Journal of Interdisciplinary Mathematics
ISSN: 0972-0502 (Print), ISSN: 2169-012X (Online)
Vol. 27 (2024), No. 5, pp. 1079–1090
DOI : 10.47974/JIM-1934

Arithmetic mean of interval valued intuitionistic fuzzy soft sets and its application in diagnosing infectious diseases

Shewali Saika [§]
Department of Mathematics
The Assam Kaziranga University
Jorhat 785006
Asaam
India

Manash Jyoti Borah [†]
Department of Mathematics
Bahona College
Jorhat 785101
Assam
India

Dimpal Jyoti Mahanta [*]
Department of Mathematics
The Assam Kaziranga University
Jorhat 785006
Asaam
India

Abstract

The main goal of this work is to present a new approach to the arithmetic mean calculation of interval-valued Intuitionistic fuzzy soft sets. Averaging the upper and lower bounds of matrices is the process involved in this method. The study uses shortened Intuitionistic fuzzy soft matrices to extend the representation of interval-valued Intuitionistic fuzzy soft matrices, building on Sanchez's method for medical diagnosis. This method's

[§] *E-mail:* **shewalisaikia200@gmail.com**
[†] *E-mail:* **mjyotibora9@gmail.com**
[*] *E-mail:* **dimpaljmahanta@gmail.com (Corresponding Author)**

effectiveness in differentiating between infectious diseases with similar symptoms is demonstrated by its practical application.

Subject Classification: *03B52, 94D05.*

Keywords: *Interval valued Intuitionistic fuzzy soft sets, Interval valued Intuitionistic fuzzy soft matrix, arithmetic mean, Infectious diseases.*

1. Introduction

Uncertainty is a common characteristic of complex problems come upon in various fields such as engineering, social science, economics, medical science, agriculture, and management. Traditional mathematical tools are not suitable for solving problems containing uncertainties. Because data in these situations do not analyze correctly. Thus, there is an issue with making actual decisions. Fuzzy sets, introduced by Zadeh, provide a framework for representing elements of a set with varying degrees of membership between zero and one. However, fuzzy sets are unable to handle the non-membership values of objects. In 1986, Atnassove [1] presented Intuitionistic fuzzy sets, which require the totality of membership and non-membership degrees to be less than or equal to one. Soft set theory, suggested by Molodtsov in 1999 [2] offers a versatile approach to problem-solving. The hybridization of fuzzy sets and soft sets led to the development of fuzzy soft sets by Maji et al. [7] in 2001. In 2004, Maji et al. [6] further extended this concept to Intuitionistic fuzzy soft sets, merging Intuitionistic fuzzy sets and soft sets. Interval-valued fuzzy soft sets were introduced by Yang et al. [12] in 2009 by combining interval-valued fuzzy sets and soft sets. Jiang et al. [3] in 2010 familiarized the concept of interval-valued Intuitionistic fuzzy soft sets, which combines Intuitionistic fuzzy sets and soft sets. In 2015, Mukherjee and Sarkar [8] proposed a similarity measure for interval-valued Intuitionistic fuzzy soft sets founded on the distance between them, demonstrating its applicability in medical diagnosis. Matrices have significant applications in the fields of science and engineering. The types and operations of interval-valued Intuitionistic fuzzy soft matrices based on weight were studied by Rajarajeswari et al. [10] in 2014. Rajarajeswari and Dhanalakshmi [11] proposed a novel method in 2015, applicable to medical diagnosis, by utilizing interval-valued Intuitionistic fuzzy soft matrices. In 2019, Nithya [9] extended Sanchez's method for medical diagnosis by presenting a matrix representation of intuitionistic fuzzy soft sets using intuitionistic fuzzy soft complement. "In 2019, Kamaci [4] offered some concepts, including the restricted intersection and restricted union of two interval-valued intuitionistic fuzzy soft sets for the selection of an appropriate hospital for a patient affected by a particular disease." These concepts were built on the analysis of multiple procedures on the interval-valued intuitionistic fuzzy soft set By Kumar, D. & Kumari [5] the interval-valued fuzzy parameterized intuitionistic fuzzy soft set

(IVFPIFS set) was first presented in 2022. Interval-valued fuzzy parameterized (fuzzy) soft sets, intuitionistic fuzzy soft sets, fuzzy parameterized intuitionistic fuzzy soft sets, and fuzzy soft sets are all extended by this set. The IVFPIFS sets have definitions for fundamental operations such as complement, union, and intersection. In addition, the properties of these operations are studied in detail. Using the aggregation operators, an algorithm based on the IVFPIFS sets is finally constructed. The given examples verify the validity and feasibility of the proposed algorithm.

The idea of using arithmetic mean to convert interval-valued Intuitionistic fuzzy soft matrices into shortened Intuitionistic fuzzy soft matrices is implemented in this paper. Using these shortened Intuitionistic fuzzy soft matrices, we extend Sanchez's method for medical diagnosis. This is how this paper is structured:

In introduction an outline of the topic is offered. In section 2 basic definitions and examples of fuzzy soft sets and fuzzy soft matrices are reviewed. In section 3 introductions to shorten Intuitionistic fuzzy soft sets and Intuitionistic fuzzy soft matrices. In section 4 application of shorten Intuitionistic fuzzy soft matrices in medical diagnosis is discussed. In section 5 Summary of the paper is provided.

2. Preliminaries

This section briefly describes the theory of fuzzy soft sets and fuzzy matrices, as well as certain basic definitions and examples.

Definition 2.1: Choose Û to be the starting universe set and Ë to be a set of parameters. The power set of Û can be symbolized as $P(\text{Û})$. While £ is a mapping defined by $£: \text{Ë} \rightarrow P(\text{Û})$, afterwards a pair (£, Ë) is called a soft set over Û. It's evident that a soft set is a mapping from parameters to subsets of Û, encapsulated within the power set notation, thus forming a parameterized family of subsets of the universe rather than a singular set. [11]

Definition 2.2: Assume Û represents an initial universe set, and Ë is a set of parameters. Let Đ is a subset of Ë. Now, consider a pair (£, Đ), called fuzzy soft set over Û. At this point, £ is a mapping defined as $£: \text{Đ} \rightarrow I^{\text{Û}}$, where $I^{\text{Û}}$denotes the assemblage of all fuzzy subsets of Û.

In simpler terms, a fuzzy soft set above Û is a pair consisting of a mapping (£) from a subset of parameters Đ to the collection of all fuzzy subsets of Û. [11]

Definition 2.3: The representation for the Universal set is$\text{Û} = \{\text{ã}_1, \text{ã}_2, \text{ã}_3, \dots \text{ã}_m\}$. $\text{Ë} = \{©_1, ©_2, ©_3, \dots ©_n\}$ denotes the set of parameters. The fuzzy soft set in the fuzzy soft class (Û, Ë). is represented by Đ ⊆ Ë and $\text{Ñ}_{m\times n} = [a_{ij}]_{m\times n}$ $i = 1,2,3, \dots m,\ j = 1,2,3, \dots n$.is the fuzzy soft (£, Đ) matrix illustration.

Where $a_{ij} = \begin{cases} \mu_j(\tilde{a}_i) & \text{if } ©_j \in Đ \\ 0 & \text{if } ©_j \notin Đ \end{cases}$

Assuming that $\mu_j(\tilde{a}_i)$ represents the membership of $\tilde{a}_i$ in the fuzzy set $£(©_j)$. [11]

Definition 2.4: Assume that Ë is a set of parameters and that Û be an original universe set Let Đ ⊆ Ë. An Intuitionistic fuzzy soft set over Û is indicated by pair $(£, Đ)$, where £ a mapping is given by $£: Đ \to I^{Û}$ and $I^{Û}$ represents the gathering of all Intuitionistic fuzzy subsets of Û. [11]

Definition 2.5: Consider $Û = \{\tilde{a}_1, \tilde{a}_2, \tilde{a}_3, \dots \tilde{a}_m\}$ be the initial Universal set and let Ë be the set of parameters specified by $Ë = \{©_1, ©_2, ©_3, \dots ©_n\}$. Suppose that Đ ⊆ Ë. Let us assume that the fuzzy soft class (Û, Ë) has an Intuitionistic fuzzy soft set (£, Đ). Then the Intuitionistic fuzzy soft set (£, Đ) in a matrix form [10] as $\tilde{N}_{m\times n} = [a_{ij}]_{m\times n}$ $i = 1,2,3, \dots m, j = 1,2,3, \dots n$

$$\text{Where } a_{ij} = \begin{cases} \mu_j(\tilde{a}_i), \upsilon_j(\tilde{a}_i) & \text{if } ©_j \in Đ \\ (0,1) & \text{if } ©_j \notin Đ \end{cases}$$

Definition 2.6: Let $Û = \{\tilde{a}_1, \tilde{a}_2, \tilde{a}_3, \dots \tilde{a}_m\}$ be the original Universal set and Ë be the set of parameters specified by $Ë = \{©_1, ©_2, ©_3, \dots ©_n\}$. Let Đ ⊆ Ë and (£, Đ) be an interval valued Intuitionistic fuzzy soft set in the fuzzy soft class (Û, Ë). Then the interval valued Intuitionistic fuzzy soft set (£, Đ) in a matrix form [11] as $\tilde{N}_{m\times n} = [a_{ij}]_{m\times n}$ $i = 1,2,3, \dots m, j = 1,2,3, \dots n$

$$\text{Where } a_{ij} = \begin{cases} [\mu_{jL}(\tilde{a}_i), \mu_{jU}(\tilde{a})]\ [\nu_{jL}(\tilde{a}_i), \nu_{jU}(\tilde{a}_i)] & if\ ©_j \in Đ \\ ([0,0][1,1]) & if\ ©_j \notin Đ \end{cases}$$

Definition 2.7: The membership value matrix A as $MV(\tilde{N}) = [\delta(\tilde{N}_{ij})]_{m\times n}$, where $\delta(\tilde{N}_{ij}) = \mu_{\tilde{N}}(\tilde{a}_i) - \nu_{\tilde{N}}(\tilde{a}_i)$ $\forall\ i = 1,2,3 \dots.\ m,\ j = 1,2,3 \dots.n$

Where $\mu_{\tilde{N}}(\tilde{a}_i)$ and $\nu_{\tilde{N}}(\tilde{a}_i)$ represent the Intuitionistic fuzzy membership function and Intuitionistic fuzzy non-membership function respectively of $\tilde{a}_i$ in the Intuitionistic fuzzy soft set. [9]

Definition 2.8: Let $\tilde{N} = [a_{ij}]_{m\times n}$, $a_{ij} = (\mu_{\tilde{N}}(\tilde{a}_i), \nu_{\tilde{N}}(\tilde{a}_i))$; $\mu_{\tilde{N}}(\tilde{a}_i)$and $\nu_{\tilde{N}}(©_i)$ characterize the Intuitionistic fuzzy membership function and Intuitionistic fuzzy non-membership function respectively of $\tilde{a}_i$, so that $\delta_{ij} = \mu_{\tilde{N}}(\tilde{a}_i) - \nu_{\tilde{N}}(\tilde{a}_i)$ gives the Intuitionistic fuzzy membership value of $\tilde{a}_i$.

Also let $\check{S} = [b_{ij}]_{n\times p}$, $a_{ij} = (\mu_{\check{S}}(\tilde{a}_i), \nu_{\check{S}}(\tilde{a}_i))$; $\mu_{\check{S}}(\tilde{a}_i) and\ \nu_{\check{S}}(\tilde{a}_i)$ signify the Intuitionistic fuzzy membership function and Intuitionistic fuzzy non-membership function respectively of $\tilde{a}_i$, so that $\delta_{ij} = \mu_{\check{S}}(\tilde{a}_i) - \nu_{\check{S}}(\tilde{a}_i)$ gives the Intuitionistic fuzzy membership [9] of $\tilde{a}_i$.

Now we define the product of Ñ and Š as

$$\tilde{N}.\check{S} = [\max\min(\mu_{\tilde{N}}(\tilde{a}_i), \mu_{\tilde{N}}(\tilde{a}_i)), \min\max(\nu_{\check{S}}(\tilde{a}_i), \nu_{\check{S}}(\tilde{a}_i))]$$

3. Major section

The definitions of the shortened Intuitionistic fuzzy soft set and shortened Intuitionistic fuzzy soft matrix were presented in this section.

Definition 3.1: Let $\hat{U} = \{\tilde{a}_1, \tilde{a}_2, \tilde{a}_3, \dots \tilde{a}_m\}$ be the universal set and Ë stand the set of parameters provided byË $= \{©_1, ©_2, ©_3, \dots ©_n\}$. In the fuzzy soft class (Û, Ë), let Đ ⊆ Ë and (£, Đ)be an interval valued Intuitionistic fuzzy soft set, A mapping for £ can be obtained by £: Đ → $I^{\hat{U}}$, wherever $I^{\hat{U}}$ stand for the group of all interval valued Intuitionistic fuzzy soft set is

$$£(©_j) = \{\tilde{a}_i, ([\mu_{jL}(\tilde{a}_i), \mu_{jU}(\tilde{a}_i)][\nu_{jL}(\tilde{a}_i), \nu_{jU}(\tilde{a}_i)])\ \forall\ ©_j \in Đ \text{ and } \forall\ \tilde{a}_i \in \hat{U}\}$$

$([\mu_{jL}(\tilde{a}_i), \mu_{jU}(\tilde{a}_i)]\ and\ [\nu_{jL}(\tilde{a}_i), \nu_{jU}(\tilde{a}_i)])$ Signifies the membership and non membership of $\tilde{a}_i$ in the interval valued Intuitionistic fuzzy soft set $£(©_j)$. The Intuitionistic fuzzy soft set $(Sn, (£, Đ)) = \{\tilde{a}_i, \left(\frac{\mu_{jL}(\tilde{a}_i)+\mu_{jU}(\tilde{a}_i)}{2}, \frac{\nu_{jL}(\tilde{a}_i)+\nu_{jU}(\tilde{a}_i)}{2}\right)$ ∀ $©_j$ ∈ Đ and ∀ $\tilde{a}_i$ ∈ Û} is called sho. rtened Intuitionistic fuzzy soft set (SIFSS).

Definition 3.2: Assume that Let $\hat{U} = \{\tilde{a}_1, \tilde{a}_2, \tilde{a}_3, \dots \tilde{a}_m\}$ is the universal set and that Ë is the set of parameters that are known by Ë $= \{©_1, ©_2, ©_3, \dots ©_n\}$.Let Đ ⊆ Ë and (£, Đ)be an interval valued Intuitionistic fuzzy soft set in the fuzzy soft class (Û, Ë), where £ is a mapping defined £: Đ → $I^{\hat{U}}$, where $I^{\hat{U}}$denotes the set of all interval valued Intuitionistic fuzzy subsets of Û. Then, in matrix form, the shortened Intuitionistic fuzzy soft set $(Sn(£, Đ))$over Û as

$$Đ_{m\times n} = [d_{ij}]_{m\times n}\ i = 1,2,3, \dots m, j = 1,2,3, \dots n$$

$$\text{Where } d_{ij} = \begin{cases} \frac{\mu_{jL}(\tilde{a}_i)+\mu_{jU}(\tilde{a}_i)}{2}, \frac{\nu_{jL}(\tilde{a}_i)+\nu_{jU}(\tilde{a}_i)}{2} & \text{if } ©_j \in Đ \\ (0,1) & \text{if } ©_j \notin Đ \end{cases}$$

Thus, by shortening the Intuitionistic fuzzy soft matrix $Đ_{m\times n}$, we can identify any shortened Intuitionistic fuzzy soft set $(Sn(£, Đ))$ in the Intuitionistic fuzzy soft class (Û, Ë) SIFSM will stand for the set of all $m \times n$ shorten Intuitionistic fuzzy soft matrices.

Example: Assume that $\hat{U} = \{\breve{\mathfrak{h}}_1, \breve{\mathfrak{h}}_2, \breve{\mathfrak{h}}_3, \breve{\mathfrak{h}}_4\}$ is the universal set and that the set of parameters is represented by $\ddot{E} = \{©_1, ©_2, ©_3\}$Examine the mapping £ between the set of all interval valued Intuitionistic fuzzy subsets of power set $\hat{U}$ and the parameter set defined by $Đ = \{©_1, ©_2\} \subseteq \ddot{E}$. Let the Intuitionistic fuzzy soft set $(£, Đ)$be an interval valued set.

$$£(©_1) = \{\breve{\mathfrak{h}}_1([0.5,0.7][0.1,0.2]), \breve{\mathfrak{h}}_2([0.7,0.8][0.05,0.1]),$$
$$\breve{\mathfrak{h}}_3([0.5,0.6][0.3,0.35]), \mathfrak{h}_4([0.4,0.5][0.2,0.3])\}$$
$$£(©_2) = \{\breve{\mathfrak{h}}_1([0.6,0.7][0.25,0.3]), \breve{\mathfrak{h}}_2([0.7,0.8][0.3,0.35]),$$
$$\breve{\mathfrak{h}}_3([0.6,0.8][0.3,0.35]), \breve{\mathfrak{h}}_4([0.8,0.9][0.2,0.2])\}$$

Our representation this interval valued Intuitionistic fuzzy soft set-in matrix form as

$$\begin{bmatrix} [0.5,0.7][0.1,0.2] & [0.6,0.7][0.25,0.3] & [0.0,0.0][1.0,1.0] \\ [0.7,0.8][0.05,0.1] & [0.7,0.8][0.3,0.35] & [0.0,0.0][1.0,1.0] \\ [0.5,0.6][0.3,0.35] & [0.6,0.8][0.3,0.35] & [0.0,0.0][1.0,1.0] \\ [0.4,0.5][0.2,0.3] & [0.8,0.9][0.2,0.2] & [0.0,0.0][1.0,1.0] \end{bmatrix}$$

We have shortened Intuitionistic fuzzy soft matrix as

$$\begin{bmatrix} (0.60,0.15) & (0.65,0.275) & (0,0,1.0) \\ (0.75,0.075) & (0.75,0.325) & (0.0,1.0) \\ (0.55,0.325) & (0.70,0.325) & (0.0,1.0) \\ (0.45,0.25) & (0.85,0.20) & (0.0,1.0) \end{bmatrix}$$

4. Utilizing interval valued Intuitionistic fuzzy soft sets in diagnosing infectious disease

In a hospital scenario where patients exhibit symptoms indicative of various infectious diseases, we begin by constructing an interval-valued Intuitionistic fuzzy soft set built on the patients and their symptoms. From this set, we derive two relation matrices: the "patient symptoms matrix" and its complement, known as the "patient non-symptom matrix." These matrices are then transformed into shortened Intuitionistic fuzzy soft matrices.

Subsequently, another interval-valued Intuitionistic fuzzy soft set is formed based on the symptoms associated with diseases. From this set, we generate the "symptoms disease matrix" and its complement, termed the "non-symptoms disease matrix," which are also converted into shortened Intuitionistic fuzzy soft matrices. Utilizing Definition 2.8, we derive four relation matrices: the "Patient symptoms diseases matrix," "Patient symptoms non-diseases matrix," "Patient non-symptoms diseases matrix," and "Patient non-symptoms non-diseases matrix."

Applying Definition 2.7, we compute the corresponding membership value matrices. The diagnosis score for a specific disease is determined by subtracting the membership value matrices of the patient symptom disease matrix and the patient non-symptom disease matrix. Similarly, the diagnosis score against the disease is calculated by subtracting the membership value matrices of the patient symptom non-disease matrices and the patient non-symptom non-disease matrices. By identifying the maximum difference in diagnosis scores for and against the disease, we can conclude the likely disease a patient is suffering from.

In the event of a tie, the process is reiterated by reassessing the symptoms of the patients.

Algorithm

I. Enter an interval-valued Intuitionistic fuzzy soft set and compute the complement of the set, which represents the symptoms of the hospital patients. Compute the matching relation matrices for the patient's non-symptomatic and symptomatic conditions next.
II. Enter the interval-valued Intuitionistic fuzzy soft set and figure out the medical knowledge about illnesses and their symptoms that is the complement of the interval-valued Intuitionistic fuzzy soft set. Then, for the disease matrix with symptoms and the disease matrix without symptoms, compute the corresponding relation matrices.
III. From the interval-valued Intuitionistic fuzzy soft matrix, create shortened Intuitionistic fuzzy soft matrices.
IV. Calculate the disease, non-disease, non-symptom, and non-symptom-disease matrices for each patient's symptoms and non-symptoms.
V. Determine the matching matrices of membership values.
VI. Calculate the disease's diagnostic scores for and against it.
VII. Determine the maximum difference for and against the disease to determine which condition the patient most likely has.

Application

Take in to consideration a situation where four patients, $P = \{P_1, P_2, P_3, P_4\}$ are admitted to a hospital exhibiting symptoms including temperature, gastrointestinal problems, and body pain. Assume that viral fever, typhoid and malaria are the potential illness linked to these symptoms, they are represented as $S = \{ S_1, S_2, S_3\}$.

Supposing we have a set (£, S) which is interval-valued Intuitionistic fuzzy soft defined over the set of patients P. Here, £ represents a mapping $£ : S \to I^p$ which provides an approximate depiction of the symptoms exhibited by patients in the hospital. The dataset used for this analysis is considered from the study of Rajarajeswari and Dhanalakshmi [11]

$$(£, S) = \{£(S_1) = \{(P_1, [0.80, 0.90][0.05, 0.10]), (P_2, [0.00,0.05][0.75,0.80]),$$
$$(P_3, [0.80,0.90]\ [0.10,0.10]), (P_4, [0.60,0.8][0.05,0.10])\}$$

$£(S_2) = \{(P_1, [0.60,0.70][0.05,0.10]), (P_2, [0.40,0.45][0.30,0.40]),$
$(P_3, [0.80,0.90]\ [0.10,0.10]), (P_4, [0.50,0.55][0.30,0.40])\}$
$£(S_3) = \{(P_1, [0.20,0.20][0.80,0.80]), (P_2, [0.60,0.70][0.05,0.10]),$
$(P_3, [0.00,0.20]\ [0.50,0.60], (P_4, [0.30,0.40][0.30,0.40])\}\}$

A relation matrix A_1 known as patient symptom matrix is generated from interval valued Intuitionistic fuzzy soft set $(£, S)$.

$$A_1 = \begin{bmatrix} [0.80,0.90][0.05,0.10] & [0.60,0.70][0.05,0.10] & [0.20,0.20][0.80,0.80] \\ [0.00,0.05][0.75,0.80] & [0.40,0.45][0.30,0.40] & [0.60,.070][0.05,0.10] \\ [0.80,0.90][0.05,0.10] & [0.80,0.90][0.10,0.10] & [0.00,0.20][0.50,0.60] \\ [0.60,0.80][0.05,0.10] & [0.50,0.55][0.30,0.40] & [0.30,0.40][0.30,0.40] \end{bmatrix}$$

$$Sn(A_1) = \begin{bmatrix} (0.85,0.075) & (0.65,0.075) & (0.20,0.80) \\ (0.025,0.775) & (0.425,0.35) & (0.65,0.075) \\ (0.85,0.075) & (0.85,0.10) & (0.10,0.55) \\ (0.70,0.075) & (0.525,0.35) & (0.35,0.35) \end{bmatrix}$$

The set$(£, S^c)$, complement of $(£, S)$ gives patient non symptom matrix.

$$A_2 = \begin{bmatrix} [0.05,0.10][0.80,0.90] & [0.05,0.10][0.60,0.70] & [0.80,0.80][0.20,0.20] \\ [0.75,0.80][0.00,0.05] & [0.30,0.40][0.40,0.45] & [0.05,0.10][0.60,070] \\ [0.05,0.10][0.80,0.90] & [0.10,0.10][0.80,0.90] & [0.50,0.60][0.00,0.20] \\ [0.05,0.10][0.60,0.80] & [0.30,0.40][0.50,0,55] & [0.30,0.40][0.30,0.40] \end{bmatrix}$$

$$Sn(A_2) = \begin{bmatrix} (0.075.0.85) & (0.075,0.65) & (0.80,0.20) \\ (0.775,0.025) & (0.35,0.425) & (0.075,0.65) \\ (0.075,0.85) & (0.10,0.85) & (0.55,0.10) \\ (0.075,0.70) & (0.35,0.525) & (0.35,0.35) \end{bmatrix}$$

Let us now consider the universal set $S = \{ S_1, S_2, S_3\}$, where S_1, S_2, S_3 stands for the symptoms of body pain, stomach problems and temperature respectively. We also have the set $Đ = \{ d_1, d_2, d_3\}$ is another one that we have. Within this set the diseases viral fever, typhoid and malaria respectively are expressed by $d_1, d_2,$ and d_3. Assume we have an Intuitionistic fuzzy soft set $(Ñ, Đ)$ over S that is interval-valued. An approximation of the interval-valued Intuitionistic fuzzy soft health information of the three diseases and their corresponding signs are given by Ñ which in this instance is a mapping $Ñ : Đ \to I^S$

$(Ñ, Đ) = \{Ñ(d_1) = \{(S_1, [0.60,0.70][0.10,0.20]), (S_2, [0.30,0.40][0.40,0.50]),$
$(S_3, [0.10,0.10]\ [0.80,0.80])\}$
$Ñ(d_2) = \{(S_1, [0.60,0.70][0.20,0.20]), (S_2, [0.20,0.30][0.40,0.60]),$
$(S_3, [0.20,0.30]\ [0.50,0.70])\}$

$\tilde{N}(d_3) = \{(S_1, [0.30,0.50][0.30,0.40]), (S_2, [0.70,0.80][0.10,0.20]),$
$(S_3, [0.70,0.80][0.20,0.20])\}\}$

This interval valued Intuitionistic fuzzy soft set (*Ñ, Đ)* provides symptom diseases matrix B_1

$$B_1 = \begin{bmatrix} [0.60,0.70][0.10,0.20] & [0.60,0.70][0.20,0.20] & [0.30,0.50][0.30,0.40] \\ [0.30,0.40][0.40,0.50] & [0.20,0.30][0.40,0.60] & [0.70,0.80][0.10,0.20] \\ [0.10,0.10][0.80,0.80] & [0.20,0.30][0.50,0.70] & [0.70,0.80][0.20,0.20] \end{bmatrix}$$

$$Sn(B_1) = \begin{bmatrix} (0.65,0.15) & (0.65,0.20) & (0.40,0.35) \\ (0.35,0.45) & (0.25,0.50) & (0.75,0.15) \\ (0.10,0.80) & (0.25,0.60) & (0.75,0.20) \end{bmatrix}$$

The set $(\tilde{N}, Đ^c)$, complement of $(\tilde{N}, Đ)$ gives non symptom diseases matrix.

$$B_2 = \begin{bmatrix} [0.10,0.20][0.60,0.70] & [0.20,0.20][0.60,0.70] & [0.30,0.40][0.30,0.50] \\ [0.40,0.50][0.30,0.40] & [0.40,0.60][0.20,0.30] & [0.10,0.20][0.70,0.80] \\ [0.80,0.80][0.10,0.10] & [0.50,0.70][0.20,0.30] & [0.20,0.20][0.70,0.80] \end{bmatrix}$$

Patient symptoms diseases matrix

$$T_1 = Sn(A_1)Sn(B_1) = \begin{bmatrix} (0.65,0.15) & (0.65,0.20) & (0.65,0.35) \\ (0.35,0.45) & (0.25,0.50) & (0.65,0.20) \\ (0.65,0.15) & (0.65,0.20) & (0.75,0.15) \\ (0.65,0.45) & (0.65,0.50) & (0.525,0.35) \end{bmatrix}$$

Patient symptoms non diseases matrix

$$T_2 = Sn(A_1)Sn(B_2) = \begin{bmatrix} (0.45,0.65) & (0.50,0.65) & (0.35,0.40) \\ 4(0.65,0.10) & (0.60,0.25) & (0.65,0.75) \\ (0.65,0.35) & (0.50,0.25) & (0.35,0.40) \\ (.0.45,0.35) & (0.50,0.35) & (0.35,0.75) \end{bmatrix}$$

Patient non symptoms diseases matrix

$$T_3 = Sn(A_2)Sn(B_1) = \begin{bmatrix} (0.35,0.65) & (0.25,0.60) & (0.75,0.20) \\ (0.65,0.15) & (0.65,0.20) & (0.40,0.35) \\ (0.10,0.80) & (0.25,0.60) & (0.55,0.20) \\ (.0.65,0.525) & (0.65,0.525) & (0.40,0.35) \end{bmatrix}$$

Patient non symptoms non diseases matrix

$$T_4 = Sn(A_2)Sn(B_2) = \begin{bmatrix} (0.80,0.20) & (0.60,0.25) & (0.20,0.75) \\ (0.35,0.425) & (0.35,0.425) & (0.35,0.40) \\ (0.55,0.10) & (0.55,0.25) & (0.20,0.75) \\ (.0.35,0.35) & (0.35,0.35) & (0.35,0.70) \end{bmatrix}$$

Membership value matrices by using definition 2.7

$$MV(T_1) = \begin{bmatrix} 0.50 & 0.45 & 0.30 \\ -0.10 & -0.25 & 0.45 \\ 0.50 & 0.45 & 0.50 \\ 0.20 & 0.15 & 0.175 \end{bmatrix} \qquad MV(T_2) = \begin{bmatrix} -0.20 & -0.15 & -0.05 \\ 0.55 & 0.35 & -0.10 \\ 0.10 & 0.25 & -0.05 \\ 0.10 & 0.15 & -0.40 \end{bmatrix}$$

$$MV(T_3) = \begin{bmatrix} -0.30 & -0.35 & 0.55 \\ 0.50 & 0.45 & 0.05 \\ -0.70 & -0.35 & 0.35 \\ 0.125 & -0.125 & 0.05 \end{bmatrix} \qquad MV(T_4) = \begin{bmatrix} 0.60 & 0.35 & -0.55 \\ -0.075 & -0.075 & -0.05 \\ 0.45 & 0.30 & -0.55 \\ 0 & 0 & -0.35 \end{bmatrix}$$

Compute the diagnosis scores S_{T_1} and S_{T_2} for and against the disease

$$S_{T_1} = \begin{bmatrix} 0.50 & 0.45 & 0.55 \\ 0.50 & 0.45 & 0.45 \\ 0.50 & 0.45 & 0.60 \\ 0.20 & 0.15 & 0.175 \end{bmatrix} \qquad S_{T_2} = \begin{bmatrix} 0.60 & 0.35 & -0.05 \\ 0.55 & 0.35 & -0.05 \\ 0.45 & 0.30 & -0.05 \\ 0.10 & 0.15 & -0.35 \end{bmatrix}$$

Difference for and against the diseases.

$$S_{T_1} - S_{T_1} = \begin{bmatrix} -0.10 & 0.10 & 0.60 \\ -0.05 & 0.10 & 0.50 \\ 0.05 & 0.15 & 0.65 \\ 0.10 & 0 & 0.525 \end{bmatrix}$$

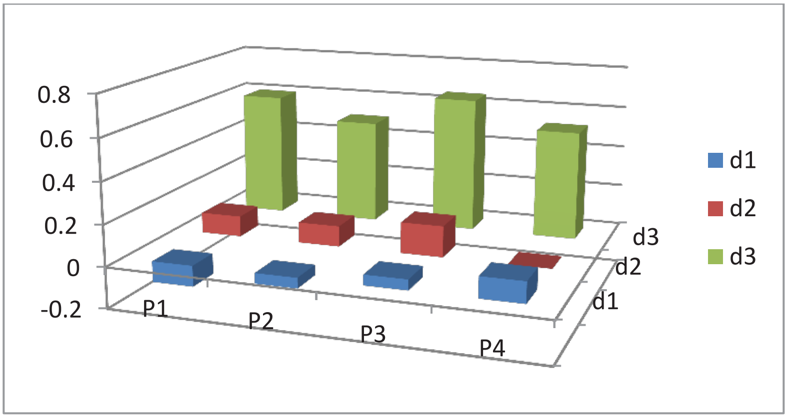

Figure 1
Relation between patient P_1, P_2, P_3, P_4 and diseases

All four patients have the highest possible score for malaria disease across all reductions, as determined by computing the diagnosis scores for and against each disease and comparing the results (See Figure 1).

By expending the demonstration of interval-valued Intuitionistic fuzzy soft matrices that are shortened into Intuitionistic fuzzy soft matrices, we expanded

Sanchez's method for diagnosing infectious diseases in this study. By using the same data set taken into consideration from the study of Rajarajeswari and Dhanalashmi [11]. We use the SIFSM for disease diagnosis in patients who suffer from various diseases such as viral fever, typhoid, and malaria.We take into consideration four patients who have either malaria, typhoid fever, or viral fever. Temperature, stomach issues, and body pain are among the symptoms taken into account for diagnosis.

By employing the Shortened Intuitionistic Fuzzy Soft Matrix (SIFSM) method, we came to the conclusion that the four patients had malaria. Compared to Rajarajeswari and Dhanalashmi's method [12], which used a weighted vector to transform interval-valued Intuitionistic fuzzy soft matrix into a suspicious reduced Intuitionistic fuzzy soft matrix. Our method is more logical since it makes use of our recently developed conception of shortened Intuitionistic fuzzy soft matrices, which we derive from the simple arithmetic mean of the interval-valued Intuitionistic fuzzy soft matrices' upper and lower bounds.

Conclusion

To sum up, our extended method, which uses shortened Intuitionistic fuzzy soft matrices, works well for making medical diagnoses based on patient symptoms. The results obtained using the methods we've presented are conservative because they agree with earlier studies [11]. The study also reveals that the suggested approach's computational process differs from that of the current approaches. Our findings concur with the conclusions drawn in [11] notwithstanding the disparity in the conversion methodology. This study's single value, which enables objective and well-founded conclusions, makes its output extremely valuable and reliable.

Conflict of interest

All authors declare no conflict of interest.

References

[1] Atanassov, K. Intuitionistic fuzzy sets. Fuzzy Sets and Systems, 20(1), 87-96 (1986). https://doi. org/10.1016/S0165-0114.

[2] Atanassov, K. Interval-valued intuitionistic fuzzy sets. In Intuitionistic fuzzy sets (139-177). Physica, Heidelberg (1999).

[3] Jiang, Y., Tang, Y., Chen, Q., Liu, H., & Tang, J. Interval-valued intuitionistic fuzzy soft sets and their properties. *Computers & Mathematics with Applications*, 60(3), 906-918 (2010).

[4] Kamaci, H. Interval-valued fuzzy parameterized intuitionistic fuzzy soft sets and their applications. *Cumhuriyet Science Journal*, 40(2), 317-331 (2019).

[5] Kumar, D. & Kumari, A. Utilization of interval-valued intuitionistic fuzzy soft set in the health sector. *International Journal of Health Sciences*. 8437-8444 (2022). 10.53730/ijhs.v6nS6.12135.

[6] Maji, P. K., Roy, A. R., Biswas, R. On intuitionistic fuzzy soft sets. *The Journal of Fuzzy Mathematics*, 12(3), 669–683 (2004).

[7] Maji. P. K., Biswas. R. K., & Roy, A. *Fuzzy soft sets. J.Fuzzy Math.* 9. 589-602 (2001).

[8] Mukherjee, A., & Sarkar, S. Distance-based similarity measures for interval-valued intuitionistic fuzzy soft sets and its application. New Trends Math. Sci, 3, 34-42 (2015).

[9] Nithy, A. An application of intuitionistic fuzzy soft sets in drug addiction using intuitionistic fuzzy soft complement. Prapti, Research Journal, 3, 16-24 (2019).

[10] Rajarajeswari, P., & Dhanalakshmi, P. Interval-valued fuzzy soft matrix theory. *Annals of Pure and Applied Mathematics*, 7(2), 61-72 (2014).

[11] Rajarajeswari, P., & Dhanalakshmi, P. An application of interval-valued intuitionistic fuzzy soft matrix theory in medical diagnosis. *Annals of Fuzzy Mathematics and Informatics*, 9(3), 463-472 (2015).

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

Received March, 2024