soft set (f, A) is a parameterized family $\{f(e_i) : i=1, 2, 3, 4, 5\}$ of subsets of U and gives us a collection of approximate description of an object. $f(e_1) = \{h_2, h_4\}$ means 'houses h_2 and h_4 are expensive'.

(d)[1] Let U={x_1, x_2, x_3, …… ,x_n}be the universe and E={ e_1, e_2, e_3, …. , e_m}be the set of parameters. Let (F,E) be an interval valued fuzzy soft sets over U, F is a mapping given by F:E→ *IVFS*^{U} and IV*FS*^{U} is the set of all interval-valued fuzzy sets of U.

An interval-valued fuzzy soft set (IVFSset) can be represented in a tabular form as follows:

	e_1	e_2	e_3	……..	e_m
x_1	$[a_{11},b_{11}]$	$[a_{12},b_{12}]$	$[a_{13},b_{13}]$	……. .	$[a_{1m},b_{1m}]$
x_2	$[a_{21},b_{21}]$	$[a_{22},b_{22}]$	$[a_{23},b_{23}]$	……..	$[a_{2m},b_{2m}]$.

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x_n	$[a_{n1},b_{n1}]$	$[a_{n2},b_{n2}]$	$[a_{n3},b_{n3}]$	…….. $[a_{nm},b_{nm}]$

Table 3: Tabular presentation of an IVFSset

where $[a_{ij},b_{ij}] \subseteq [0,1]$ for all i=1,2,3,….,n and j = 1,2,3, ….. ,m.

Now we represent this IVFSset as a matrix as follows:

$$\begin{bmatrix} c_{11} & c_{12} & c_{13} & \ldots\ldots & c_{1m} \\ c_{21} & c_{22} & c_{23} & \ldots\ldots & c_{2m} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ c_{n1} & c_{n2} & c_{n3} & \ldots\ldots & c_{nm} \end{bmatrix}$$

where $c_{ij} = b_{ij} - a_{ij}$ for all i=1,2,3,….,n and j = 1,2,3, ….. ,m.

We denote $(c_{11},c_{21},c_{31}, \ldots, c_{n1})$ as $\overrightarrow{F(e_1)}$ etc.

Definition 2..2: [1] Let (F,E) and (G,E) be two interval valued- fuzzy soft sets(IVFSs) over U respectively, where F is a mapping given by F:E→ $IVFS^U$ and G is a mapping

given by G:E→ $IVGS^U$ and IVFS^U ,IV GS^U are the set of all interval-valued fuzzy sets of U. Then we define similarity measure between the IVFSSs (F,E) and (G,E) denoted by S(F,G) as

$$S(F,G) = \frac{\sum_{i=1}^{m}\left(\overrightarrow{F(e_i)}\bullet\overrightarrow{G(e_i)}\right)}{\sum_{i=1}^{m}\left(\left(\overrightarrow{F(e_i)}\right)^2 \vee \left(\overrightarrow{G(e_i)}\right)^2\right)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2.1)$$

where $\overrightarrow{F(e_i)} = (c_{1i},c_{2i},c_{3i}, \ldots, c_{ni})$, i = 1,2,3, ….. ,m .

Theorem 2.3:[3] S(F,G) be the similarity measure between two IVFSsets (F,E) and (G,E) then

(i) S(F,G) = S(G,F)

(ii) $0 \le S(F,G) \le 1$

(iii) S(F,G) = 1 if and only if (F,E) = (G,E).

Proof: Obvious from the above definition.

Example 2..4: LetU = $\{x_1,x_2,x_3\}$be the universe. E = $\{e_1,e_2,e_3\}$ be the set of parameters. We consider two IVFS sets(F,E) and (G,E) .

Tabular form of (F,E):

	e_1	e_2	e_3
x_1	[0.7,0.9]	[0.6,0.7]	[0.5,0.8]
x_2	[0.6,0.8]	[0.2,0.5]	[0.6,0.9]
x_3	[0.5,0.6]	[0.0,0.7]	[0.2,1.0]

Table 4:Tabular presentation of IVFS set (F,E)

Tabular form of (G,E):

	e_1	e_2	e_3
x_1	[0.2,0.8]	[0.4,0.9]	[0.3,0.6]
x_2	[0.4,0.7]	[0.4,0.5]	[0.8,0.9]
x_3	[0.0,1.0]	[0.2,0.5]	[0.8,1.0]

Table 5: Tabular presentation of IVFS set (G,E)

Therefore the corresponding matrices F and G of (F,E) and (G,E) respectively are given by

$$F=\begin{pmatrix}0.2 & 0.1 & 0.3\\ 0.2 & 0.3 & 0.3\\ 0.1 & 0.7 & 0.8\end{pmatrix} \text{ and } G=\begin{pmatrix}0.6 & 0.5 & 0.3\\ 0.3 & 0.1 & 0.1\\ 1.0 & 0.3 & 0.2\end{pmatrix}$$

Therefore by **(2.1)** similarity measure between (F,E) and (G,E) is given by

$$S(F,G)=\frac{\sum_{i=1}^{3}\left(\overrightarrow{F(e_i)}\bullet\overrightarrow{G(e_i)}\right)}{\sum_{i=1}^{3}\left(\left(\overrightarrow{F(e_i)}\right)^2\vee\left(\overrightarrow{G(e_i)}\right)^2\right)}$$

$$\cong 0.2972$$

Example 2..5: LetU = $\{x_1,x_2,x_3,x_4\}$be the universe . E = $\{e_1,e_2,e_3\}$ be the set of parameters. We consider two IVFS sets (F_1,E) and (G_1,E) ..

Tabular form of (F_1,E):

	e_1	e_2	e_3
x_1	[0.2,0.9]	[0.0,1.0]	[0.2,0.8]
x_2	[0.4,0.8]	[0.3,0.9]	[0.3,1.0]
x_3	[0.4,1.0]	[0.3,0.7]	[0.0,0.7]
x_4	[0.1,0.9]	[0.5,1.0]	[0.3,0.8]

Table 6: Tabular presentation of IVFS set (F_1,E)

Tabular form of (G_1,E):

	e_1	e_2	e_3
x_1	[0.1,0.9]	[0.4,1.0]	[0.0,0.8]
x_2	[0.2,0.7]	[0.1,0.9]	[0.3,1.0]
x_3	[0.0,0.8]	[0.4,0.9]	[0.2,0.7]
x_4	[0.2,1.0]	[0.0,1.0]	[0.3,1.0]

Table 5: tabular presentation of IVFS set (G_1,E)

Therefore the corresponding matrices F_1 and G_1 of (F_1,E) and (G_1,E) respectively are given by

$$F_1=\begin{pmatrix}0.7 & 1.0 & 0.6\\ 0.4 & 0.6 & 0.7\\ 0.6 & 0.4 & 0.7\\ 0.8 & 0.5 & 0.5\end{pmatrix} \text{ and } G_1=\begin{pmatrix}0.8 & 0.6 & 0.8\\ 0.5 & 0.8 & 0.7\\ 0.8 & 0.5 & 0.5\\ 0.8 & 1.0 & 0.7\end{pmatrix}$$

Therefore by equation **(2.1)** similarity measure between (F_1,E) and (G_1,E) is given by,

$$S(F_1,G_1)=\frac{\sum_{i=1}^{3}\left(\overrightarrow{F_1(e_i)}\bullet\overrightarrow{G_1(e_i)}\right)}{\sum_{i=1}^{3}\left(\left(\overrightarrow{F_1(e_i)}\right)^2\vee\left(\overrightarrow{G_1(e_i)}\right)^2\right)}\cong 0.847$$

Definition 2.6: [5] Let U=$\{x_1,x_2,x_3,\ldots\ldots,x_n\}$be the universe. E=$\{e_1,e_2,e_3,\ldots\ldots,e_m\}$be the set of parameters. Let (F_1,E) and (G_1,E) be two IVFS sets over U respectively. F_1 is a mapping given by F_1:E→ IVF_1S^U and G_1 is a mapping given by G_1:E→ IVG_1S^U . IVF_1S^U , IVG_1S^U are the set of all interval-valued fuzzy sets of U. Then we define the following distances between (F_1,E) and (G_1,E).

a. Hamming distance:

$$d_H(F_1,G_1)=\frac{1}{2m}\left[\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\left|M_{F_1L}(e_i)(x_j)-M_{G_1L}(e_i)(x_j)\right|+\left|M_{F_1U}(e_i)(\ldots\right.\right.\right.$$
$$\left.\left.+\left|W_{F_1}(e_i)(x_j)-W_{G_1}(e_i)(x_j)\right|\right)\right]$$

b. Normalised Hamming distance:

$$d_{NH}(F_1,G_1)=\frac{1}{2mn}\left[\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\left|M_{F_1L}(e_i)(x_j)-M_{G_1L}(e_i)(x_j)\right|+\left|M_{F_1U}(e_i)(x_j)-M_{G_1U}(e_i)(x_j)\right|+\left|W_{F_1}(e_i)(x_j)-W_{G_1}(e_i)(x_j)\right|\right)\right]$$

c. Euclidean distance:

$$d_E(F_1,G_1)=\left[\frac{1}{2m}\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\left(M_{F_1L}(e_i)(x_j)-M_{G_1L}(e_i)(x_j)\right)^2+\left(M_{F_1U}(e_i)(x_j)-M_{G_1U}(e_i)(x_j)\right)^2+\left(W_{F_1}(e_i)(x_j)-W_{G_1}(e_i)(x_j)\right)^2\right)\right]^{\frac{1}{2}}$$

d. Normalised Euclidean distance:

$$d_{NE}(F_1,G_1)=\left[\frac{1}{2mn}\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\left(M_{F_1L}(e_i)(x_j)-M_{G_1L}(e_i)(x_j)\right)^2+\left(M_{F_1U}(e_i)(x_j)-M_{G_1U}(e_i)(x_j)\right)^2+\left(W_{F_1}(e_i)(x_j)-W_{G_1}(e_i)(x_j)\right)^2\right)\right]^{\frac{1}{2}}$$

Here M_L, M_U W denote respectively the lower limit, .

upper limit and amplitude (upper limit – lower limit) of the corresponding interval.

Definition 2.7:[5] Let (F_1,E) and (G_1,E) be two IVFS sets) over the universe U. E be the set of parameters . Then the similarity measure between (F_1,E) and (G_1,E) denoted by S(F_1,G_1) is defined as

$$S(F_1,G_1)=\frac{1}{1+d(F_1,G_1)} \quad \text{………………..}\mathbf{(2.2)}$$

where d(F_1,G_1) denotes the distance between (F_1,E) and (G_1,E).

Clearly S(F_1,G_1) satisfies all the properties stated in **Theorem 2.3 .**

Example 2.8: LetU = {x_1,x_2,x_3}be the universe. E = { e_1,e_2,e_3} be the set of parameters. We consider two IVFS sets (F_1,E) and (G_1,E) ..

Tabular form of (F_1,E):

	e_1	e_2	e_3
x_1	[0.7,0.9]	[0.6,0.7]	[0.5,0.8]
x_2	[0.6,0.8]	[0.2,0.5]	[0.6,0.9]
x_3	[0.5,0.6]	[0.0,0.7]	[0.2,1.0]

Table 6: tabular presentation of IVFS set (F_1,E)

Tabular form of (G_1,E):

	e_1	e_2	e_3
x_1	[0.2,0.8]	[0.4,0.9]	[0.3,0.6]
x_2	[0.4,0.7]	[0.4,0.5]	[0.8,0.9]
x_3	[0.0,1.0]	[0.2,0.5]	[0.8,1.0]

Table 7: tabular presentation of IVFS set (G_1,E)

The sub-intervals of the unit interval denote the range of the symptoms

Now by definition **2.6(a)** the Hamming distance between (F_1,E) and (G_1,E) is given by

d_H(F_1,G_1) = 1.2

Therefore by **(2.2)** the similarity measure between (F_1,E) and (G_1,E) based on Hamming distance is given by

$$S(F_1,G_1)=\frac{1}{1+d_H(F_1,G_1)}\cong\ 0.45$$

Example 2.9: Let U={x_1,x_2,x_3,x_4} be the universe. E = { e_1,e_2,e_3} be the set of parameters. We consider two

IVFS sets (F_1,E) and (G_1,E) .

Tabular form of (F_1,E):

	e_1	e_2	e_3
x_1	[0.2,0.9]	[0.0,1.0]	[0.2,0.8]
x_2	[0.4,0.8]	[0.3,0.9]	[0.3,1.0]
x_3	[0.4,1.0]	[0.3,0.7]	[0.0,0.7]
x_4	[0.1,0.9]	[0.5,1.0]	[0.3,0.8]

Table 8: Tabular presentation of IVFS set (F_1,E)

Tabular form of (G_1,E):

	e_1	e_2	e_3
x_1	[0.1,0.9]	[0.4,1.0]	[0.0,0.8]
x_2	[0.2,0.7]	[0.1,0.9]	[0.3,1.0]
x_3	[0.0,0.8]	[0.4,0.9]	[0.2,0.7]
x_4	[0.2,1.0]	[0.0,1.0]	[0.3,1.0]

Table 9: tabular presentation of IVFS set (G_1,E)

Now by definition **2.6** the Hamming distance between (F_1,E) and (G_1,E) is given by

$$d_H(F_1,G_1)=\frac{1}{2.3}\left[\sum_{i=1}^{3}\sum_{j=1}^{4}\left(\left|M_{F_1L}(e_i)(x_j)-M_{G_1L}(e_i)(x_j)\right|+\left|M_{F_1U}(e_i)(x_j)-M_{G_1U}(e_i)(x_j)\right|\right.\right.$$
$$\left.\left.+\left|W_{F_1}(e_i)(x_j)-W_{G_1}(e_i)(x_j)\right|\right)\right]$$
$$=0.9$$

.Therefore by equ.**(2.2)** the similarity measure between (F_1,E) and (G_1,E) based on Hamming distance is given by

$$S(F_1,G_1)=\frac{1}{1+d_H(F_1,G_1)}$$
$$=\frac{1}{1+0.9}$$
$$=\frac{1}{1.9}$$
$$\cong 0.52$$

Definition 2.10: [3] Let U={x_1,x_2,x_3, …… ,x_n}be the universe. E={ e_1,e_2,e_3 ,……. , e_m}be the set of parameters. Let (F_1,E) and (G_1,E) be two IVFS sets over U .E be the set of parameters . Then the similarity measure between (F_1,E) and (G_1,E) denoted by S(F_1,G_1) is defined as

$$S(F_1,G_1)=\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\left|M_{F_1L}(e_i)(x_j)-M_{G_1L}(e_i)(x_j)\right|\wedge\left|M_{F_1U}(e_i)(x_j)\cdots\right.\right.}{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\left|M_{F_1L}(e_i)(x_j)-M_{G_1L}(e_i)(x_j)\right|\vee\left|M_{F_1U}(e_i)(x_j)\cdots\right.\right.}$$

……………**(2.3)**

Example 2.11: LetU={x_1,x_2,x_3}be the universe. E={e_1,e_2,e_3} be the set of parameters. We consider two IVFS sets (F_1,E) and (G_1,E) .

Tabular form of (F_1,E):

	e_1	e_2	e_3
x_1	[0.7,0.9]	[0.6,0.7]	[0.5,0.8]
x_2	[0.6,0.8]	[0.2,0.5]	[0.6,0.9]
x_3	[0.5,0.6]	[0.0,0.7]	[0.2,1.0]

Table 10: tabular presentation of IVFS set (F_1,E)

Tabular form of (G_1,E):

	e_1	e_2	e_3
x_1	[0.2,0.8]	[0.4,0.9]	[0.3,0.6]
x_2	[0.4,0.7]	[0.4,0.5]	[0.8,0.9]
x_3	[0.0,1.0]	[0.2,0.5]	[0.8,1.0]

Table 11: Tabular presentation of IVFS set (G_1,E)

Now by definition **2.9** the similarity measure between (F_1,E) and (G_1,E) is given by

$$S(F_1,G_1)=\frac{\sum_{i=1}^{3}\sum_{j=1}^{3}\left(\left|M_{F_1L}(e_i)(x_j)-M_{G_1L}(e_i)(x_j)\right|\wedge\left|M_{F_1U}(e_i)(x_j)-M_{G_1U}(e_i)(x_j)\right|\right)}{\sum_{i=1}^{3}\sum_{j=1}^{3}\left(\left|M_{F_1L}(e_i)(x_j)-M_{G_1L}(e_i)(x_j)\right|\vee\left|M_{F_1U}(e_i)(x_j)-M_{G_1U}(e_i)(x_j)\right|\right)}$$

$\cong 0.42$

Example 2.12: Let U={x_1,x_2,x_3,x_4} be the universe. E={e_1,e_2,e_3} be the set of parameters. We consider two IVFS sets (F_1,E) and (G_1,E) .

Tabular form of (F_1,E):

	e_1	e_2	e_3
x_1	[0.2,0.9]	[0.0,1.0]	[0.2,0.8]
x_2	[0.4,0.8]	[0.3,0.9]	[0.3,1.0]
x_3	[0.4,1.0]	[0.3,0.7]	[0.0,0.7]
x_4	[0.1,0.9]	[0.5,1.0]	[0.3,0.8]

Table 12: Tabular presentation of IVFS set (F_1,E)

Tabular form of (G_1,E):

	e_1	e_2	e_3
x_1	[0.1,0.9]	[0.4,1.0]	[0.0,0.8]
x_2	[0.2,0.7]	[0.1,0.9]	[0.3,1.0]
x_3	[0.0,0.8]	[0.4,0.9]	[0.2,0.7]
x_4	[0.2,1.0]	[0.0,1.0]	[0.3,1.0]

Table 13: tabular presentation of IVFS set (G_1,E)

Now by definition **2.9** the similarity measure between (F_1,E) and (G_1,E) is given by

$$S(F_1,G_1)=\frac{\sum_{i=1}^{3}\sum_{j=1}^{4}\left(\left|M_{F_1L}(e_i)(x_j)-M_{G_1L}(e_i)(x_j)\right|\wedge\left|M_{F_1U}(e_i)(x_j)-\cdots\right.\right.}{\sum_{i=1}^{3}\sum_{j=1}^{4}\left(\left|M_{F_1L}(e_i)(x_j)-M_{G_1L}(e_i)(x_j)\right|\vee\left|M_{F_1U}(e_i)(x_j)-\cdots\right.\right.}$$

$\cong 0.185$

Definition 2.13:[3] Let (F,E) and (G,E) be two IVFS sets over U. Then (F,E) and (G,E) are said be α-similar, denoted by $(F,A)\overset{\alpha}{\cong}(G,B)$ if and only if S((F,E),(G,E)) > α for α ∈(0,1). We call the two IVFS sets significantly similar if S((F,E),(G,E)) >$\frac{1}{2}$.

Example 2.13: Consider the example **2.4**. In this example the similarity measure between the IVF setSs(F,E) and (G,E) , is S(F,G) = 0.2972 <$\frac{1}{2}$. Therefore (F,E) and (G,E) are not

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significantly similar. But if we consider example **2.5** then similarity measure between IVFS sets (F_1,E) and (G_1,E) is $S(F_1,G_1)=0.847 > \frac{1}{2}$ therefore (F_1,E) and (G_1,E) are significantly similar.

3. Application on COVID-19

First we construct a decision making method based on similarity measure of two IVFS sets. It is a medical diagnosis problem on COVID-19..

Similarity measure of two IVFS sets based on Hamming distance can be applied to estimate the possibility that an ill person having certain symptoms. He/She is suffering from COVID-19 or not .We construct an IVFS set for the disease and another IVFS set for ill person. Then we find the similarity measure of these two IVFS sets. If the similarity measure is greater than or equal to **C (which can be fixed by a medical expert person**) then we conclude that the person is possibly suffering from COVID-19 . If the similarity measure is less than **C** then the person is not possibly suffering from the disease COVID-19.

The steps of this algorithm are:

Step 1. An IVFS set (F,A) is Constructed for disease over the universe U. It is based on an expert.

Step 2. An IVFS set (G,B) is Constructed over the universe U for a patient.

Step 3. Calculate the Hamming distance between (F,A) and (G,B).

Step 4. Calculate similarity measure of (F,A) and (G,B).

Step 5. Estimate result by using the similarity.

We take **C = 0.5 .**

we choose a range belongs to [0,1]. For measuring the symptoms e_1 to e_6 [0.0-0.19], [0.2-0.39], [0.4-0.59] ,[0.6-0.79], [0.8-0.1], are the scales -, Low, Moderate , Highly moderate, High, Very high respectively(according to the medical experts}...

Example 3.1: Assume that the universal set U contains only two elements x_1(COVID-19positive) and x_2 (not COVID-19positive) . So. U={x_1, x_2}. Here the set of parameters is a set of certain visible symptoms. Let E={e_1,e_2,e_3,e_4,e_5,e_6}, where e_1=fever, e_2=dry cough, e_3=tiredness, e_4 = headache, , e_5 =Loss of taste or smell, e_6= difficulty breathing or shortness of breath ..

Step 1: Construct a IVFSset (F,A) over U for COVID-19 patient as given below, which can be prepared with the help of a medical expert persons.

$F(x_1)$= { e_1= Fever [0.2,0.7],.e_2= Dry cough[0.3,0.8] , e_3 =Tiredness[0.7,1.0], e_4= Headache[0.4,0.8] , e_5 =Loss of taste or smell[0.5,0.7], e_6= difficulty breathing or shortness of breath[0.2,0.6]} .

Thus e_1= Fever [0.2,0.7] means the patient has fever increasing from moderate to high.. Similarly for the others.

$F(x_2)$= { e_1= Fever[0.1,0.3],.e_2= Dry cough[0.2,0.5] , e_3 =Tiredness[0.4,0.6], e_4= Headache[0.3,0.4] , e_5 =Loss of taste or smell[0.5,0.6], e_6= difficulty breathing or shortness of breath[0.3,0.5]}

Thus,

(F, A)	e_1	e_2	e_3	e_4	e_5	e_6
x_1	[0.2,0	[0.3,0	[0.7,1	[0.4,0	[0.5,0	[0.2,0

	.7]	.8]	.0]	.8]	.7]	.6]
x_2	[0.1,0.3]	[0.2,0.5]	[0.4,0.6]	[0.3,0.4]	[0.5,0.6]	[0.3,0.5]

Table 14: tabular presentation of IVFSS (F,A)

Step 2: Construct a IVFSS (G,B) over U based on data of ill person as given below.

(G, B)	e_1	e_2	e_3	e_4	e_5	e_6
x_1	[0.8,1.0]	[0.0,0.2]	[0.1,0.3]	[0.0,0.2]	[0.1,0.2]	[0.7,1.0]
x_2	[0.8,0.9]	[0.7,1.0]	[0.0,0.1]	[0.9,1.0]	[0.9,1.0]	[0.4,1.0]

Table 15: tabular presentation of IVFSS (G,B)

where A=B=E={e_1,e_2,e_3,e_4,e_5,e_6},

The sub-intervals of the unit interval denote the range of the symptoms.

Step 3: Calculate Hamming distance of (F,A) and (G,B):

Now by definition **2.1** the Hamming distance between (F,A) and (G,B) is given by

$$d_H(F,G) = \frac{1}{2.6}\left[\sum_{i=1}^{6}\sum_{j=1}^{2}\left(\left|M_{FL}(e_i)(x_j) - M_{GL}(e_i)(x_j)\right| + \left|M_{FU}(e_i)(x_j) - M_{GU}(e_i)(x_j)\right| + \left|W_F(e_i)(x_j) - W_G(e_i)(x_j)\right|\right)\right]$$

$$= 1.117$$

Step 4: Calculate similarity measure of (F,A) and (G,B):

By equation **(2.2)** the similarity measure between (F,A) and (G,B) based on Hamming distance is given by

$$S(F,G) = \frac{1}{1+d_H(F,G)}$$

$$= \frac{1}{1+1.117}$$

$$= \frac{1}{2.117}$$

$$\cong 0.47 < 0.5$$

Step 5: Here similarity measure between two IVFSSs (F,A) and (G,B) that is S(F,G)=0.47<**0.5**, therefore the person is not possibly suffering from COVID-19.

Example 3.2: Consider the example **3.1** with different person.

Step 1: Construct a IVFSS (F,A) over U for COVID-19 as given below, which can be prepared with the help of a medical expert persons.

(F, A)	e_1	e_2	e_3	e_4	e_5	e_6
x_1	[0.2,0.7]	[0.3,0.8]	[0.7,1.0]	[0.4,0.8]	[0.5,0.7]	[0.2,0.6]
x_2	[0.1,0.3]	[0.2,0.5]	[0.4,0.6]	[0.3,0.4]	[0.5,0.6]	[0.3,0.5]

Table 16: tabular presentation of IVFSS (F,A)

Step 2: Construct a IVFSS (H,B) over U based on data of ill person as given below.

(H, B)	e_1	e_2	e_3	e_4	e_5	e_6
x_1	[0.1,0.6]	[0.1,0.4]	[0.3,0.9]	[0.3,0.8]	[0.3,0.7]	[0.3,0.7]
x_2	[0.2,0.5]	[0.3,0.8]	[0.4,0.7]	[0.2,0.5]	[0.4,0.8]	[0.4,0.6]

Table 17: tabular presentation of IVFSS (H,B)

where A=B=E={e_1,e_2,e_3,e_4,e_5,e_6},

Step 3: Calculate Hamming distance of (F,A) and (H,B):

Now by definition **2.1** the Hamming distance between (F,A) and (H,B) is given by

$$d_H(F,H)=\frac{1}{2.6}\left[\sum_{i=1}^{6}\sum_{j=1}^{2}\Big(\left|M_{FL}(e_i)(x_j)-M_{HL}(e_i)(x_j)\right|+\left|M_{FU}(e_i)(x_j)-M_{HU}(e_i)(x_j)\right| + \left|W_F(e_i)(x_j)-W_H(e_i)(x_j)\right|\Big)\right]$$
$$=0.42$$

Step 4: Calculate similarity measure of (F,A) and (H,B):

By equation **(2.2)** the similarity measure between (F,A) and (H,C) based on Hamming distance is given by

$$S(F,H)=\frac{1}{1+d_H(F,H)}$$
$$=\frac{1}{1+0.42}$$
$$=\frac{1}{1.42}$$
$$\cong 0.704 > 0.5$$

Step 5: Here similarity measure between two IVFSSs (F,A) and (H,B) that is S(F,H)=0.704>**0.5**, therefore the person is possibly suffering from COVID-19.

4. Conclusions

Here we have defined different types of similarity measure between two IVFSsets and proposed similarity measures of two IVFSsets. Then we construct a decision making method based on similarity measures. Finally we give two simple examples to show the possibilities of diagnosis of COVID-19 diseases. In these examples if we use the other distances, we can obtain similar

results. Thus we can use the method to solve the problem that contain uncertainty such as problem in social, economic system, pattern recognition, medical diagnosis, game theory coding theory and so on. Lastly we observe that all the parameters are important for COVID-19 patients.

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References

[1] Hong-meiJu and Feng-Ying Wang, A similarity measure for interval-valued fuzzy sets and its application in supporting medical diagnostic reasoning, The Tenth International Symposium on Operation Research and Its Applications ISORA 2011 251–257.

[2] D.Molodtsov, Soft set theory–first results, Computers and Mathematics with Application 37 (1999) 19–31.

[3] Anjan Mukherjee and SadhanSarkar, Similarity measures of interval-valued fuzzy soft sets and their application in decision making problems, Annals of Fuzzy Mathematics and Informatics, 8(9) (2014) 447– 460.

[4]Anjan Mukherjee and Abhik Mukherjee, Application of Fuzzy Matrix Theory In COVID-19 Pandemic,IOSR Journal of Mathematics (IOSR-JM) Volume 16, Issue 4 Ser. V (Jul.–Aug. 2020), PP 52-56.

[5] X.B.Yang, T.Y.Lin, J.Y.Yang, Y.Li and D.Yu, Combination of interval-valued fuzzy set and soft set, Computers and Mathematics with Applications 58(3) (2009) 521–527.

[6] L.A. Zadeh, Fuzzy set, Information and Control 8 (1965) 338–353.

[7] L.A. Zadeh, The concept of a linguistic variable and its application to approximate reasoning-1, Information Sciences 8 (1975) 199–249.