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Applications of Disease Identification in the Advancement of Intuitionistic Fuzzy Sets with Interval

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Abstract:

The Euclidean, Normalized Euclidean, Normalized Hamming, and Hamming distance measurements of IVIFSST are among the various distance measures examined in this article. The IVIFSST component plays a more important role in this case since the second type of IVIFS provides the best answer for determining the shortest distance when making a decision, even though the IFS and their extensions of membership grades as well as the non-membership grades are not constantly feasible to our fulfillment. There is a reasonable possibility that a non-zero hesitation part will exist at every evaluation point when employing this notion, especially in medical diagnosis. The IVIFSST played a crucial part in the medical field in determining reliable identification values. Lastly, we determine the shortest path between utilizing normalized hamming distance measurements over IVIFSST to assess patients and illness.

Keywords: Intuitionistic Fuzzy Sets, Intuitionistic Fuzzy Sets of Second Type, Interval Valued Intuitionistic Fuzzy Sets, Interval Valued Intuitionistic Fuzzy Sets of Second Type.

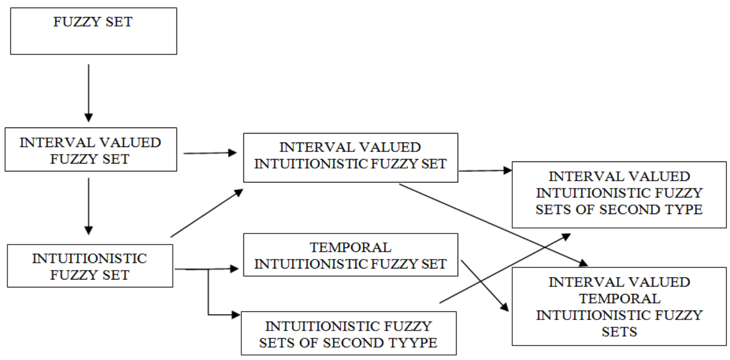
2000 AMS Subject Classification: 03D45, 03F55, 03B20, 03E72.

1 Introduction

A novel wing of IVIFS, Interval Valued Intuitionistic Fuzzy Sets of Second Type (IVIFSST), was introduced by the corresponding author [9] and some of its characteristics were determined. The several distance measures, such as d_H −Hamming, d_{NH} −Normalized Hamming, d_E-Euclidean, and

d_{NE} –Normalized Euclidean distance measures over IVIFSST, will be examined in this research work. The results will also be compared with the current IVIFS measurements. Additionally, we use the IVIFSST idea in medical diagnosis to identify the normalized hamming distance measure to determine the shortest distance.

Intuitionistic fuzzy sets (IFS) [3] were first described by Atanassos K. T in 1986, which are fuzzy subsets and also an excellent simplification of fuzzy sets. Since the inception of IFS, numerous researchers have exposed their significance in the speculation and apply it in the several areas, including pattern detection, machine learning, similarity processing, decision making, and more. Many authors illustrate numerous implications using this intuitionistic concept of fuzzy sets. In the year 1994, K. T. Atanassov have introduce the few operations over intuitionistic fuzzy sets. Ranjit Biswas along with A. Ranjan Roy and D. Supriya Kumar [7] wished-for certain operations over IFS in 2000 and also proposed medical diagnosis through intuitionistic fuzzy sets (IFS) in 2001. In 2010, Beloslav Riecan and Atanassov, K.T. proposed n-extraction as well as division operations across fuzzy intuitionistic sets [18].



Additionally, both IFS and IVFS are oversimplified by the term Interval Valued Intuitionistic Fuzzy Sets [IVIFS] [2], which was initially used by George Gargov and Krassimir T. Atanasov in 1989. As IVIFS developed further, a number of scholars expressed interest in the theory and used it in diverse contexts. IVIFS operators were later introduced by K. T. Atanassov in 1994 [4]. Zeshui Xu [24] presented methods for gathering IVIFS data and reaching a conclusion in 2007. Following the application of this idea to group decision-making issues by Gui, Wu Wei, and Xiang – Rong Wang [25, 26], numerous arithmetic IVIFS aggregation operators were built-up in the year 2007.

In 2012, Bhowmik, Madhumangal Pal, and Monoranjan presented some new results on comprehensive IVIFS. Interval-valued intuitionistic hesitant fuzzy aggregation operators were suggested by Zhiming Zhang [30] and used in fuzzy group decision aggregations as well. In 2014, a novel procedures over interval valued intuitionistic hesitant FS was projected by Florentin Smarandache & Broumi in 2014. In the year 2017, Vivekanandan, S. N. Iyengar [22] studied the tricky tasks for choosing the complicate features from the enormous set of existing features and predict the heart disease are conceded out. In 2017, Sai Prasad Potharaju and Sreedevi M [19] , studied a novel M-Cluster of quality choosing approach based on symmetrical uncertainty for growing classification accuracy of medical datasets further in 2018 the same author investigated new system for categorization precision of wisdom algorithms over the cardio topography data by using the pre processing method. Further in 2019, Y. K. Chiam, Md. S Amin and V. Kasturi Devi [27] investigate the important of features along information pulling out technique that can develop the truth of predict cardiovascular infection.

The article is organized as follow: in the second sector, we examine a range of distance measures over IVIFSST in addition to provide a few basic definitions. Using a variety of operators, we examine the characteristics of hamming distance in the third section. The idea of IVIFSST is applied to medical diagnostics in the fourth section, and the outcome is examined using the available metrics. The last portion concludes this paper.

2. Preliminaries

Definition 2.1[3] Assume that the set X is not empty. Items with the following structure (IFS) are considered intuitionistic fuzzy sets. For Z in X, the formula is

$$Z = \{\langle w, \chi_Z(w), \phi_Z(\mathrm{w})\rangle |\ w \in X\}$$

For any element $w \in X$ with the condition $0 \leq \chi_Z(w) + \phi_Z(\mathrm{w}) \leq 1$, the elements are represented by the degrees of membership $\chi_Z: X \to [0,1]$ and non-membership $\phi_Z: X \to [0,1]$ respectively.

Definition 2.2[1] Let's fix a set X. The Intuitionistic Fuzzy Sets of Second Type (IFSST) Z in X is an object of the following kind.

$$Z = \{\langle w, \chi_Z(w), \phi_Z(\mathrm{w})\rangle |\ w \in X\}$$

It is represented as $\chi_Z: X \to [0,1]$ and $\phi_Z: X \to [0,1]$, where χ_Z and ϕ_Z represent the degree of membership grade and the degree of non-membership grade of the element $w \in X$, correspondingly, when

$$0 \leq \chi_Z^2(w) + \phi_Z^2(x) \leq 1.$$

Definition 2.3[2] The source Z in X is defined as an Interval Valued Intuitionistic Fuzzy Set (IVIFS) in the following way.

$$Z = \{\langle w, M_Z(w), N_Z(w)\rangle |\ w \in X\}$$

where W_Z & N_Z : X → [0, 1]. The member is represented as $M_Z(w) = [M_{ZL}(w),\ M_{ZU}(w)]$, and the non-member is represented as $N_Z(w) = [N_{ZL}(w), N_{ZU}(w)]$. The interval $M_Z(w)$ and $N_Z(w)$ show the amount grade of membership value and the grade of non-membership of a component w belongs to X. given that

$$M_{ZU}(w) + N_{ZU}(w) \leq 1\ \forall\ w \in X$$

Definition 2.4[9] The second-type interval-valued Intuitionistic fuzzy sets (IVIFSST) Z in X are Provided by

$$Z = \{\langle x, M_Z(w), N_Z(w)\rangle |\ w \in X\}$$

where W_Z & N_Z : X → [0, 1]. The member is represented as $M_Z(w) = [M_{ZL}(w),\ M_{ZU}(w)]$, and the non-member is represented as $N_Z(w) = [N_{ZL}(w), N_{ZU}(w)]$. The interval $M_Z(w)$ and $N_Z(w)$ show the amount of membership and the degree of non-membership of a component w in X. given that

$$M^2_{ZU}(w) + N^2_{ZU}(w) \le 1 \; \forall \, w \in X$$

Definition 2.5[4] In $X = \{w_1, w_2, .. w_n\}$, let A and B be two intuitionistic fuzzy sets of second type. The different distance measurements are defined as follows:

d_{HIFSST} −Hamming Distance (A, B)

$$= \frac{1}{4}\sum_{i=1}^{n}\left[\left|\mu^2{}_A(w_i) - \mu^2{}_B(w_i)\right| + \left|\nu^2{}_A(w_i) - \nu^2{}_B(w_i)\right| + |\pi^2{}_A(w_i) - \pi^2{}_B(w_i)|\right]$$

Normalized Hamming Distance ($d_{NHIFSST}$ (A, B))

$$= \frac{1}{4\boldsymbol{n}}\sum_{i=1}^{n}\left[\left|\mu^2{}_A(w_i) - \mu^2{}_B(w_i)\right| + \left|\nu^2{}_A(w_i) - \nu^2{}_B(w_i)\right| + |\pi^2{}_A(w_i) - \pi^2{}_B(w_i)|\right]$$

d_{EIFSST} −Euclidean Distance (A, B)

$$= \frac{1}{2}\sum_{i=1}^{n}\left[\left(\mu^2{}_A(w_i) - \mu^2{}_B(w_i)\right)^2 + \left(\nu^2{}_A(w_i) - \nu^2{}_B(w_i)\right)^2 + \left(\pi^2{}_A(w_i) - \pi^2{}_B(w_i)\right)^2\right]^{\frac{1}{2}}$$

Normalized Euclidean Distance ($d_{NEIFSST}$ (A, B))

$$= \frac{1}{2\sqrt{\mathrm{n}}}\sum_{i=1}^{n}\left[\left(\mu^2{}_A(w_i) - \mu^2{}_B(w_i)\right)^2 + \left(\nu^2{}_A(w_i) - \nu^2{}_B(w_i)\right)^2 + \left(\pi^2{}_A(w_i) - \pi^2{}_B(w_i)\right)^2\right]^{\frac{1}{2}}$$

Example 2.6 Suppose that two vehicles, M and N, begin to move from the same spot and they are crossed paths in different ways. The second types of IFS are used to calculate the distance between two autos. Examine the second type of IFSs M and N in X = {a, b, c, d}.

M $= < 0.6, 0.4, 0 >/a + < 0.4, 0.2, 0.4 >/b + < 0.5, 0.1, 0.4 >/c + < 0.2, 0.3, 0.5 >/$d

N $= < 0.3, 0.4, 0.3 >/a + < 0.2, 0.7, 0.1 >/b + < 0.5, 0.3, 0.2 >/c$

Consequently, when considering all three factors, the Hamming distance equals (membership, non-membership, and uncertainty)

$$= \frac{1}{2}\,[|0.62 - 0.32| + |0.42 - 0.42| + |02 - 0.32| + |0.42 - 0.22| + |0.22 - 0.72| +$$

$$|0.42 - 0.12| + |0.52 - 0.52| + |0.12 - 0.32| + |0.42 - 0.22| + |0.22 - 02|$$

$$+|0.32 - 12| + |0.52 - 02]$$

$$= 1.24$$

Thus, 0.31 is the Normalized Hamming distance. When considering only the two parameters (membership and non-membership), the Hamming distance equals

$$= \frac{1}{2}\left[|0.62 - 0.32| + |0.42 - 0.42| + |0.42 - 0.22| + |0.22 - 0.72| + |0.52 - 0.52| + |0.12 - 0.32| + |0.22 - 02| + |0.32 - 12|\right]$$

$$= 1.87$$

Thus, 0.47 is the Normalized Hamming distance. Considering the three factors of membership, non -membership, and uncertainty, the Euclidean distance equals

$$=0.5^{0.5}\left[(0.6^2 - 0.3^2)^2 + (0.4^2 - 0.4^2)^2 + (0^2 - 0.3^2)^2 + (0.4^2 - 0.2^2)^2 + (0.2^2 - 0.7^2)^2 + (0.4^2 - 0.1^2)^2 + (0.5^2 - 0.5^2)^2 + (0.1^2 - 0.3^2)^2 + (0.4^2 - 0.2^2)^2 + (0.2^2 - 0^2)^2 + (0.3^2 - 1^2)^2 + (0.5^2 - 0^2)^2\right.$$

= 1

Therefore, 0.5 is the Normalized Euclidean distance. When considering only two parameters (membership and non-membership), the Euclidean distance equals

$$=0.5^{0.5}\left[(0.6^2 - 0.3^2)^2 + (0.4^2 - 0.4^2)^2 + (0.4^2 - 0.2^2)^2 + (0.2^2 - 0.7^2)^2 + +(0.5^2 - 0.5^2)^2 + (0.1^2 - 0.3^2)^2 + (0.2^2 - 0^2)^2 + (0.3^2 - 1^2)^2\right.$$

= 0.75

Thus, 0.43 is the Normalized Euclidean distance.

Definition 2.7[15] Assume that A and B are in IVIFSST and that X is a non-empty set. The different measures of distance between A and B are then defined as follows

$d_H(A,B)$- Hamming Distance

$$= \frac{1}{4}\sum_{i=1}^{n}\left[\left|M^2{}_{AL}(w_i) - M^2{}_{BL}(w_i)\right| + \left|M^2{}_{AU}(w_i) - M^2{}_{BU}(w_i)\right| + \left|N^2{}_{AL}(w_i) - N^2{}_{BL}(w_i)\right| + \left|N^2{}_{AU}(w_i) - N^2{}_{BU}(w_i)\right| + \left|\pi^2{}_{AL}(w_i) - \pi^2{}_{BL}(w_i)\right| + \left|\pi^2{}_{AU}(w_i) - \pi^2{}_{BU}(w_i)\right|\right]$$

$d_{NH}(A,B)$- Normalized Hamming Distance

$$= \frac{1}{4n}\sum_{i=1}^{n}\left[\left|M^2{}_{AL}(w_i) - M^2{}_{BL}(w_i)\right| + \left|M^2{}_{AU}(w_i) - M^2{}_{BU}(w_i)\right| + \left|N^2{}_{AL}(w_i) - N^2{}_{BL}(w_i)\right| + \left|N^2{}_{AU}(w_i) - N^2{}_{BU}(w_i)\right| + \left|\pi^2{}_{AL}(w_i) - \pi^2{}_{BL}(w_i)\right| + \left|\pi^2{}_{AU}(w_i) - \pi^2{}_{BU}(w_i)\right|\right]$$

$d_E(A,B)$ −Euclidean Distance

$$d_E(A,B) = \frac{1}{2}\sum_{i=1}^{n}\left[\left(M^2{}_{AL}(w_i) - M^2{}_{BL}(w_i)\right)^2 + \left(M^2{}_{AU}(w_i) - M^2{}_{BU}(w_i)\right)^2\right.$$

$$+\left(N^2{}_{AL}(w_i)-N^2{}_{BL}(w_i)\right)^2+\left(N^2{}_{AU}(w_i)-N^2{}_{BU}(w_i)\right)^2$$

$$+\left(\pi^2{}_{AL}(w_i)-\pi^2{}_{BL}(w_i)\right)^2+\left(\pi^2{}_{AU}(w_i)-\pi^2{}_{BU}(w_i)\right)^2\Big]^{\frac{1}{2}}$$

$d_{NE}(A,B)$-**Normalized Euclidean Distance**

$$=\frac{1}{2\sqrt{n}}\sum_{i=1}^{n}\Big[\left(M^2{}_{AL}(w_i)-M^2{}_{BL}(w_i)\right)^2+\left(M^2{}_{AU}(w_i)-M^2{}_{BU}(w_i)\right)^2$$

$$+\left(N^2{}_{AL}(w_i)-N^2{}_{BL}(w_i)\right)^2+\left(N^2{}_{AU}(w_i)-N^2{}_{BU}(w_i)\right)^2$$

$$+\left(\pi^2{}_{AL}(w_i)-\pi^2{}_{BL}(w_i)\right)^2+\left(\pi^2{}_{AU}(w_i)-\pi^2{}_{BU}(w_i)\right)^2\Big]^{\frac{1}{2}}$$

Example 2.8 In Interval-valued Intuitionistic Fuzzy Sets of Second Type, let's consider A and B as follows:

$$A = \{<[0.6,0.3],[0.2,0.2],[0.2,0.5]>,<[0.5,0.3],[0.3,0.4],[0.2,0.3]>\}$$

$$B = \{<[0.5,0.2],[0.4,0.3],[0.1,0.5]>,<[0.4,0.3],[0.1,0.3],[0.5,0.4]>\}$$

Then,

i. d_H (A, B)-Hamming Distance is 0.15;
ii. d_{NH} (A, B)-Normalized Hamming Distance is 0.08;
iii. d_E(A, B)-Euclidean Distance is 0.37; and
iv. d_{NE} (A, B)-Normalized Euclidean Distance is 0.26.

We suppose that the d_{NH} (A, B)-Normalized Hamming Distance yields the best result between A and B based on the aforementioned results. Because A and B are only a very short or tiny distance apart. For this reason, we employ the d_{NH} (A, B) (A, B)-Normalized Hamming distance in our applications due to its high accuracy assurance rate.

3. Relation between various distance measure using different operators

This section, we study various distance metrics to examine the relationships between different operators.

Theorem 3.1 Let X be a set that isn't empty. In the case of any two IVIFSSTs A and B, we have

(i) $d_{HIVIFSST}(A, A.B) = d_{HIVIFSST}(B, A+B)$,

(ii) $d_{HIVIFSST}(A+B, A@B) = d_{HIVIFSST}(A.B, A@B)$,

(iii) $d_{HIVIFSST}\left(G_{\alpha,\beta}(A),\ F_{\alpha,\beta}(A)\right) = d_{HIVIFSST}(H_{\alpha,\beta}(A),\ J_{\alpha,\beta}(A))$,

(iv) $d_{HIVIFSST}\left(F_{\alpha,\beta}(A),\ H_{\alpha,\beta}(A)\right) = d_{HIVIFSST}(G_{\alpha,\beta}(A),\ J_{\alpha,\beta}(A))$.

Proof: Let

$$A = \{\langle w, [M_{AL}(w), M_{AU}(w)], [N_{AL}(w), N_{AU}(w)]\rangle \mid w \in X\}$$

And

$$B = \{\langle w, [M_{BL}(w), M_{BU}(w)], [N_{BL}(w), N_{BU}(w)]\rangle \mid w \in X\}$$

Then,

$$A + B = \{\langle w, [M_{AL}^2(w) + M_{BL}^2(w) - M_{AL}^2(w).M_{BL}^2(w), M_{AU}^2(w) + M_{BU}^2(w) - M_{AU}^2(w).M_{BU}^2(w)], [N_{AL}^2(w).N_{BL}^2(w), N_{AU}^2(w).N_{BU}^2(w)]\rangle \mid w \in X\}$$

$$A.B = \{< w, [M^2{}_{AL}(w)M^2{}_{BL}(w), M^2{}_{AU}(w)M^2{}_{BU}(w)], [N^2{}_{AL}(w) + N^2{}_{BL}(w) - N^2{}_{AL}(w)N^2{}_{BL}(w), N^2{}_{AU}(w) + N^2{}_{BU}(w) - N^2{}_{AU}(w)N^2{}_{BU}(w)] \mid w \in X\}$$

$$A \$ B = \{< w, \left[\sqrt{M_{AL}(w)M_{BL}(w)}, \sqrt{M_{AU}(w)M_{BU}(w)}\right], \left[\sqrt{N_{AL}(w)N_{BL}(w)}, \sqrt{N_{AU}(w)N_{BU}(w)}\right] > \mid w \in X\}$$

$$A \# B = \{< w, \left[\frac{2M_{AL}(w)M_{BL}(w)}{M^2{}_{AL}(w) + M^2{}_{BL}(w)}, \frac{2M_{AU}(w)M_{BU}(w)}{M^2{}_{AU}(w) + M^2{}_{BU}(w)}\right], \left[\frac{2N_{AL}(w)N_{BL}(w)}{N^2{}_{AL}(w) + N^2{}_{BL}(w)}, \frac{2N_{AU}(w)N_{BU}(w)}{N^2{}_{AU}(w) + N^2{}_{BU}(w)}\right] > \mid w \in X\}$$

$$A @ B = \{< w, \left[\frac{M^2{}_{AL}(w) + M^2{}_{BL}(w)}{2}, \frac{M^2{}_{AU}(w) + M^2{}_{BU}(w)}{2}\right], \left[\frac{N^2{}_{AL}(w) + N^2{}_{BL}(w)}{2}, \frac{N^2{}_{AU}(w) + N^2{}_{BU}(w)}{2}\right] > \mid w \in X\}$$

$$F_{\alpha,\beta}(A) = \left\{\langle w, \left[M_{AL}(w), \sqrt{M^2{}_{AU}(w) + \alpha^2\left(1 - M^2{}_{AU}(w) - N^2{}_{AU}(w)\right)}\right], \left[N_{AL}(w), \sqrt{N^2{}_{AU}(w) + \beta^2\left(1 - M^2{}_{AU}(w) - N^2{}_{AU}(w)\right)}\right]\right\rangle \mid w \in \mathrm{X}\right\}$$

$$G_{\alpha,\beta}(A) = \{\langle w, [\alpha M_{AL}(w), \alpha M_{AU}(w)], [\beta N_{AL}(w), \beta N_{AU}(w)]\rangle \mid w \in \mathrm{X}\}$$

$$H_{\alpha,\beta}(A) = \left\{\langle w, [\alpha\, M_{AL}(w), \alpha\, M_{AU}(w)], \left[N_{AL}(w), \sqrt{N^2{}_{AU}(w) + \beta^2\left(1 - M^2{}_{AU}(w) - N^2{}_{AU}(w)\right)}\right]\right\rangle \mid w \in \mathrm{X}\right\}$$

$$J_{\alpha,\beta}(A) = \left\{\left\langle w_., \left[M_{AL}(w_.), \sqrt{M^2{}_{AU}(w_.) + \alpha^2\left(1 - M^2{}_{AU}(w_.) - N^2{}_{AU}(w_.)\right)}\right],\right.\right.$$

$$\left.\left.[\beta N_{AL}(w_.), \beta N_{AU}(w_.)]\right\rangle \middle| w_. \in X\right\}$$

Now, (i)

$$d_{HIVIFSST}(A, A.B) = \frac{1}{4}\sum_{i}^{n}\left\{\left|M_{AL}^2(w_i) - M_{AL}^2(w_i).M_{BL}^2(w_i)\right| + \left|M_{AU}^2(w_i) - M_{AU}^2(w_i).M_{BU}^2(w_i)\right|,\right.$$

$$\left.\begin{matrix}\left|N_{AL}^2(w_i) - N_{AL}^2(w_i) - N_{BL}^2(w_i) + N_{AL}^2(w_i).N_{BL}^2(w_i)\right| + \\ \left|N_{AU}^2(w_i) - N_{AU}^2(w_i) - N_{BU}^2(w_i) + N_{AU}^2(w_i).N_{BU}^2(w_i)\right|\end{matrix}\right\}$$

$$= \frac{1}{4}\sum_{i}^{n}\left\{\left|M_{AL}^2(w_i) - M_{AL}^2(w_i).M_{BL}^2(w_i)\right| + \left|M_{AU}^2(w_i) - M_{AU}^2(w_i).M_{BU}^2(w_i)\right|,\right.$$

$$\left.\left|N_{BL}^2(w_i) - N_{AL}^2(w_i).N_{BL}^2(w_i)\right| + \left|N_{BU}^2(w_i) - N_{AU}^2(w_i).N_{BU}^2(w_i)\right|\right\}$$

and

$$d_{HIVIFSST}(B, A + B) = \frac{1}{4}\sum_{i}^{n}\left\{\left|M_{BL}^2(w_i) - M_{BL}^2(w_i) - M_{AL}^2(w_i) + M_{AL}^2(w_i).M_{BL}^2(w_i)\right| +\right.$$

$$\left|M_{BU}^2(w_i) - M_{BU}^2(w_i) - M_{AU}^2(w_i) + M_{AU}^2(w_i).M_{BU}^2(w_i)\right|,$$

$$\left|N_{BL}^2(w_i) - N_{BL}^2(w_i).N_{AL}^2(w_i)\right| +$$

$$\left.\left|N_{BU}^2(w_i) - N_{BU}^2(w_i).N_{AU}^2(w_i)\right|\right\}$$

$$= \frac{1}{4}\sum_{i}^{n}\left\{\left|-M_{AL}^2(w_i) + M_{AL}^2(w_i).M_{BL}^2(w_i)\right| + \left|-M_{AU}^2(w_i) + M_{AU}^2(w_i).M_{BU}^2(w_i)\right|,\right.$$

$$\left.\left|N_{BL}^2(w_i) - N_{AL}^2(w_i).N_{BL}^2(w_i)\right| + \left|N_{BU}^2(w_i) - N_{AU}^2(w_i).N_{BU}^2(w_i)\right|\right\}$$

$$= \frac{1}{4}\sum_{i}^{n}\left\{\left|M_{AL}^2(w_i) - M_{AL}^2(w_i).M_{BL}^2(w_i)\right| + \left|M_{AU}^2(w_i) - M_{AU}^2(w_i).M_{BU}^2(w_i)\right|,\right.$$

$$\left.\left|N_{BL}^2(w_i) - N_{AL}^2(w_i).N_{BL}^2(w_i)\right| + \left|N_{BU}^2(w_i) - N_{AU}^2(w_i).N_{BU}^2(w_i)\right|\right\}$$

Therefore,

$$d_{HIVIFSST}(A, A.B) = d_{HIVIFSST}(B, A + B).$$

Hence proved the first part of the theorem.

We have to prove that (ii) $d_{HIVIFSST}(A + B, A@B) = d_{HIVIFSST}(A.B, A@B)$

$d_{HIVIFSST}(A + B, A@B) =$

$$= \frac{1}{4}\sum_{i}^{n}\left\{\left|M_{AL}^{2}(w_i) + M_{BL}^{2}(w_i) - M_{AL}^{2}(w_i).M_{BL}^{2}(w_i) - \frac{M_{AL}^{2}(w_i) + M_{BL}^{2}(w_i)}{2}\right| + \left|M_{AU}^{2}(w_i) + M_{BU}^{2}(w_i) - M_{AU}^{2}(w_i).M_{BU}^{2}(w_i) - \frac{M_{AU}^{2}(w_i) + M_{BU}^{2}(w_i)}{2}\right|, \left|N_{AL}^{2}(w_i).N_{BL}^{2}(w_i) - \frac{N_{AL}^{2}(w_i) + N_{BL}^{2}(w_i)}{2}\right| + \left|N_{AU}^{2}(w_i).N_{BU}^{2}(w_i) - \frac{N_{AU}^{2}(w_i) + N_{BU}^{2}(w_i)}{2}\right|\right\}$$

$$= \frac{1}{4}\sum_{i}^{n}\left\{\left|\frac{M_{AL}^{2}(w_i) + M_{BL}^{2}(w_i)}{2} - M_{AL}^{2}(w_i).M_{BL}^{2}(w_i)\right| + \left|\frac{M_{AU}^{2}(w_i) + M_{BU}^{2}(w_i)}{2} - M_{AU}^{2}(w_i).M_{BU}^{2}(w_i)\right|, \left|\frac{N_{AL}^{2}(w_i) + N_{BL}^{2}(w_i)}{2} - N_{AL}^{2}(w_i).N_{BL}^{2}(w_i)\right| + \left|\frac{N_{AU}^{2}(w_i) + N_{BU}^{2}(w_i)}{2} - N_{AU}^{2}(w_i).N_{BU}^{2}(w_i)\right|\right\}$$

$$d_{HIVIFSST}(A.B, A@B) = \frac{1}{4}\sum_{i}^{n}\left\{\left|M_{AL}^{2}(w_i).M_{BL}^{2}(w_i) - \frac{M_{AL}^{2}(w_i) + M_{BL}^{2}(w_i)}{2}\right| + \left|M_{AU}^{2}(w_i).M_{BU}^{2}(w_i) - \frac{M_{AU}^{2}(w_i) + M_{BU}^{2}(w_i)}{2}\right|, \left|N_{AL}^{2}(w_i) + N_{BL}^{2}(w_i) - N_{AL}^{2}(w_i).N_{BL}^{2}(w_i) - \frac{N_{AL}^{2}(w_i) + N_{BL}^{2}(w_i)}{2}\right| + \left|N_{AU}^{2}(w_i) + N_{BU}^{2}(w_i) - N_{AU}^{2}(w_i).N_{BU}^{2}(w_i) - \frac{N_{AU}^{2}(w_i) + N_{BU}^{2}(w_i)}{2}\right|\right\}$$

$$= \frac{1}{4}\sum_{i}^{n}\left\{\left|M_{AL}^{2}(w_i).M_{BL}^{2}(w_i) - \frac{M_{AL}^{2}(w) + M_{BL}^{2}(w_i)}{2}\right| + \left|M_{AU}^{2}(w_i).M_{BU}^{2}(w_i) - \frac{M_{AU}^{2}(w_i) + M_{BU}^{2}(w_i)}{2}\right|, \left|-N_{AL}^{2}(w_i).N_{BL}^{2}(w_i) + \frac{N_{AL}^{2}(w_i) + N_{BL}^{2}(w_i)}{2}\right| + \left|-N_{AU}^{2}(w_i).N_{BU}^{2}(w_i) + \frac{N_{AU}^{2}(w_i) + N_{BU}^{2}(w_i)}{2}\right|\right\}$$

$$= \frac{1}{4}\sum_{i}^{n}\left\{\left|\frac{M_{AL}^{2}(w_i) + M_{BL}^{2}(w_i)}{2} - M_{AL}^{2}(w_i).M_{BL}^{2}(w_i)\right| +\right.$$

$$\left|\frac{M_{AU}^2(w_i)+M_{BU}^2(w_i)}{2}-M_{AU}^2(w_i).M_{BU}^2(w_i)\right|,$$

$$\left|\frac{N_{AL}^2(w_i)+N_{BL}^2(w_i)}{2}-N_{AL}^2(w_i).N_{BL}^2(w_i)\right|+\left|\frac{N_{AU}^2(w_i)+N_{BU}^2(w_i)}{2}-N_{AU}^2(w_i).N_{BU}^2(w_i)\right|\Bigg\}$$

Therefore,

$$d_{HIVIFSST}(A+B,A@B)=d_{HIVIFSST}(A.B,A@B).$$

This proved the second part of theorem. Similarly we can prove the remaining parts.

Theorem 3.2 Let X be a set that isn't empty. In the case of any two IVIFSSTs A and B, we have

(i) $d_{EIVIFSST}(A,A.B)=d_{EIVIFSST}(B,A+B)$,

(ii) $d_{EIVIFSST}(A+B,A@B)=d_{EIVIFSST}(A.B,A@B)$,

(iii) $d_{EIVIFSST}\left(G_{\alpha,\beta}(A),\ F_{\alpha,\beta}(A)\right)=d_{EIVIFSST}(H_{\alpha,\beta}(A),\ J_{\alpha,\beta}(A))$,

(iv) $d_{EIVIFSST}\left(F_{\alpha,\beta}(A),\ H_{\alpha,\beta}(A)\right)=d_{EIVIFSST}(G_{\alpha,\beta}(A),\ J_{\alpha,\beta}(A))$.

Proof: This proof is similar to the previous theorem.

Algorithm 3.3

STEP 1: $Z=\{\langle w,\chi_Z(w)\rangle|w\in X\}$ The degrees of member in between zero & one, further we have move to the next pace. (Z is a **FS.**)

STEP 2: $Z=\{\langle w,\chi_Z(w),\phi_Z(\mathrm{w})\rangle|w\in X\}$ The degrees of membership and non-membership function lies between zero and one with the condition $0\leq\chi_Z(w)+\phi_Z(\mathrm{w})\leq 1$. Then, we shift to another footstep (Z – is a **IFS**).

STEP 3: $Z=\{\langle w,\chi_Z(w),\phi_Z(\mathrm{w})\rangle|\ w\in X\}$ with the condition $M_{ZU}(w)+N_{ZU}(w)\leq 1\ \forall\, w\in X$ then we move the next step. (Z is a **IVIFS.**)

STEP 4: $Z=\{\langle x,M_Z(w),N_Z(w)\rangle|\ w\in X\}$ where $M_Z(w)[M_{ZL}(w),\ M_{ZU}(w)]$ and $N_Z(w)=[N_{ZL}(w),N_{ZU}(w)]$. The interval $M_Z(w)$ and $N_Z(w)$ show the amount of membership and the degree of non-membership of a component w in X. given that $M_{ZU}^2(w)+N_{ZU}^2(w)\leq 1\ \forall\, w\in X$

STEP 5: Find the Normalized Hamming distance measure to find the shortest distance between sickness and patients

STEP 6: Result and discussion.

4. Utilizing the IVIFS extension for medical diagnosis

Now a day, a lot of people think about using variables whose effects are obscure or confusing. This forms the basis of the notion that word meanings in many languages are more significant than numerical values. However, there may be activities that are excluded, therefore in some situations like medical identification using the membership to explain disparities is insufficient. Since the second kind of interval-valued Intuitionistic fuzzy sets employs intervals with non-membership functions and membership functions for fuzzy scenarios, it is appropriate in this instance. Using the normalized $d_{NH} - H$amming distance metric, we determine the shortest distance between the patient and the sickness over the second category of interval-valued Intuitionistic fuzzy sets and we compare the results.

	Cough	Headache	Abdominal pain	Temperature
Malaria	([0.2,0.1],[.04,0.2])	([0.6, 0.7],[0.1,0.2])	([0.3,0.5],[.5,0.4])	([0.7,0.2],[.1,0.4])
Pneumonia	([0.2,0.1],[.04,0.2])	([0.6, 0.7],[0.1,0.2])	([0.3,0.5],[.5,0.4])	([0.7,0.2],[.1,0.4])
Dengue	([0.2,0.1],[.04,0.2])	([0.6, 0.7],[0.1,0.2])	([0.3,0.5],[.5,0.4])	([0.7,0.2],[.1,0.4])
Typhoid	([0.2,0.1],[.04,0.2])	([0.6, 0.7],[0.1,0.2])	([0.3,0.5],[.5,0.4])	([0.7,0.2],[.1,0.4])

Table 1: Diseases vs. Symptoms

The following table represents the result of the analysis. For diagnostic purposes we presume that a sample has been collected from the patient and examined.

	Cough	Headache	Abdominal pain	Temperature
K_1	([0.3,0.2],[0.3,0.2])	([0.1, 0.3],[0.2,0.3])	([0.5,0.4],[0,0.2])	([0.4,0.4],[0.3,0.6])
K_2	([0.4,0.2],[0.2,0.5])	([0.6, 0.4],[0.3,0.1])	([0.5,0.6],[0.1,0.2])	([0.4,0.2],[0.4,0.6])
K_3	([0.3,0.4],[0.2,0.2])	([0.1, 0.5],[0.6,0.2])	([0.7,0.3],[0.2,0])	([0.3,0.5],[0.5,0.5])
K_4	([0.7,0.2],[0.6,0.3])	([0.4, 0.1],[0.2,0.5])	([0.4,0.2],[0.4,0.6])	([0.6,0.2],[0.2,0.5])

Table 2: Patients vs. Symptoms

Results and Discussion

The following table is the result of calculating the distance between each patient in Table 2 and each disease in Table 1 based on high opinion to each symptom using the Normalized Hamming distance metric d_{NH}

IVIFS	Malaria	Pneumonia	Dengue	Typhoid
K_1	0.2063	**0.1937**	0.2687	**0.1937**
K_2	**0.1687**	0.1937	0.1937	**0.1687**
K_3	**0.1437**	0.2063	**0.1437**	0.1813
K_4	**0.1563**	**0.1563**	0.1938	0.1938

Table 3: Patients vs. Diseases for IVIFS

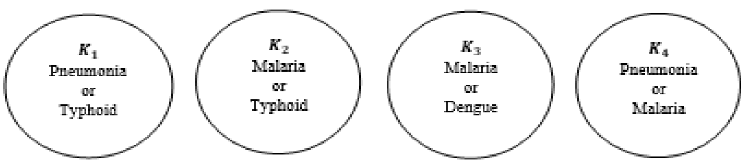


Table 3 Interval Valued Intuitionistic Fuzzy Sets allow us to deduce that K_1 has either typhoid or pneumonia diagnosis, K_2 has either a malaria or typhoid diagnosis, K_3 has either a malaria or dengue and K_4 has either a dengue or malaria diagnosis.We require additional research because the Diagnosis of the condition is ambiguous.

IVIFSST	Malaria	Pneumonia	Dengue	Typhoid
K_1	0.1456	**0.1394**	0.1956	0.1544
K_2	**0.1031**	0.1306	0.1294	0.1036
K_3	**0.0918**	0.1431	0.0981	0.1331
K_4	**0.1131**	0.1181	0.1431	0.1518

Table 4: Patients vs. Diseases for IVIFSST

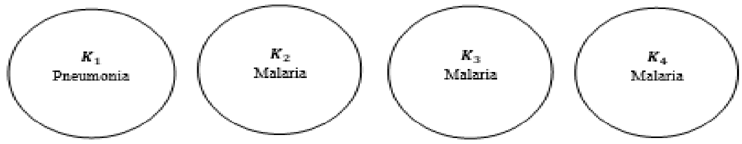


Table 4 indicates that K_1 has a malaria diagnosis, while K_2, K_3, and K_4 have dengue diagnoses. We concluded that, as compared to the current IVIFS, the use of the d_{NH} - normalized Hamming distance measure in IVIFSST plays a crucial role in obtaining the shortest distance. **Remark:** If the distance between the patient and the disease mentioned above is too tiny, the patient is most likely to have that specific disease.

4. Conclusion

We have examined a variety of distance measures over the IVIFSST, including d_E (Euclidean distance), d_{NE} (Normalized Euclidean distance), d_{NH} (Normalized Hamming distance), and d_H(Hamming distance). We have also examined their properties and relationships. In the medical area, in particular, the Normalized Hamming measure (d_{NH}) provided precise identification results. This demonstrates that an essential tool for finding the shortest path exists in the extension of interval-valued intuitionistic fuzzy sets.

Future Work: In future research, its open define some more problems and study the similarity measure and various distance method between intervals valued Intuitionistic fuzzy sets with time movements moreover study the real life application of IVTIFSST, such as model recognition, supplier selection, as well as image processing, carrier choosing and so on.

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