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Full Length Research Article

AN APPLICATION OF INTUITIONISTIC FUZZY MULTISET DISTANCE MEASURE TO RADIOLOGICAL FINDING AND CLIMATE CHANGE

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ABSTRACT
A Distance measure of Intuitionistic fuzzy multiset plays a vital role in solving problems associated with uncertainties. Attempt were made by different researchers in making efforts to comes up with distance measure that will address the problems faced by decision makers especially when multiple criteria were involved, in this paper, we look at the demerits of some of the existing distance measures and proposed a new one that will bridge the gaps of the existing ones, we then applied it in radiological findings, by considering four patients and five diseases, we discovered that while three patients were suffering from one disease or the other, the fourth patient is not suffering from any of the diseases, thus, we suggest further investigation on him. We also applied it to climate change by considering four areas affected by different types of erosion, and it was discovered that some areas were affected, while one area is not affected.

***Keywords*:** Distance measures; fuzzy sets; fuzzy multisets; intuitionistic fuzzy sets; intuitionistic fuzzy multisets;

INTRODUCTION
In classical set theory, a set is a well-defined collection of distinct and definite objects of our intuition into a whole. Accordingly, one of the underlying assumptions of this set theory dictates that no element shall appear more than once. The collection {a,b,b,c} consequently becomes a set only after deleting the repeated elements, viz, {a,b,c}. Indeed, this did not go hand in hand with the requirements of various other sciences in seeking mathematical formulation of some of the challenging problems. As such, a multiset, which is a set with repetition, was involved; see (Blizard, 1990; Singh and Isah, 2016; Girish and John, 2012; Isah and Tella, 2015).
Decision making is one of the most difficult task human being used to face especially when multiple criteria decision making was involved, with the introduction of fuzzy sets by Zadeh 'in 1965, the issues of uncertainty has been considerably tackled to enhance the solution of many decision-making problems including career determination pattern recognition, medical diagnosis among others." Atanassov (1986) generalized the concept of fuzzy sets where he introduced the concept of intuitionistic fuzzy sets (IFS) by assigning a membership degree and a non-membership of the fuzzy sets". Yager (1986) was the first person to introduce the concept of fuzzy mset, where he combines both the concept of fuzzy set and mset. "Shinoj and John (2012) introduced the concept of intuitionistic fuzzy mset by combining the concept of intuitionistic fuzzy set and fuzzy mset". Many similarity measures have been proposed by different researchers, the first study was carried out by Szmidt and Kacprzyk (2000) where they extend the well-known distance measures such as Hamming and Euclidean distance to intuitionistic fuzzy set context and compare it with the approach of ordinary fuzzy sets, "Wing and Xing (2005) Proved that the work of Szmidt and Kacprzyk were not effective in some cases". Therefore, several new distance measures and their applications were presented in (Ejagwa et al., 2016; Maheswari et al., 2022; Muthuraj and Devi, 2019; Muthuraj and Yamuna, 2021; Paramanik and Mondal, 2015; Rajarajeswari and Uma, 2013; Samuel and Narmadhangnanam, *2018*). However, some of these have some setbacks that could lead to information loss. In this paper, we looked at the demerits of some of the existing methods and introduced a new distance measure that could help in solving the problems that the decision makers face when multiple attributes are involved, and applied it in radiological findings and climate change

Preliminaries
Definition 1 Zadeh (1965). Let X be a nonempty set. A fuzzy set A drawn from X is define as $A = \{< x, \mu_A(x) >: x \in X\}$ where $\mu_A(x) \to [0,1]$ is the membership function of fuzzy set A.

Definition 2 Atanassov (1999). Let X be a nonempty set, an intuitionistic fuzzy set (IFS) A is an object having the form $A = \{< x, \mu_A(x), v_A(x), \pi_A(x) > : x \in X\}$, where the function $\mu_A(x) \to [0,1]$ and $v_A(x) \to [0,1]$, $\pi_A(x) \to [0,1]$ defined respectively the degree of membership, the degree of non-membership and the degree of uncertainty of $x \in X$ to the IFS of A with
$0 \le \mu_A(x) + v_A(x) \le 1$ and $\pi_A(x) = 1 - \mu_A(x) - v_A(x)$.
Furthermore,$\pi_A(x) = 1 - \mu_A(x) - v_A(x)$ is called the hesitation margin or the degree of uncertainty of $x \in X$ to the IFS of A and $\pi_A(x) \in [0,1]$. That is $\pi: X \to [0,1]$and$0 \le \pi_A(x) \le 1, \forall x \in X$. $\pi_A(x)$ express the lack of knowledge of whether x belong to IFS or not.

Definition 3 Jena *et al* (2001). An mset M drawn from the set X is represented by a function count M or C_M defined asC_M: X→N where N represents the sets of nonnegative integers.

Definition 4 Miyamoto (1996). Let X be a universal set, the fuzzy mset A over X is a set of ordered pairs:
$A = \{ x, \mu_A(x): x \in X\} = \{x, CM_A(x): x \in X\}\ were\ CM_A(x) = (\mu^1{}_A(x), \mu^2{}_A(x), \dots, \mu^p{}_A(x))$.
$\mu_A(x) \to [0,1]$ is called the membership function of each $x \in X$, the value of $\mu_A(x)$ is called the grade of membership of x in A.

Definition 5 Atanassov (1999). Let X be a nonempty set. An Intuitionistic Fuzzy mset A denoted by IFMS drawn from X is characterized by two functions : 'count membership' of A CM_A and 'count non membership' of A CN_A given respectively by $CM_A: X \rightarrow Q$ and $CN_A: X \rightarrow Q$ where Q is the set of all crisp multisets drawn from the unit interval [0, 1] such that for each $x \in X$, the membership sequence is defined as a decreasingly ordered sequence of elements in $CM_A(x)$ which is denoted by $(\mu^1{}_A(x), \mu^2{}_A(x), \ldots, \mu^p{}_A(x))$where $\mu^1{}_A(x) \geq \mu^2{}_A(x) \geq, \ldots, \geq \mu^p{}_A(x)$, and the corresponding non membership sequence will be denoted by $(v^1{}_A(x), v^2{}_A(x), \ldots, v^p{}_A(x))$ such that $0 \leq \mu^i{}_A(x) + v^i{}_A(x) \leq 1$ for every $x \in X$ and i=1,2,3,…,p.

Remark; We arrange the membership sequence in decreasing order but the corresponding non membership sequence may not be in decreasing or increasing order.

Definition 6 Szmid (2014). Let A, B, C∈ IFS(X). Then, the distance measure d between IFSs is a function $d: IFS \times IFS \rightarrow [0,1]$ satisfying the following conditions

1 $0 \leq d(A,B) \leq 1$ (boundedness)
2 $d(A,B) = 0$ iff $A = B$ (separability)
3 $d(A,B) = d(B,A)$ (symmetry)
4 $d(A,C) \leq d(A,B) + d(B,C) =$ (Triangular inequality)

New Distance Measure of Intuitionistic fuzzy multiset
In this section, we introduce the new distance measure and then applied it in Radiological findings and climate change.
Definition 3.1 Given a finite universe of discourse $X = (x_1, x_2, \ldots, x_n)$. Let IFMS(X) be the set of all intuitionistic fuzzy multiset over X. Let A, B ∈ IFMS(X), then
$d(A,B) = \frac{1}{4n}\int_0^1 \sum_{i=1}^n \Big\{|\mu^\iota{}_{A(x_i)} - \mu^\iota{}_{B(x_i)}| + ||\mu^\iota{}_{A(x_i)} - v^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - v^\iota{}_{B(x_i)}||\lambda + ||\mu^\iota{}_{A(x_i)} - \pi^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - \pi^\iota{}_{B(x_i)}||\, \lambda^2\Big\}\, d\lambda$ Where $\lambda\epsilon[0,1]$.

Example: Consider the three patterns P_1, P_2, P_3 and the test sample S as represented in the following table

Table 1 (Using table from the work of Maheswari et al)

	S_1	S_2	S_3
P_1	(1.0,0.0,0.0)	(0.8,0.0,0.2)	(0.7,0.1,0.2)
P_2	(0.9,0.1,0.0)	(1.0,0.0,0.0)	(0.9,0.0,0.1)
P_3	(0.6,0.2,0.2)	(0.8,0.0,0.2)	(1.0,0.0,0.0)
S	(0.5,0.3,0.2)	(0.6,0.2,0.2)	(0.8,0.1,0.1)

$d(A,B) = \frac{1}{4n}\int_0^1 \sum_{i=1}^n \Big\{|\mu^\iota{}_{A(x_i)} - \mu^\iota{}_{B(x_i)}| + ||\mu^\iota{}_{A(x_i)} - v^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - v^\iota{}_{B(x_i)}||\lambda + ||\mu^\iota{}_{A(x_i)} - \pi^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - \pi^\iota{}_{B(x_i)}||\, \lambda^2\Big\}\, d\lambda$ Where $\lambda\epsilon[0,1]$.
$d(p_1,s) = \frac{1}{12}\int_0^1 \{|1.0 - 0.5| + ||1.0 - 0.0| - |0.5 - 0.3||\lambda + ||1.0 - 0.0| - |0.5 - 0.2||\lambda^2 +$
$|0.8 - 0.6| + ||0.8 - 0.0| - |0.6 - 0.2||\lambda + ||0.8 - 0.2| - |0.6 - 0.2||\lambda^2 +$
$|0.7 - 0.8| + ||0.7 - 0.1| - |0.8 - 0.1||\lambda + ||0.7 - 0.2| - |0.8 - 0.1||\lambda^2\}d\lambda$

$$\frac{1}{12}\int_0^1 \sum_{i=1}^3 \{0.8 + 1.3\lambda + 1.1\,\lambda^2\}\, d\lambda$$

$= \frac{1}{12}[0.8\lambda + 1.3\frac{\lambda^2}{2} + 1.1\frac{\lambda^3}{3}]|_0^1 = \frac{1}{12}\Big[0.8 + 1.3\frac{1^2}{2} + 1.1\frac{1^3}{3}\Big] = \frac{1}{12}[0.8 + 0.65 + 0.3667] = \frac{1}{12}[1.8167] = 0.1514,\ d(p_1,s) = 0.1514$
$d(p_2,s) = 0.1694$, $d(p_3,s) = 0.0958$.

Proposition 3.2
Let $P = |\mu^\iota{}_{A(x_i)} - \mu^\iota{}_{B(x_i)}|$, $Q = ||\mu^\iota{}_{A(x_i)} - v^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - v^\iota{}_{B(x_i)}||$ and $R = ||\mu^\iota{}_{A(x_i)} - \pi^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - \pi^\iota{}_{B(x_i)}||$.
Let $d(A,B)$ and $d^*(A,B)$ be distance measures of IFMs with $d^*(A,B) = \sum_{i=1}^n\{6P + 3Q + 2R\}$, then $d(A,B) = \frac{1}{24n} d^*(A,B)$
Proof
Let $d(A,B)$ and $d^*(A,B)$ be two distances measure of IFMs. Then we have
$d(A,B) = \frac{1}{4n}\int_0^1 \sum_{i=1}^n \Big\{|\mu^\iota{}_{A(x_i)} - \mu^\iota{}_{B(x_i)}| + ||\mu^\iota{}_{A(x_i)} - v^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - v^\iota{}_{B(x_i)}||\lambda + ||\mu^\iota{}_{A(x_i)} - \pi^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - \pi^\iota{}_{B(x_i)}||\, \lambda^2\Big\}\, d\lambda$ Where $\lambda\epsilon[0,1]$
Integrate over the closed interval [0,1]

$$d(A,B) = \frac{1}{4n}\sum_{i=1}^n [|\mu^\iota{}_{A(x_i)} - \mu^\iota{}_{B(x_i)}|\lambda + ||\mu^\iota{}_{A(x_i)} - v^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - v^\iota{}_{B(x_i)}||\frac{\lambda^2}{2} + ||\mu^\iota{}_{A(x_i)} - \pi^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - \pi^\iota{}_{B(x_i)}||\frac{\lambda^3}{3}]_0^1$$

$= \frac{1}{4n}\sum_{i=1}^n[|\mu^\iota{}_{A(x_i)} - \mu^\iota{}_{B(x_i)}| + ||\mu^\iota{}_{A(x_i)} - v^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - v^\iota{}_{B(x_i)}||\frac{1^2}{2} + ||\mu^\iota{}_{A(x_i)} - \pi^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - \pi^\iota{}_{B(x_i)}||\frac{1^3}{3}] \quad - 0$
$\frac{1}{4n}\sum_{i=1}^n[P + Q\frac{1}{2} + R\frac{1}{3}] = \frac{1}{4n}\sum_{i=1}^n\{\frac{6P+3Q+2R}{6}\} = \frac{1}{24n}\sum_{i=1}^n\{6P + 3Q + 2R\} = \frac{1}{24n} d^*(A,B)$.

Definition 3.3 let $A = \{< x, \mu^I{}_{A(x)}, v^I{}_{A(x)} >\}$ be IFMS in the non-empty set X= $\{x_1, x_2, x_3, \ldots, x_n\}$, then the complement of A denoted by A^c is define as $A^c = \{< x, v^I{}_{A(x)}, \mu^I{}_{A(x)} >\}$
Example Consider an intuitionistic fuzzy multiset IFMS A over X
$A = \{< x_1, (0.6, 0.8), (0.1, 0.2) >, < x_2, (0.3, 0.1), (0.5, 0.9) >\}$ Where $(0.6, 0.8)$ are membership degrees of x_1, $(0.3, 0.1)$ are membership degrees of x_2 and $(0.1, 0.2)$, $(0.5, 0.9)$ are corresponding non-membership of x_1 and x_2 respectively, then
$A^c = \{< x_1, (0.1, 0.2), (0.6, 0.8) >, < x_2, (0.5, 0.9), (0.3, 0.1) >\}$.

Proposition 3.4
Let A and B be two IFMSs in the non-empty set X= $\{x_1, x_2, x_3, \ldots, x_n\}$, then,

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$d((A^c)^c, (B^c)^c) = d(A, B)$.

Proof:
Let $A = \{< x, \mu^I{}_{A(x)}, v^I{}_{A(x)} >\}$and $B = \{< x, \mu^I{}_{B(x)} v^I{}_{B(x)} >\}$, then $(A^c)^c = \overline{A^C} = \overline{\{< x, 1 - \mu^I{}_{A(x)}, 1 - v^I{}_{A(x)}\}} = \overline{\left\{< x, v^I{}_{A(x)}, \mu^I{}_{A(x)} >\right\}} = \left\{< x, \mu^I{}_{A(x)}, v^I{}_{A(x)} >\right\} = A$, also

$$(B^c)^c = \overline{B^C} = \overline{\{< x, 1 - \mu^I{}_{B(x)}, 1 - v^I{}_{B(x)}\}} = \overline{\left\{< x, v^I{}_{B(x)}, \mu^I{}_{B(x)} >\right\}} = \left\{< x, \mu^I{}_{B(x)}, v^I{}_{B(x)} >\right\} = B$$

Thus: $d((A^c)^c, (B^c)^c) = d(A, B)$.
Suppose that there are three patients: P_1, P_2, P_3 , i.e., $P = \{P_1, P_2, P_3\}$. The set of symptoms $S = \{S_1, S_2, S_3 S_4, S_5\}$.The set of diseases $D = \{D_1, D_2, D_3, \}$.

Table 2 Symptoms characteristics for patient

R	S_1	S_2	S_3	S_4	S_5
P_1	0.7,0.2, 0.1	0.6,0.2, 0.2	0.3,0.7, 0.0	0.5,0.2, 0.3	0.2,0.7, 0.1
P_2	0.7,0.1, 0.2	0.8,0.2, 0.0	0.1,0.6, 0.3	0.2,0.7, 0.1	0.1,0.5, 0.4
P_3	0.5,0.1, 0.4	0.5,0.3, 0.2	0.3,0.5, 0.2	0.7,0.1, 0.2	0.3,0.5, 0.2

Table 3 Symptoms characteristics for the diagnosis

R	S_1	S_2	S_3	S_4	S_5
D_1	0.4,0.1, 0.5	0.3,0.5, 0.2	0.1,0.6, 0.3	0.4,0.3, 0.3	0.1,0.6, 0.3
D_2	0.5,0.1, 0.4	0.3,0.6, 0.1	0.1,0.9, 0.0	0.7,0.1, 0.2	0.2,0.8, 0.0
D_3	0.6,0.3, 0.1	0.6,0.2, 0.2	0.2,0.7, 0.1	0.2,0.7, 0.1	0.1,0.8, 0.1

Using Ejegwa *et al* method

$$d(P, D) = \frac{1}{2n}\sum_{i=1}^{n}\left\{|\mu^\iota{}_{A(x_i)} - \mu^\iota{}_{B(x_i)}| + ||\mu^\iota{}_{A(x_i)} - v^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - v^\iota{}_{B(x_i)}|| + ||\mu^\iota{}_{A(x_i)} - \pi^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - \pi^\iota{}_{B(x_i)}||\right\}$$

$$\begin{aligned} d(P_1, D_1) = \frac{1}{10}\sum_{i=1}^{5}\{&|0.7 - 0.4| \\ &+ \big||0.7 - 0.2| - |0.4 - 0.1|\big| \\ &+ \big||0.7 - 0.1| - |0.4 - 0.5|\big| \\ &+ |0.6 - 0.3| \\ &+ \big||0.6 - 0.2| - |0.3 - 0.5|\big| \\ &+ \big||0.6 - 0.2| - |0.3 - 0.2|\big| \\ &+ |0.3 - 0.1| \\ &+ \big||0.3 - 0.7| - |0.1 - 0.6|\big| \\ &+ \big||0.3 - 0.0| - |0.1 - 0.3|\big| \\ &+ |0.5 - 0.4| \\ &+ \big||0.5 - 0.2| - |0.4 - 0.3|\big| \\ &+ \big||0.5 - 0.3| - |0.4 - 0.3|\big| \\ &+ |0.2 - 0.1| \\ &+ \big||0.2 - 0.7| - |0.1 - 0.6|\big| \\ &+ \big||0.2 - 0.1| - |0.1 - 0.3|\big|\} \end{aligned}$$

$\frac{1}{10}\sum_{i=1}^{5}\{1 + |0.7| + |1.1|\}$ $,= \frac{1}{10}(1 + 0.7 + 1.1) = \frac{1}{10}(2.8) = 0.2800$

$(P_1, D_1) = 0.2800, (P_1, D_2) = 0.3200, (P_1, D_3) = 0.1800$
$(P_2, D_1) = 0.4100, (P_2, D_2) = 0.4000, (P_2, D_3) = 0.2000$
$(P_3, D_1) = 0.2700, (P_3, D_2) = 0.1800, (P_3, D_3) = 0.3200$

Using Maheswari *et al* method

$d_{p,v}(A, B) = \frac{1}{4}\int_0^1 \sum_{i=1}^{n}\{|\mu_{A(x_i)} - \mu_{B(x_i)}| + |v_{A(x_i)} - v_{B(x_i)}|\lambda + |\pi_{A(x_i)} - \pi_{B(x_i)}|\lambda^2\} d\lambda$ Where $\lambda \epsilon [0,1]$

$$\begin{aligned} \frac{1}{4}\int_0^1 \sum_{I=1}^{5}\{&|0.7 - 0.4| + |0.2 - 0.1|\lambda + |0.0 - 0.2|\lambda^2 \\ &+|0.6 - 0.3| + |0.2 - 0.5|\lambda + |0.2 - 0.2|\lambda^2 \\ &+|0.3 - 0.1| + |0.7 - 0.6|\lambda + |0.0 - 0.3|\lambda^2 \\ &+|0.5 - 0.4| + |0.2 - 0.3|\lambda + |0.3 - 0.3|\lambda^2 \\ &+|0.2 - 0.1| + |0.7 - 0.6|\lambda + |0.1 - 0.3|\lambda^2\} d\lambda \end{aligned}$$

$$\frac{1}{4}\int_0^1 \sum_{I=1}^{5}\{|1| + |0.7|\lambda + |0.9|\lambda^2\} d\lambda = 0.4125$$

Similarly others
$(P_1, D_1) = 0.4125,$ $(P_1, D_2) = 0.3875$ $(P_1, D_3) = 0.2625$
$(P_2, D_1) =$ $0.4167 (P_2, D_2) = 0.616,7 (P_2, D_3) = 0.2417$
$(P_3, D_1) = 0.3708$ $(P_3, D_2) = 0.2917$,$(P_3, D_3) = 0.475$

Using new method

$$d(P, D) = \frac{1}{4n}\int_0^1 \sum_{i=1}^{n}\left\{|\mu^\iota{}_{A(x_i)} - \mu^\iota{}_{B(x_i)}| + ||\mu^\iota{}_{A(x_i)} - v^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - v^\iota{}_{B(x_i)}||\lambda + ||\mu^\iota{}_{A(x_i)} - \pi^\iota{}_{A(x_i)}| - |\mu^\iota{}_{B(x_i)} - \pi^\iota{}_{B(x_i)}||\, \lambda^2\right\} d\lambda$$

$$d(P_1,D_1)=\frac{1}{20}\int_0^1\sum_{i=1}^{5}\{|0.7-0.4| + ||0.7-0.2|-|0.4-0.1||\lambda + ||0.7-0.1|-|0.4-0.5||\lambda^2 + |0.6-0.3| + ||0.6-0.2|-|0.3-0.5||\lambda + ||0.6-0.2|-|0.3-0.2||\lambda^2 + |0.3-0.1| + ||0.3-0.7|-|0.1-0.6||\lambda + ||0.3-0.0|-|0.1-0.3||\lambda^2 + |0.5-0.4| + ||0.5-0.2|-|0.4-0.3||\lambda + ||0.5-0.3|-|0.4-0.3||\lambda^2 + |0.2-0.1| + ||0.2-0.7|-|0.1-0.6||\lambda + ||0.2-0.1|-|0.1-0.3||\lambda^2\}d\lambda$$

$$(P_1,D_1)=\frac{1}{20}\int_0^1\sum_{i=1}^{5}\{1.0+|0.7|\lambda+|1.1|\lambda^2\}d\lambda$$

$$(P_1,D_1)=\frac{1}{20}(1.0+0.35+0.3667)$$

= 0.0858

Similarly, others

$(P_1,D_2)=0.0683$, $(P_1,D_3)=0.0508$,
$(P_2,D_1)=0.0950$, $(P_2,D_2)=0.0808$, $(P_2,D_3)=0.0383$,
$(P_3,D_1)=0.0567$, $(P_3,D_2)=0.0450$, $(P_3,D_3)=0.0700$.

Table 4: Result obtained using Ejegwaa *et al's* method

	D_1	D_2	D_3
P_1	0.2800	0.3200	**0.1800**
P_2	0.3400	0.4000	**0.2000**
P_3	0.3000	**0.1800**	0.3200

Table 5 Results obtained Using Maheswari et al.'s method

	D_1	D_2	D_3
P_1	0.4125	0.3875	**0.2625**
P_2	0.4167	0.6167	**0.2417**
P_3	0.3708	**0.2917**	0.4750

Table 6: Results obtained using the new method

	D_1	D_2	D_3
P_1	0.0858	0.0683	**0.0508**
P_2	0.0950	0.0808	**0.0383**
P_3	0.0567	**0.0450**	0.0700

Comparing the two existing results and new method, it shows that the new method is far better than the existing ones

Application in radiological findings

Radiology otherwise known as diagnostic imaging, is a series of different tests that take pictures or
Images of various parts of the body. Many of these tests are unique in that they allow doctors to
See inside the body. A number of different imaging exams can be used to provide this view,
Including X-ray, Magnetic resonance imaging (MRI), ultrasound, and Computer axial tomography
Scan (CT scan) and Positron emission tomography (PET scan) etc. Ontario Association of
Radiologist (2023).

Radiological findings are very helpful in the diagnosis, treatment, follow-up, and evaluation of
Response to treatment of chemical patients, Mostafa and Ali (2016).

For the purpose of this research, we will concentrate on radiological findings in the diagnosis of patients based on the doctor's request. Suppose that a doctor request for radiological findings on $\boldsymbol{\mu_A(x)}$ suspected diseases based on the complaints by patients to radiographers, let the request be represented by $\boldsymbol{R} = \{\boldsymbol{Abdominal\ scan, Pelvic\ scan, X-ray}\}$ and the suspected diseases by the doctor based on patient's complaints be represented by
$SD = \{liver\ problem, kidney\ problem, ulcer, appendix, heart\ problem\}$
.

Suppose also there are four patients, Ayuba, Farida, Samuel, John, represented as $\{Ay, Fa, Sa, Jh\}$, to have better and accurate results, the doctor requests that the investigation on each patient should be carried out three times by different radiographers.

Table 7: Request vs Suspected Diseases

R	Abdominal scan	Pelvic scan	X-ray
Liver problem	0.8,0.1,0.1	0.3,0.6,0.1	0.0,0.5,0.5
Kidney problem	0.7,0.2,0.1	0.4,0.2,0.4	0.1,0.7,0.2
ulcer	0.9,0.1,0.0	0.5,0.0,0.5	0.5,0.4,0.1
Appendix	0.3,0.6,0.1	0.8,0.2,0.0	0.0,1.0,0.0
Heart problem	0.5,0.3,0.2	0.2,0.0,0.8	1.0,0.0,0.0

Table 8 Request vs patients

F	Abdominal scan	Pelvic scan	X-ray
Ay	(0.8,0.2,0.0) (0.6,0.4,0.0) (0.7,0.0,0.3)	(0.9,0.0,0.1) (0.8,0.2,0.0) (0.8,0.1,0.1)	(0.2,0.6,0.3) (0.1,0.7,0.2) (0.3,0.4,0.3)
Fa	(0.5,0.5,0.0) (1.0,0.0,0.0) (0.9,0.1,0.0)	(0.6,0.3,0.1) (0.3,0.6,0.1) (0.4,0.4,0.2)	(0.1,0.7,0.2) (0.3,0.6,0.1) (0.2,0.8,0.0)
Sa	(0.4,0.3,0.3) (0.5,0.1,0.4) (0.3,0.6,0.1)	(0.8,0.1,0.1) (0.9,0.0,0.1) (0.6,0.4,0.0)	(0.2,0.8,0.0) (0.0,1.0,0.0) (0.1,0.7,0.2)
Jh	(0.2,0.8,0.0) (0.3,0.1,0.6) (0.4,0.6,0.0)	(0.5,0.5,0.0) (0.1,0.6,0.3) (0.5,0.4,0.1)	(1.0,0.0,0.0) (0.1,0.8,0.1) (0.9,0.0,0.0)

After taking the average, table 8 can be represented as

Table 9 Request vs patients

F	Abdominal scan	Pelvic scan	X-ray
Ay	0.70,0.20,0.10	0.83,0.10,0.07	0.2,0.56,0.26
Fa	0.80,0.20,0.00	0.43,0.43,0.13	0.20,0.70,0.10
Sa	0.40,0.33,0.26	0.76,0.16,0.06	0.10,0.83,0.06
Jh	0.30,0.50,0.20	0.37,0.50,0.10	0.67,0.26,0.06

Now, using the new method, we can obtain the radiological findings of each patient based on the doctor's request as follows

Table 10 Results obtained after calculating table 8 and 9

	Liver problem	Kidney problem	Ulcer	Appendix	Heart problem
Ay	0.1318	**0.0985**	0.1409	0.1068	0.2361
Fa	**0.0608**	**0.0497**	0.1044	0.1808	0.2511
Sa	0.1706	0.1289	0.2081	**0.0592**	0.1972
Jh	0.1567	0.1422	0.1756	0.1744	0.1097

Therefore, the above table shows that Ayuba surfer from kidney, Farida surfer from liver and kidney, Samuel suffers from appendix problem while John is not suffering from any of these diseases, therefore further examination be carrying on him to determine the disease he is suffering.

3.7 Application in climate change

Climate change refers to long-term shifts in temperatures and weather patterns. Such shifts can be natural, due to changes in the sun's activity or large volcanic eruptions or human activities such as burning of fossil fuels, deforestation, overgrazing etc. WHO (2016).

Some of the effects of climate change are floods, erosion, drought, shortage of food, poverty, and displacement, etc. For this paper, we concentrate on erosion as one of the effects of climate change. Suppose that there are four areas $\{A_1, A_2, A_3, A_4\}$ that are affected by erosion and we intend to checkmate and see the type of erosion affecting a particular area, assume that there are three different set of surveyors who are independent with each other to survey the same area affected with the type of erosion as

Table 11: Erosion vs Causes

	Poor vegetation	Cultivation	Over grazing	Runoff water	Improper design
Rill erosion	0.6,0.0, 0.4	0.5,0.3, 0.2	0.5,0.3, 0.2	0.4,0.4, 0.2	0.2,0.6, 0.2
Soil erosion	0.8,0.1, 0.1	0.7,0.2, 0.1	0.6,0.1, 0.3	0.6,0.4, 0.0	0.2,0.7, 0.1
Tunnel erosion	0.1,0.6, 0.3	0.3,0.7, 0.0	0.2,0.7, 0.1	0.1,0.9, 0.0	0.8,0.2, 0.0
Gully erosion	0.2,0.5, 0.3	0.6,0.3, 0.1	0.3,0;0, 0.7	0.1,0.9, 0.0	0.3,0.6, 0.1
Splash erosion	0.5,0.5, 0.0	0.6,0.4, 0.0	0.5,0.4, 0.1	0.6,0.4, 0.0	0.3,0.7, 0.0

Table 12: Causes vs affected area

	Poor vegetation	Cultivation	Over grazing	Runoff water	Improper design
A_1	0. 0.7,0.0,0.3 0. 0.8,0.2,0.0 0.5,0.5,0.0	0.5,0.2,0.3 0.3,0.7,0.0 0.8,0.0,0.2	0.4,0.4,0.2 0.6,0.3,0.1 0.5,0.0,0.5	0.3,0.7,0.0 0.5,0.3,0.2 0.4,0.5,0.1	0.0,0.2,0.8 0.3,0.7,0.0 0.2,0.6,0.2
A_2	0.7,0.1,0.2 0.6,0.3,0.1 0.8,0.2,0.0	0.6,0.4,0.0 0.6,0.0,0.4 0.5,0.5,0.0	0.7,0.2,0.1 0.6,0.3,0.1 0.5,0.0,0.5	0.6,0.3,0.1 0.8,0.2,0.0 0.3,0.5,0.2	0.1,0.7,0.2 0.4,0.5,0.1 0.3,0.3,0.4
A_3	0.1,0.7,0.2 0.5,0.4,0.1 0.3,0.2,0.5	0.7,0.0,0.3 0.5,0.3,0.2 0.6,0.3,0.1	0.5,0.5,0.0 0.3,0.4,0.3 0.7,0.0,0.3	0.8,0.2,0.0 0.7,0.1,0.2 0.8,0.2,0.0	0.0,0.6,0.6 0.5,0.0,0.5 0.6,0.2,0.2
A_4	0.0,0.3,0.7 0.5,0.3,0.2 0.4,0.6,0.0	0.5,0.5,0.0 0.7,0.3,0.0 0.5,0.3,0.2	0.7,0;0,0.3 0.5,0.4,0.1 0.6,0.2,0.1	1.0,0.0,0.0 0.9,0.0,0.1 1.0,0.0,0.0	0.9,0.1,0.0 0.7,0.1,0.2 0.5,0.3,0.2

After taking the average, Table 12 can also be written as

	Poor vegetation	Cultivation	Over grazing	Runoff water	Improper design
A_1	0.67,0.23,0.10	0.53,0.30,0.17	0.50,0.23,0.27	0.40,0.50,0.10	0.17,0.50,0.33
A_2	0.70,0.20,0.10	0.57,0.30,0.13	0.60,0.17,0.23	0.57,0.33,0.10	0.27,0.50,0.23
A_3	0.27,0.43,0.27	0.60,0.20,0.20	0.50,0.30,0.20	0.77,0.13,0.07	0.37,0.20,0.43
A_4	0.30,0.40,0.30	0.57,0.37,0.06	0.60,0.20,0.17	0.97,0.0,0.03	0.70,0.17,0.13

Now, computing tables 11 and 12

Table 13 Results obtained after calculating tables 5 and 6

	Rill erosion	Soil erosion	Tunnel erosion	Gully erosion	Splash erosion
A_1	**0.0317**	**0.0456**	0.1606	0.1133	**0.0641**
A_2	**0.0613**	**0.0467**	0.1733	0.1173	**0.0598**
A_3	0.1006	0.1136	0.1549	**0.0894**	**0.0708**
A_4	0.1527	0.1515	0.1505	0.1354	0.1082

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From the table 7 above, it shows that both Area one and two are affected by rill erosion, soil erosion and splash erosion, Area three is affected by gully and splash erosion and Area four is not affected by any of the erosions.
Therefore, further investigation should be carried out to determine the type of erosion that is affecting the area.

Conclusion
The distance measure of intuitionistic fuzzy multiset presented in this paper could help the researchers and decision makers in making appropriate and accurate decisions, especially when multiple criteria are involved in providing better and accurate results.

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