ON T- CONORM OF INTERVAL-VALUED INTUITIONISTIC FUZZY WEIGHTED AGGREGATION AND ITS APPLICATION OF MCDM IN AGRICULTURE

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Abstract:

Multi- Criteria Decision Making (MCDM) which that addresses the problem of making a suitable choice from a set of alternatives which are characterized in their attributes is a normal human activity. For this, used the Mathematical tool called Fuzzy Soft Matrix. In this paper, to find the suitable agricultural place which gives more benefit to the farmer with the help of T- Conorm of Interval- valued Intutionistic Fuzzy Weighted Aggregation (IVIFWA) in Multi Criteria Decision Making .

Keywords:

Fuzzy, Fuzzy Soft Matrix, Intuitionistic Fuzzy soft Matrix, Interval- Valued Intuitionistic Fuzzy Weighted Aggregation, T-Conorm, T- Conorm of Interval- Valued Intuitionistic Fuzzy Weighted Aggregation.

1. Introduction:

Multi- Criteria Decision Making is sub- discipline of Operations Research that explicitly evaluates multiple conflicting criteria in decision making. In our daily lives, we usually weight multiple criteria implicitly and we may be comfortable with the consequences of such decisions that are made based on only intuition. On the other hand, stakes are high, it is important to properly structure the problem and explicitly evaluate multiple criteria structuring complex problems well and considering multiple criteria explicitly leads to more informed and better decisions. There have been important advances in this field since the start of the modern multiple criteria decision making in the early 1960's.

MCDM is concerned with structuring and solving decision and planning problems involving multiple criteria. The purpose is to support decision makers facing such problems. "Solving" can be interpreted in different ways. It could correspond to choosing the best altenative from a set of available alternatives (where "best" can be interpreted as "the most preferred alternative" of a decision maker). MCDM has been active area of research since the 1970's. Muti- Criteria Decision Analysis is valuable tool that we can apply to many complex decisions. It is most applicable to solving problems that are characterized as a choice among alternatives. In psychology, Decision Making is regarded as the cognitive process resulting in the selection of a belief or a course of action among several alternative possibilities. Every decision making is a process of identifying and choosing alternatives based on values, preferences and beliefs of the decision maker.

Interval- Valued Intuitionistic Fuzzy set generalized by Atanassov and Gargov, can be used to characterized the uncertain information more sufficiently and accurately when we face the fact that the values of membership and non membership function in an Intuitionistic fuzzy set are difficult to be expressed as exact real numbers in many real world decision making problems. The Interval- Valued Intutionistic Fuzzy Weighted Averaging Operator is generalized by Xu in 2007. The Interval- Valued IntuitionisticFuzzy Weighted Geometric Operator is Generalized by Xu and Chen in 2007. In this paper, we used the T-Conorm of Interval- Valued Intuitionistic Fuzzy Weighted Aggregation. Finally, an illustrative decision making problem in agriculture to demonstrate , how to apply the IVIFWA Operator.

2. Preliminaries:

In this section [9],[10], We recall some basic definitions of Fuzzy Soft Matrix, Intuitionistic Soft Matrix, Interval- valued Intuitionistic Fuzzy Weighted Aggregation T-Conorm, operators of T- Conorm.

Definition 2.1 (Fuzzy Soft Set)

Let U= $\{ c_1, c_2, c_3, \ldots\ldots c_m \}$ be universal set and E be the set of parameters given by E = $\{ e_1, e_2, e_3, \ldots\ldots e_n \}$.Let A$\subset$ E and (F, A) fuzzy soft set in the fuzzy soft class (U, E). Then represent the fuzzy soft set (F, A) in matrix form as

$A_{m\times n} = [a_{ij}]_{m\times n}$ or $A = [a_{ij}]$ where i=1,2,…m ; j=1,2,….n.

Where $a_{ij} = \mu_j (c_i)$ if $e_j \in A$; 0 if $e_j \notin A$.

Here $\mu_j (c_i)$ represents the membership of c_i in the fuzzy set F(e_j). The set of all m$\times$n fuzzy soft matrices over U would be denoted by $FSM_{m\times n}$.

Definition 2.2 (Intuitionistic Fuzzy Soft Matrix)

Let U be an initial universe, E be the set of parameters and A$\subseteq$ E. Let (f_A , E) be an intuitionistic fuzzy soft set over U. Then a subset of UXE is uniquely defined by

$R_A = \{ (u, e) : e \in A, u \in f_A (e) \}$ which is called relation form of (f_A , E). Then the membership and non membership functions are written by

μ_{RA} : UXE $\to$[0,1] and γ_{RA} : UXE $\to$[0,1] where

μ_{RA} : (u ,e) $\in$[0,1] and γ_{RA} : (u ,e) $\in$[0,1] are the membership value and non membership value of u $\in$ U for each e $\in$ E.

If (μ_{ij} , γ_{ij})= (μ_{RA} (u_i , e_j) , γ_{RA} (u_i , e_j)) , we can define a matrix,

$$[\mu_{ij}, \gamma_{ij}]_{m\times n} = \begin{bmatrix} (\mu_{11},\gamma_{11}) & (\mu_{12},\gamma_{12}) & \cdot & \cdot & \cdot & (\mu_{1n},\gamma_{1n}) \\ (\mu_{21},\gamma_{21}) & (\mu_{22},\gamma_{22}) & \cdot & \cdot & \cdot & (\mu_{2n},\gamma_{2n}) \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ (\mu_{m1},\gamma_{m1}) & (\mu_{m2},\gamma_{m2}) & \cdot & \cdot & \cdot & (\mu_{mn},\gamma_{mn}) \end{bmatrix}$$

Which is called an mxn IFSM of the IFSS (f_A , E) over U. Therefore , we can say that IFSS (f_A , E) is uniquely characterized by the matrix $[\mu_{ij}, \gamma_{ij}]_{mxn}$ .The set of all mxn IFS matrices will be denoted by $IFSM_{mxn}$.

Definition 2.3 (Interval -valued Intuitionistic Fuzzy Weighted Aggregation [10])

The IVIFWA operator with respect to a weighting vector ω, IVIFWA $_\omega$ is defined as

$$\text{IVIFWA}_\omega(\tilde{\alpha}_1, \tilde{\alpha}_2, , \tilde{\alpha}_3 \ldots, \tilde{\alpha}_n) = <[1- \prod_{i=1}^{n}(1-a_i)^{\omega_i}, 1- \prod_{i=1}^{n}(1-b_i)^{\omega_i}], [\prod_{i=1}^{n} c_i^{\omega_i}, \prod_{i=1}^{n} c_i^{\omega_i}]>$$

Where, $\tilde{\alpha}_i$ = <[a_i , b_i], [c_i , d_i]> (i= 1,2,…n) is a collection of IVIFNs , $\omega = (\omega_1, \omega_2, \ldots.. \omega_n)$, $\omega_i \in [0,1]$.

Definition 2.4 (T-Conorm [9])

Let S: [0,1] x [0,1] be function satisfying the following axioms

(1) S (a,0) = a, $\forall$ a $\in$ [0,1] (Identity)
(2) S (a,b) = s (b,a), $\forall$ a,b $\in$ [0,1] (commutativity)
(3) if $b_1 < b_2$, then s (a,b_1) $\leq$ s (a ,b_2) $\forall$ a , b_1, b_2 $\in$ [0,1] (monotonicity)
(4) s (a ,s(b,c)) = s (s (a,b), c), $\forall$ a ,b,c $\in$ [0,1] (associativity)

Definition 2.5 (Operators of T-Conorm [9])

(1) Maximum operator : S_M {μ_1 , μ_2 , ……… … μ_n } = max {μ_1 , μ_2 , ……… … μ_n }
(2) Product operator : S_P {μ_1 , μ_2 , ……… … μ_n } =1- $\prod_{i=1}^{n}(1-\mu_i)$
(3) Operator Lukasiewicz t- conorm (bounded t- conorm) : S_L {μ_1 , μ_2 , ……… … μ_n } = min { $\sum_{i=1}^{n}\mu_i$,1 }.

3. T-Conorm of Interval- valued Intuitionistic Fuzzy Weighted Aggregation:

3.1. Algorithm based on T- Conorm of Interval- Valued Intuitionistic Fuzzy Weighted Aggregation:

Step 1: Construct an Interval- Valued Intuitionistic Fuzzy Soft Matrix.

Step 2: To find the Interval- Valued Intuitionistic Fuzzy Weighted Aggregation Matrix.

Step 3: Compute S_M , S_P ,S_L .

Step 4: Choose the highest membership values.

Step 5: Thus the optimum decision could be obtained.

3.2. Application:

The farmer is facing the problem for choosing suitable land for cultivating the crops. Suppose U= {L_1 , L_2 } be the two agricultural land located at Panruti and Nellikupam respecteively. In L_1 and L_2 the farmer choose the the three places p_1, p_2 and p_3 then he cultivated the same crops, C ={c_1, c_2, c_3, c_4} such as wheat, paddy, groundnut, corn and let E={<(water facility, electricity)>, <(labours, working hours)>, <(nutrientsand fertilizers, pesticides)>}. To find the best agricultural land to give more benefit to the farmer by using T-Conorm of Interval-Valued Intuitionistic Fuzzy Weighted Aggregation in Multi- Criteria Decision Making.

Step 1:

Construct an Interval-Valued Intuitionistic Fuzzy set.

$L_1(p_1)$	<e_1, e_2>	<e_3, e_4>	<e_5, e_6>
c_1	<[0,0.2],[0.1,0.1]>	<[0.1,0.1],[0.1,0.2]>	<[0,0.2],[0.1,0.2]>
c_2	<[0.1,0.1],[0.1,0.2]>	<[0,0.2],[0.1,0.2]>	<[0.1,0.2],[0.1,0.2]>
c_3	<[0.1,0.2],[0.1,0.2]>	<[0,0.2],[0.1,0.2]>	<[0.1,0.2],[0.1,0.2]>
c_4	<[0.1,0],[0,0]>	<[0,0.2],[0,0]>	<[0,0.1],[0,0.2]>

$L_1(p_2)$	<e_1, e_2>	<e_3, e_4>	<e_5, e_6>
c_1	<[0.2,0.4],[0.2,0.3]>	<[0.2,0.3],[0.2,0.4]>	<[0.2,0.4],[0.2,0.4]>
c_2	<[0.2,0.3],[0.3,0.4]>	<[0.2,0.4],[0.3,0.4]>	<[0.2,0.3],[0.2,0.4]>
c_3	<[0.2,0.4],[0.2,0.4]>	<[0.2,0.3],[0.2,0.4]>	<[0.2,0.3],[0.4,0.4]>
c_4	<[0.2,0.2],[0.2,0.2]>	<[0.3,0.4],[0.2,0.2]>	<[0.2,0.2],[0.3,0.4]>

$L_1(p_3)$	<e_1, e_2>	<e_3, e_4>	<e_5, e_6>
c_1	<[0.3,0.5],[0.3,0.4]>	<[0.3,0.4],[0.3,0.5]>	<[0.3,0.5],[0.3,0.5]>
c_2	<[0.3,0.4],[0.4,0.4]>	<[0.3,0.5],[0.4,0.5]>	<[0.4,0.4],[0.3,0.5]>
c_3	<[0.3,0.5],[0.3,0.5]>	<[0.3,0.4],[0.3,0.5]>	<[0.3,0.5],[0.5,0.5]>
c_4	<[0.3,0.3],[0.3,0.3]>	<[0.4,0.5],[0.3,0.3]>	<[0.5,0.5],[0.4,0.5]>

$L_2(p_1)$	<e_1, e_2>	<e_3, e_4>	<e_5, e_6>
c_1	<[0.6,0.8],[0.6,0.7]>	<[0.6,0.7],[0.6,0.8]>	<[0.6,0.8],[0.6,0.8]>
c_2	<[0.6,0.7],[0.7,0.8]>	<[0.6,0.8],[0.7,0.8]>	<[0.6,0.7],[0.6,0.8]>
c_3	<[0.6,0.8],[0.6,0.8]>	<[0.6,0.7],[0.6,0.8]>	<[0.7,0.7],[0.6,0.8]>
c_4	<[0.6,0.6],[0.6,0.6]>	<[0.7,0.8],[0.6,0.6]>	<[0.6,0.7],[0.8,0.8]>

$L_2(p_2)$	<e_1, e_2>	<e_3, e_4>	<e_5, e_6>
c_1	<[0.7,1],[0.8,0.9]>	<[0.8,0.9],[0.8,0.9]>	<[0.8,1],[0.8,1]>
c_2	<[0.8,0.9],[0.9,1]>	<[0.8,0.9],[0.9,1]>	<[0.9,0.9],[0.8,1]>
c_3	<[0.7,1],[0.8,1]>	<[0.8,0.8],[0.8,1]>	<[0.8,1],[0.8,1]>
c_4	<[0.8,0.8],[0.8,0.8]>	<[0.8,1],[0.8,0.8]>	<[0.8,0.8],[0.9,1]>

$L_2(p_3)$	$\langle e_1, e_2 \rangle$	$\langle e_3, e_4 \rangle$	$\langle e_5, e_6 \rangle$
c_1	<[0.7,0.9],[0.8,1]>	<[0.8,1],[0.9,1]>	<[0.7,0.9],[0.9,1]>
c_2	<[0.8,1],[0.8,0.9]>	<[0.9,1],[0.8,0.9]>	<[0.8,1],[0.9,0.9]>
c_3	<[0.9,1],[0.9,1]>	<[0.7,1],[0.9,1]>	<[0.9,1],[0.8,1]>
c_4	<[0.7,1],[0.7,0.7]>	<[0.7,0.9],[0.7,0.8]>	<[0.8,0.7],[0.7,0.9]>

Step 2:

To find the Interval –Valued Intutionistic Fuzzy Weighted Aggregation Matrix,

$$\tilde{\alpha}_1(p_1) = \begin{bmatrix} <[0,0.2],[0.1,0.1]> & <[0.1,0.1],[0.1,0.2]> & <[0,0.2],[0.1,0.2]> \\ <[0.1,0.1],[0.1,0.2]> & <[0,0.2],[0.1,0.2]> & <[0.1,0.2],[0.1,0.2]> \\ <[0.1,0.2],[0.1,0.2]> & <[0,0.2],[0.1,0.2]> & <[0.1,0.2],[0.1,0.2]> \\ <[0.1,0],[0,0]> & <[0,0.2],[0,0]> & <[0,0.1],[0,0.2]> \end{bmatrix}$$

$$\tilde{\alpha}_1(p_2) = \begin{bmatrix} <[0.2,0.4],[0.2,0.3]> & <[0.2,0.3],[0.2,0.4]> & <[0.2,0.4],[0.2,0.4]> \\ <[0.2,0.3],[0.3,0.4]> & <[0.2,0.4],[0.3,0.4]> & <[0.2,0.3],[0.2,0.4]> \\ <[0.2,0.4],[0.2,0.4]> & <[0.2,0.3],[0.2,0.4]> & <[0.2,0.3],[0.4,0.4]> \\ <[0.2,0.2],[0.2,0.2]> & <[0.3,0.4],[0.2,0.2]> & <[0.2,0.2],[0.3,0.4]> \end{bmatrix}$$

$$\tilde{\alpha}_1(p_3) = \begin{bmatrix} <[0.3,0.5],[0.3,0.4]> & <[0.3,0.4],[0.3,0.5]> & <[0.3,0.5],[0.3,0.5]> \\ <[0.3,0.4],[0.4,0.5]> & <[0.3,0.5],[0.4,0.5]> & <[0.4,0.4],[0.3,0.5]> \\ <[0.3,0.5],[0.3,0.5]> & <[0.3,0.4],[0.3,0.5]> & <[0.3,0.5],[0.5,0.5]> \\ <[0.3,0.3],[0.3,0.3]> & <[0.4,0.5],[0.3,0.3]> & <[0.5,0.5],[0.4,0.5]> \end{bmatrix}$$

$$\tilde{\alpha}_2(p_1) = \begin{bmatrix} <[0.6,0.8],[0.6,0.7]> & <[0.6,0.7],[0.6,0.8]> & <[0.6,0.8],[0.6,0.8]> \\ <[0.6,0.7],[0.7,0.8]> & <[0.6,0.8],[0.7,0.8]> & <[0.7,0.6],[0.6,0.8]> \\ <[0.6,0.8],[0.6,0.8]> & <[0.6,0.7],[0.6,0.8]> & <[0.7,0.7],[0.6,0.8]> \\ <[0.6,0.6],[0.6,0.6]> & <[0.7,0.8],[0.6,0.6]> & <[0.6,0.7],[0.8,0.8]> \end{bmatrix}$$

$$\tilde{\alpha}_2(p_2) = \begin{bmatrix} <[0.7,1],[0.8,0.9]> & <[0.8,0.9],[0.8,0.9]> & <[0.8,1],[0.8,1]> \\ <[0.8,0.9],[0.9,1]> & <[0.8,0.9],[0.9,1]> & <[0.9,0.9],[0.8,1]> \\ <[0.7,1],[0.8,1]> & <[0.8,0.8],[0.8,1]> & <[0.8,1],[0.8,1]> \\ <[0.8,0.8],[0.8,0.8]> & <[0.8,1],[0.8,0.8]> & <[0.8,0.8],[0.9,1]> \end{bmatrix}$$

$$\tilde{\alpha}_2(p_3) = \begin{bmatrix} <[0.7,0.9],[0.8,1]> & <[0.8,1],[0.9,1]> & <[0.7,0.9],[0.9,1]> \\ <[0.8,1],[0.8,0.9]> & <[0.9,1],[0.8,0.9]> & <[0.8,1],[0.9,0.9]> \\ <[0.9,1],[0.9,1]> & <[0.7,1],[0.9,1]> & <[0.9,1],[0.8,1]> \\ <[0.7,1],[0.7,0.7]> & <[0.7,0.9],[0.7,0.8]> & <[0.8,0.9],[0.7,0.9]> \end{bmatrix}$$

To obtain the Interval – Valued Intuitionistic Fuzzy Weighted Aggregation Matrix,

$$\text{IVIFWA}\omega(L_1)=\begin{bmatrix} <[0.061,0.153],[0,0]> & <[0.021,0.207],[0,0]> & <[0.041,0.207],[0,0.145]> \\ <[0.300,0.551],[0.090,0.098]> & <[0.337,0.580],[0.090,0.113]> & <[0.300,0.515],[0.118,0.160]> \\ <[0.575,0.794],[0.066,0.086]> & <[0.613,0.815],[0.066,0.100]> & <[0.683,0.837],[0.090,0.144]> \end{bmatrix}$$

$$\text{IVIFWA}\omega(L_2)=\begin{bmatrix} <[0.520,0.798],[0.685,0.674]> & <[0.546,0.815],[0.685,0.702]> & <[0.546,0.791],[0.704,0.765]> \\ <[0.895,1],[0.734,0.849]> & <[0.924,1],[0.734,0.849]> & <[0.942,1],[0.734,1]> \\ <[0.977,1],[0.580,0.724]> & <[0.977,1],[0.622,0.795]> & <[0.982,1],[0.622,0.863]> \end{bmatrix}$$

Step 3:

Compute the S_M , S_P , S_L.

$S_M(L_1)= [<[0.575,0.794],[0.090,0.098]> \quad <[0.613,0.815],[0.090,0.113]> \quad <[0.683,0.837],[0.118,0.160]>]$

$S_P(L_1)= [<[0.721,0.922],[0.150,0.176]> \quad <[0.749,0.938],[0.150,0.202]> \quad <[0.787,0.937],[0.197,0.385]>]$

$S_L(L_1)=[<[0.936,1],[0.156,0.184]> \quad <[0.971,1],[0.156,0.213]> \quad <[1,1],[0.208,0.449]>]$

$S_M(L_2)= [<[0.977,1],[0.734,0.849]> \quad <[0.977,1],[0.734,0.849]> \quad <[0.982,1],[0.734,1]>]$

$S_P(L_2)= [<[0.999,1],[0.965,0.986]> \quad <[0.999,1],[0.968,0.991]> \quad <[1,1],[0.970,1]>]$

$S_L(L_2)= [<[1,1],[1,1]> \quad <[1,1],[1,1]> \quad <[1,1],[1,1]>]$

Step 4:

Choose the highest membership values.

	S_M	S_P	S_L
L_1	<[0.575,0.794],[0.090,0.098]> <[0.613,0.815],[0.090,0.113]> <[0.683,0.837],[0.118,0.160]>	<[0.721,0.922],[0.150,0.176]> <[0.749,0.938],[0.150,0.202]> <[0.787,0.937],[0.197,0.385]>	<[0.936,1],[0.156,0.184]> <[0.971,1],[0.156,0.213]> <[1,1],[0.208,0.449]>
L_2	<[0.977,1],[0.734,0.849]> <[0.977,1],[0.734,0.849]> <[0.982,1],[0.734,1]>	<[0.999,1],[0.965,0.986]> <[0.999,1],[0.968,0.991]> <[1,1],[0.970,1]>	<[1,1],[1,1]> <[1,1],[1,1]> <[1,1],[1,1]>

i.e., L_2 is the highest membership values.

Step 5:

L_2 is the best suitable agricultural land choosen by the farmer.

Conclusion:

In this paper, we study the definition of Interval- valued Intuionistic Fuzzy Weighted Aggregation and to find the T- Conorm of Interval- valued Intuionistic Fuzzy Weighted Aggregation in Multi- Criteria Decision Making with illustrated an example in the field of agriculture.

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