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Multi Attribute Decision Making Approach for Solving Intuitionistic Fuzzy Soft Matrix

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Abstract. This paper introduces the concept of intuitionistic fuzzy dominance matrix (IFDM) for solving multi attribute decision making (MADM) problems in intuitionistic fuzzy soft sets. during decision making problems, dominance of one expert over others play an important role to find out the optimal alternatives. We have proposed an algorithm approach to solve MADM problems using IFDM. Finally the proposed algorithm is illustrated using a numerical example.

Keywords: Soft set, fuzzy soft set, intuitionistic fuzzy soft set, intuitionistic fuzzy dominance matrix.

AMS mathematics Subject Classification (2010): 03E72, 03F55, 90B06

1. Introduction

Most of our real life problems in medical science, engineering, management, environment and social science often involve data which are not always all crisp, precise and deterministic in character because of various uncertainties typical for these problems. Such uncertainties are usually being handled with the help of the topics like probability, fuzzy sets, intuitionistic fuzzy sets, interval mathematics and rough sets etc.Many researchers have applied fuzzy optimization techniques in Decision making [7-12, 20-24] based on the mathematical formulation of fuzzy sets introduced by Zadeh [27]. However, Molodtsov [18] has shown that each of the above topics suffers from some inherent difficulties due to inadequacy of their parameterization tools and introduced a concept called 'Soft Set Theory' having parameterization tools for successfully dealing with various types of uncertainties. The absence of any restrictions on the approximate description in soft set theory makes this theory very convenient and easily applicable in practice. Research on soft sets has been very wide spread and many important results have been achieved in the theoretical aspect. Maji et al. introduced several algebraic operations in soft set theory and published a detailed theoretical study on soft sets [15]. The same authors also extended crisp soft sets to fuzzy soft sets [14] and intuitionistic fuzzy soft sets [15]. At the same time, there has been some progress concerning practical applications of soft set theory, especially the use of soft sets in decision making

[1,2,5,6,13-17,25,26]. Recently, Cagman et al. [3,4] introduced soft matrix and applied it in decision making problems.

Decision making is the study of identifying and choosing alternatives based on the values and preferences of the decision maker. Aim of our paper is to introduce a new concept to represent a decision making system with the help of intuitionistic fuzzy dominance matrix. We have used intuitionistic fuzzy decision matrix to present the options of individual decision makers. This matrix is formed with a finite set of alternative and criteria, where opinion of a decision maker is presented using fuzzy value. The rest of this paper organized as follows. Section 2 reviews some basic ideas related with this paper. In section 3, we propose the intuitionistic fuzzy dominance matrix and some operations on it. An algorithm approach is proposed in section 4 to present the application of IFDM in decision making problems followed by a numerical example. Finally the key conclusions are given in section 5.

2. Preliminaries

This section, briefly reviews the basic characteristics of fuzzy set and intuitionstic fuzzy soft sets.

Definition 2.1. **(Soft set)**
Let U be an initial universe, P (U) be the power set of U, E be the set of all parameters and A⊆ E. A soft set (f_A, E) on the universe U is defined by the set of order pairs (f_A, E) = {(e, f_A (e)): e∈ E, f_A∈ P (U)} where f_A : E → P (U) such that f_A (e) = ϕ
if e ∉ A.Here f_A is called an approximate function of the soft set.

Example 1. Let U = $\{u_1,u_2,u_3,u_4\}$ be a set of four shirts and
E = {white(e_1),red(e_2),blue (e_3)} be a set of parameters. If A = $\{e_1 ,e_2\}$ ⊆ E.
Let $f_A(e_1)$ = $\{u_1, u_2 ,u_3, u_4\}$ and $f_A(e_2)$= $\{u_1,u_2,u_3\}$ then we write the soft set (f_A , E)= {(e_1, $\{u_1, u_2 ,u_3, u_4\}$), (e_2,$\{u_1,u_2,u_3\}$)} over U which describe the "colour of the shirts" which Mr. X is going to buy. We may represent the soft set in the following form:

U	e_1	e_2	e_3
u_1	1	1	0
u_2	1	1	0
u_3	1	1	0
u_4	1	0	0

Definition 2.2. (Fuzzy soft set) Let U be an initial universe, E be the set of all parameters and A⊆ E. A pair (F, A) is called a fuzzy soft set over U where F: A → $\tilde{P}$(U) is a mapping from A into $\tilde{P}$(U), where $\tilde{P}$(U) denotes the collection of all subsets of U.

Example 2. Consider the above example, here we cannot express with only two real numbers 0 and 1, we can characterized it by a membership function instead of crisp

number 0 and 1, which associate with each element a real number in the interval [0,1].Then
$(f_A, \mathrm{E}) = \{f_A(e_1) = \{(u_1, 0.7), (u_2, 0.5), (u_3, 0.4), (u_4, 0.2)\},$
$f_A(e_2) = \{(u_1, 0.5), (u_2, 0.1), (u_3, 0.5)\}$ is the fuzzy soft set representing the "colour of the shirts" which Mr. X is going to buy. We may represent the fuzzy soft set in the following

U	e_1	e_2	e_3
u_1	0.7	0.5	0
u_2	0.5	0.1	0
u_3	0.4	0.5	0
u_4	0.2	0	0

Definition 2.3. (Intuitionistic fuzzy soft set)
Let U be an initial universal set and let E be set of parameters and A⊆ E. Let P (U) denotes the set of all intuitionistic fuzzy sets of U. A pair (F, A) is called an intuitionistic fuzzy soft set over U if F is a mapping given by F: A → P (U).

Example 3. Suppose that there are four people in the universe given by,
$\mathrm{U} = \{u_1, u_2, u_3, u_4\}$ and $\mathrm{E} = \{e_1, e_2, e_3\}$ where e_1 stands for young , e_2 stands for smart, e_3 stands for middle-aged. Suppose that
$\mathrm{F}(e_1) = \left\{\frac{u_1}{(0.5,0.2)}, \frac{u_2}{(0.9,0.1)}, \frac{u_3}{(0.4,0.1)}, \frac{u_4}{(0.0,0.5)}\right\}$, $\mathrm{F}(e_2) = \left\{\frac{u_1}{(0.3,0.1)}, \frac{u_2}{(0.8,0.2)}, \frac{u_3}{(0.0,0.4)}, \frac{u_4}{(0.5,0.3)}\right\}$,
$\mathrm{F}(e_3) = \left\{\frac{u_1}{(0.4,0.2)}, \frac{u_2}{(0.7,0.3)}, \frac{u_3}{(0.4,0.3)}, \frac{u_4}{(0.6,0.0)}\right\}$

Thus intuitionistic fuzzy soft set is a parameterized family of all Intuitionistic fuzzy set of *U* and gives us a approximate description of the object. We may represent the soft set in the following:

U	e_1	e_2	e_3
u_1	(0.5,0.2)	(0.3,0.1)	(0.4,0.2)
u_2	(0.9,0.1)	(0.8,0.2)	(0.7,0.3)
u_3	(0.4,0.1)	(0.0,0.4)	(0.4,0.3)
u_4	(0.0,0.5)	(0.5,0.3)	(0.6,0.0)

Definition 2.4. (Row-intuitionistic fuzzy soft matrix)
An intuitionistic fuzzy soft matrix of order $1\times n$ i.e., with a single row is called a row-intuitionistic fuzzy soft matrix.

Example 4. Suppose the universe set U contains only one dress d_1 and parameter set E = {costly, beautiful, cheap, comfortable}= $\{e_1, e_2, e_3, e_4\}$. Let $A = \{e_2, e_3, e_4\} \subset \mathrm{E}$ and

$F_A(\mathrm{e}_2)$ = $\left\{\frac{\mathrm{d}_1}{(0.8,0.1)}\right\}$,$F_A(\mathrm{e}_3)$ = $\left\{\frac{\mathrm{d}_1}{(0.3,0.7)}\right\}$, $F_A(\mathrm{e}_4)$ = $\left\{\frac{\mathrm{d}_1}{(0.6,0.3)}\right\}$ .Hence the intuitionistic fuzzy soft matrix (a_{ij}) is written by, (a_{ij}) = [(0,1) (0.8,0.1) (0.3,0.7) (0.6,0.3)] which contains a single row and so it is a row-intuitionistic fuzzy soft matrix.

Definition 2.5. (Column-intuitionistic fuzzy soft matrix)
An intuitionistic fuzzy soft matrix of order m×1 i.e., with a single column is called a column -intuitionistic fuzzy soft matrix.

Example 5. Suppose the initial universe set U contains four dresses $\{d_1, d_2, d_3, d_4\}$ and the parameter set E contains only one parameter given by E ={beautiful }={e_1}. Let F: E → P (U) such that F(e_1) = $\left\{\frac{d_1}{(0.7,0.2)}, \frac{d_2}{(0.2,0.6)}, \frac{d_3}{(0.8,0.1)}, \frac{d_4}{(0.4,0.5)}\right\}$. Hence the intuitionistic fuzzy soft matrix (a_{ij}) is written by

$$(a_{ij})=\begin{pmatrix} (0.7,0.2) \\ (0.2,0.6) \\ (0.8,0.1) \\ (0.4,0.5) \end{pmatrix}$$

which contains a single column and so it is a column -intuitionistic fuzzy soft matrix.

Definition 2.6. (Complement of an intuitionistic fuzzy soft matrix)
Let (a_{ij}) be an $m \times n$ intuitionistic fuzzy soft matrix, where a_{ij} = (μ_{ij}, v_{ij}) for all i, j.Then the complement of (a_{ij}) is denoted by $(a_{ij})^{\,o}$ and defined by, $(a_{ij})^{\,o} = (c_{ij})$ is also an intuitionistic fuzzy soft matrix of order $m \times n$ and c_{ij} = (v_{ij}, μ_{ij}) for all i, j.

Example 6.

$$\text{Let } (a_{ij})=\begin{pmatrix} (0.2,0.7) & (0.0,0.9) & (0.3,0.5) & (0,1) & (0.9,0.1) \\ (0.8.0.1) & (0.9,0.1) & (0.4,0.6) & (0,1) & (0.1,0.8) \\ (0.4,0.1) & (0.3,0.6) & (0.8,0.1) & (0,1) & (0.5,0.4) \\ (0.6,0.3) & (0.4,0.6) & (0.8,0.1) & (0,1) & (0.3,0.5) \\ (0.7,0.2) & (0.6,0.3) & (0.3,0.7) & (0,1) & (0.1,0.8) \end{pmatrix}.$$

The complement of (a_{ij}) is

$$(a_{ij})^{\,o}=\begin{pmatrix} (0.7,0.2) & (0.9,0.0) & (0.5,0.3) & (1,0) & (0.1,0.9) \\ (0.1,0.8) & (0.1,0.9) & (0.6,0.4) & (1,0) & (0.8,0.1) \\ (0.1,0.4) & (0.6,0.3) & (0.1,0.8) & (1,0) & (0.4,0.5) \\ (0.3,0.6) & (0.6,0.4) & (0.1,0.8) & (1,0) & (0.5,0.3) \\ (0.2,0.7) & (0.3,0.6) & (0.7,0.3) & (1,0) & (0.8,0.1) \end{pmatrix}.$$

Definition 2.7. (Sum of the intuitionistic fuzzy soft matrices)
Two intuitionistic fuzzy soft matrices A and B are said to be conformable for addition, if they be of the same order. The addition of two intuitionistic fuzzy soft matrices $(a_{ij}$) and

(b_{ij}) of order $m\times n$ is defined by, $(a_{ij})\oplus(b_{ij}) = (c_{ij})$ is also an $m\times n$ intuitionistic fuzzy soft matrix and c_{ij} = ($\max\{\mu_{a_{ij}}, \mu_{b_{ij}}\}$, $\min\{v_{a_{ij}}, v_{b_{ij}}\}$) for all i, j.

Example 7. Let U be the set of four cities, given by, U = $\{u_1, u_2, u_3, u_4, u_5\}$. Let E be the set of parameters given by, E = { highly, immensely, moderately, average, less } = $\{e_1, e_2, e_3, e_4, e_5\}$ (say). Let $A\subset E$, given by, $A = \{e_1, e_2, e_3, e_5\}$ and

$$F_A(e_1)=\left\{\frac{u_1}{(0.2,0.7)},\frac{u_2}{(0.8,0.1)},\frac{u_3}{(0.4,0.1)},\frac{u_4}{(0.6,0.3)},\frac{u_5}{(0.7,0.2)}\right\},$$
$$F_A(e_2)=\left\{\frac{u_1}{(0.0,0.9)},\frac{u_2}{(0.9,0.1)},\frac{u_3}{(0.3,0.6)},\frac{u_4}{(0.4,0.6)},\frac{u_5}{(0.6,0.3)}\right\},$$
$$F_A(e_3)=\left\{\frac{u_1}{(0.3,0.5)},\frac{u_2}{(0.4,0.6)},\frac{u_3}{(0.8,0.1)},\frac{u_4}{(0.8,0.1)},\frac{u_5}{(0.3,0.7)}\right\},$$
$$F_A(e_5)=\left\{\frac{u_1}{(0.9,0.1)},\frac{u_2}{(0.1,0.8)},\frac{u_3}{(0.5,0.4)},\frac{u_4}{(0.3,0.5)},\frac{u_5}{(0.1,0.8)}\right\}.$$

Hence the intuitionistic fuzzy soft matrix (a_{ij}) is written by,

$$(a_{ij})=\begin{pmatrix} (0.2,0.7) & (0.0,0.9) & (0.3,0.5) & (0,1) & (0.9,0.1) \\ (0.8.0.1) & (0.9,0.1) & (0.4,0.6) & (0,1) & (0.1,0.8) \\ (0.4,0.1) & (0.3,0.6) & (0.8,0.1) & (0,1) & (0.5,0.4) \\ (0.6,0.3) & (0.4,0.6) & (0.8,0.1) & (0,1) & (0.3,0.5) \\ (0.7,0.2) & (0.6,0.3) & (0.3,0.7) & (0,1) & (0.1,0.8) \end{pmatrix}.$$

Now consider another intuitionistic fuzzy soft matrix (b_{ij}) associated with the intuitionistic fuzzy soft set over the same universe U. Let $B = \{e_1, e_4, e_5\}\subset E$ and

$$F_B(e_1)=\left\{\frac{u_1}{(0.3,0.7)},\frac{u_2}{(0.9,0.1)},\frac{u_3}{(0.4,0.5)},\frac{u_4}{(0.7,0.2)},\frac{u_5}{(0.6,0.2)}\right\},$$
$$F_B(e_4)=\left\{\frac{u_1}{(0.2,0.7)},\frac{u_2}{(0.3,0.7)},\frac{u_3}{(0.7,0.1)},\frac{u_4}{(0.2,0.8)},\frac{u_5}{(0.3,0.6)}\right\},$$
$$F_B(e_5)=\left\{\frac{u_1}{(0.8,0.1)},\frac{u_2}{(0.2,0.7)},\frac{u_3}{(0.6,0.4)},\frac{u_4}{(0.3,0.5)},\frac{u_5}{(0.2,0.6)}\right\}.$$

Hence the intuitionistic fuzzy soft matrix (b_{ij}) is written by

$$(b_{ij}) = \begin{pmatrix} (0.3,0.7) & (0,1) & (0,1) & (0.2,0.7) & (0.8,0.1) \\ (0.9,0.1) & (0,1) & (0,1) & (0.3,0.7) & (0.2,0.7) \\ (0.4,0.5) & (0,1) & (0,1) & (0.7,0.1) & (0.6,0.4) \\ (0.7,0.2) & (0,1) & (0,1) & (0.2,0.8) & (0.3,0.5) \\ (0.6,0.2) & (0,1) & (0,1) & (0.3,0.6) & (0.2,0.6) \end{pmatrix}$$

Therefore the sum of the intuitionistic fuzzy soft matrices (a_{ij}) and (b_{ij}) is,

$$(a_{ij})\oplus(b_{ij})\begin{pmatrix}(0.3,0.7) & (0.0,0.9) & (0.3,0.5) & (0.2,0.7) & (0.9,0.1)\\(0.9,0.1) & (0.9,0.1) & (0.4,0.6) & (0.3,0.7) & (0.2,0.7)\\(0.4,0.1) & (0.3,0.6) & (0.8,0.1) & (0.7,0.1) & (0.6,0.4)\\(0.7,0.2) & (0.4,0.6) & (0.8,0.1) & (0.2,0.8) & (0.3,0.5)\\(0.7,0.2) & (0.6,0.3) & (0.3,0.7) & (0.3,0.6) & (0.2,0.6)\end{pmatrix}$$

Definition 2.8. (Subtraction of the intuitionistic fuzzy soft matrices)
Two intuitionistic fuzzy soft matrices A and B are said to be conformable for subtraction, if they be of the same order. For any two intuitionistic fuzzy soft matrices (a_{ij}) and (b_{ij}) of order $m\times n$, the subtraction of (b_{ij}) from (a_{ij}) is defined as $(a_{ij}) \ominus (b_{ij}) = (c_{ij})$ is also an $m\times n$ intuitionistic fuzzy soft matrix and c_{ij} = (max $\{\mu_{a_{ij}}, \mu_{b^0_{ij}}\}$, min$\{v_{a_{ij}}, v_{b^0_{ij}}\}$) for all i, j, where (b^0_{ij}) is the complement of (b_{ij}).

Example 8. Consider the intuitionistic fuzzy soft matrices (a_{ij}) and (b_{ij}) in the previous example,

$$(a_{ij})=\begin{pmatrix}(0.2,0.7) & (0.0,0.9) & (0.3,0.5) & (0,1) & (0.9,0.1)\\(0.8.0.1) & (0.9,0.1) & (0.4,0.6) & (0,1) & (0.1,0.8)\\(0.4,0.1) & (0.3,0.6) & (0.8,0.1) & (0,1) & (0.5,0.4)\\(0.6,0.3) & (0.4,0.6) & (0.8,0.1) & (0,1) & (0.3,0.5)\\(0.7,0.2) & (0.6,0.3) & (0.3,0.7) & (0,1) & (0.1,0.8)\end{pmatrix},$$

$$(b_{ij}) = \begin{pmatrix}(0.3,0.7) & (0,1) & (0,1) & (0.2,0.7) & (0.8,0.1)\\(0.9,0.1) & (0,1) & (0,1) & (0.3,0.7) & (0.2,0.7)\\(0.4,0.5) & (0,1) & (0,1) & (0.7,0.1) & (0.6,0.4)\\(0.7,0.2) & (0,1) & (0,1) & (0.2,0.8) & (0.3,0.5)\\(0.6,0.2) & (0,1) & (0,1) & (0.3,0.6) & (0.2,0.6)\end{pmatrix}.$$

$$\text{Now } (b_{ij})^{o} = \begin{pmatrix}(0.7,0.3) & (1,0) & (1,0) & (0.7,0.2) & (0.1,0.8)\\(0.1,0.9) & (1,0) & (1,0) & (0.7,0.3) & (0.7,0.2)\\(0.5,0.4) & (1,0) & (1,0) & (0.1,0.7) & (0.4,0.6)\\(0.2,0.7) & (1,0) & (1,0) & (0.8,0.2) & (0.5,0.3)\\(0.2,0.6) & (1,0) & (1,0) & (0.6,0.3) & (0.6,0.2)\end{pmatrix}$$

Therefore, the subtraction of the intuitionistics fuzzy soft matrix (b_{ij}) from (a_{ij}) is

$$(a_{ij})\ominus(b_{ij})=\begin{pmatrix}(0.2,0.7) & (0.0,0.9) & (0.3,0.5) & (0,1) & (0.1,0.8)\\(0.1,0.9) & (0.9,0.1) & (0.4,0.6) & (0,1) & (0.1,0.8)\\(0.4,0.4) & (0.3,0.6) & (0.8,0.1) & (0,1) & (0.4,0.6)\\(0.2,0.7) & (0.4,0.6) & (0.8,0.1) & (0,1) & (0.3,0.5)\\(0.2,0.6) & (0.6,0.3) & (0.3,0.7) & (0,1) & (0.1,0.8)\end{pmatrix}$$

3. Intuitionistic fuzzy dominance matrix

The problem we deal with is the choosing of best alternative(s) among a finite set of alternatives $X = \{x_1, x_2, x_3, \dots, x_m\}, m \geq 2$, depending on a finite set of attributes $C = \{c_1, c_2, c_3, \dots, c_n\}, n \geq 2$ the alternatives will be classified from best to worst, using the information known (attributes) according to a set of experts E=$\{e_1, e_2, \dots, e_k\}, k \geq 2$. Intuitionistic fuzzy dominance degree represents the dominance of expert over other expert on an alternative attribute pair.

An Intuitionistic fuzzy dominance matrix R on a set of alternatives X is a Intuitionistic fuzzy set on the product set E×E. It is characterized by a membership function μ: E × E → [0,1], γ: E × E → [0,1] when cardinality of X is small, the dominance matrix may be conveniently represented by n×n matrix, R= (r_{ij}), $r_{ij} = \mu$ (e_i, e_j) for all $i, j \in$ {1,2,…,k}, $i \neq j$ interpreted as the dominance degree or intensity of the expert e_i over e_j on the set of (x_i, c_j), $i \in$ {1,2,...,m}, $j \in$ {1,2,…,n} where $r_{ij} = 0$ indicates that e_i is prefered $to\ e_j$; $r_{ij} <\ 0$ indicates that e_j is prefered $to\ e_i$. Dominance degree of expert e_i over e_j on the set of (x_i, c_j), $i \in$ {1,2,...,m}, $j \in$ {1,2,…,n} can be calculated as $r_{ij}^{A,B} = d_{ij}^A - d_{ij}^B$, $1 \leq i \leq m$, $1 \leq j \leq n$, A,B ∈ E, where d_{ij}^A and d_{ij}^B are intuitionistic fuzzy decision matrices of experts A and B respectively.

4. Algorithm approach

Step 1: Intuitionistic fuzzy decision matrices of two expert e_1, e_2 are constructed and taken as input for a MADM problem with alternatives $X = \{x_1, x_2, x_3, \dots, x_m\}, m \geq 2$ and n attributes $C = \{c_1, c_2, c_3, \dots, c_n\}, n \geq 2$ a fuzzy decision matrix D=(d_{ij}) can be represented below.

$$D = (d_{ij})_{m\times n} = \begin{pmatrix} d_{11} & d_{12} & \dots & d_{1n} \\ d_{21} & d_{22} & \dots & d_{2n} \\ \dots & \dots & \dots & \dots \\ d_{m1} & d_{m2} & \dots & d_{mn} \end{pmatrix},\ d_{ij} \in [0,1]$$

Step 2: Intuitionistic fuzzy dominance matrix R is constructed based on the subtraction of fuzzy decision matrix D of individual experts.

$$R = (r_{ij})_{m\times n} = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{pmatrix},\ r_{ij} \in [-1,1]$$

$$r_{ij}^{A,B} = d_{ij}^A - d_{ij}^B,\ 1 \leq i \leq m,\ 1 \leq j \leq n,\ A,B \in E.$$

Step 3: Choice value ch^i of the i^{th} alternative is calculated by adding all dominance value corresponding to that alternative. $ch^i = \sum_{j=1}^{n} (r_{ij})$, $i \in [1,2, \dots, m]$.

Step 4: If $ch^i = \sum_i Max\ ch^i$, $\forall\ i \in [1,2, \dots, m]$, alternative x_k is selected.

Step 5: If k has more than one value, then any one of x_k may be chosen.

Example 9. Let U= $\{C_1, C_2, C_3, C_4\}$ be the set of four cities and E = {High population density, Destruction of government property, Pre and post attack hiding, Maximum media coverage} be the set of parameters (attributes), given by E= $\{e_1, e_2, e_3, e_4\}$. A set of three terrorist M={X, Y, Z} be planned to attack a city in bit worn the above four. The problem is to find the city which is most dangerous among these four cities for having attack from all of the terrorists X, Y and Z.

The Intuitionistic fuzzy soft decision matrices of the terrorists X, Y and Z are

$$X = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \end{array} \begin{array}{c} \begin{array}{cccc} e_1 & e_2 & e_3 & e_4 \end{array} \\ \begin{pmatrix} (0.8,0.1) & (0.7,0.1) & (0.0,1.0) & (0.9,0.1) \\ (0.4,0.5) & (0.3,0.7) & (0.0,1.0) & (0.4,0.5) \\ (0.6,0.3) & (0.4,0.3) & (0.0,1.0) & (0.6,0.2) \\ (0.7,0.1) & (0.5,0.2) & (0.0,1.0) & (0.7,0.2) \end{pmatrix} \end{array},$$

$$Y = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \end{array} \begin{array}{c} \begin{array}{cccc} e_1 & e_2 & e_3 & e_4 \end{array} \\ \begin{pmatrix} (0.7,0.2) & (0.6,0.1) & (0.0,1.0) & (0.8,0.1) \\ (0.3,0.5) & (0.3,0.7) & (0.0,1.0) & (0.4,0.5) \\ (0.5,0.3) & (0.5,0.3) & (0.0,1.0) & (0.6,0.4) \\ (0.6,0.2) & (0.4,0.2) & (0.0,1.0) & (0.6,0.2) \end{pmatrix} \end{array},$$

$$Z = \begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \end{array} \begin{array}{c} \begin{array}{cccc} e_1 & e_2 & e_3 & e_4 \end{array} \\ \begin{pmatrix} (0.0,1.0) & (0.8,0.1) & (0.2,0.7) & (0.9,0.1) \\ (0.0,1.0) & (0.3,0.7) & (0.9,0.1) & (0.4,0.5) \\ (0.0,1.0) & (0.5,0.2) & (0.6,0.3) & (0.7,0.1) \\ (0.0,1.0) & (0.6,0.2) & (0.4,0.5) & (0.6,0.2) \end{pmatrix} \end{array}.$$

The solution is shown below.

Step 1: The Intuitionistic fuzzy dominance soft matrices of X and Y are calculated as

$$\begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \end{array} \begin{array}{c} \begin{array}{cccc} e_1 & e_2 & e_3 & e_4 \end{array} \\ \begin{pmatrix} (0.7,0.2) & (0.6,0.1) & (0.0,1.0) & (0.8,0.1) \\ (0.3,0.5) & (0.3,0.7) & (0.0,1.0) & (0.4,0.5) \\ (0.5,0.3) & (0.4,0.3) & (0.0,1.0) & (0.6,0.4) \\ (0.6,0.2) & (0.4,0.2) & (0.0,1.0) & (0.6,0.2) \end{pmatrix} \end{array}.$$

The Intuitionistic fuzzy dominance soft matrices of Y and Z are calculated as

$$\begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \end{array} \begin{array}{c} \begin{array}{cccc} e_1 & e_2 & e_3 & e_4 \end{array} \\ \begin{pmatrix} (0.0,1.0) & (0.6,0.1) & (0.0,1.0) & (0.8,0.1) \\ (0.0,1.0) & (0.3,0.7) & (0.0,1.0) & (0.4,0.5) \\ (0.0,1.0) & (0.5,0.3) & (0.0,1.0) & (0.7,0.4) \\ (0.0,1.0) & (0.6,0.2) & (0.0,1.0) & (0.6,0.2) \end{pmatrix} \end{array}.$$

The Intuitionistic fuzzy dominance soft matrices of Z and X are calculated as

$$\begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \end{array} \begin{array}{c} \begin{array}{cccc} e_1 & e_2 & e_3 & e_4 \end{array} \\ \begin{pmatrix} (0.0,1.0) & (0.7,0.1) & (0.0,1.0) & (0.9,0.1) \\ (0.0,1.0) & (0.3,0.7) & (0.0,1.0) & (0.4,0.5) \\ (0.0,1.0) & (0.4,0.3) & (0.0,1.0) & (0.6,0.2) \\ (0.0,1.0) & (0.5,0.2) & (0.0,1.0) & (0.6,0.2) \end{pmatrix} \end{array}.$$

Step 2: Aggregated IFDM

	e_1	e_2	e_3	e_4	Choice Parameter	Choice value
C_1	(0.7,1.0)	(0.7,0.1)	(0.0,1.0)	(0.9,0.1)	(0.9,0.1)	**1.0**
C_2	(0.3,1.0)	(0.3,0.7)	(0.0,1.0)	(0.4,0.3)	(0.4,0.3)	0.7
C_3	(0.5,1.0)	(0.4,0.3)	(0.0,1.0)	(0.7,0.4)	(0.7,0.3)	**1.0**
C_4	(0.6,1.0)	(0.6,0.2)	(0.0,1.0)	(0.6,0.2)	(0.6,0.2)	0.8

In this study, since the maximum choice value is 1.0, so cities $C_1$and C_3 will be selected.

5. Conclusion

IFDM is mainly useful in such situations where decision makers are able to express their opinions about all the attributes in terms of fuzzy value. In simple way, when there is no missing or unknown information, IFDM is proved to be more effective. This study has introduced intuitionistic fuzzy dominance matrix for solving MADM problems in uncertain environment. Researchers can develop more efficient decision making algorithm using IFDM. Intuitionistic rough set and vague soft set based real life decision making problems which may contain more than one decision maker and to realize this procedure we also apply it to more relevant.

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