
Ranking Alternatives using Euclidean Distance in Intuitionistic Fuzzy Environment through Promethee-Ii Method

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Abstract:

Decision Making is part of our life in day to day system, when it has more preference and more priorities it becomes complicated and it turns to be problem on Multiple Criterion Decision Making. This article mainly concentrates its attention towards capturing preference against criteria with appropriate weights using Preference ranking for organization method for Enriched Evaluation (PROMETHEE-II)[11] a complete ranking method in intuitionistic fuzzy environment. It is illustrated with suitable real time problem related to road traffic accidents.

Keywords: MCDM, Promethee-II, Intuitionistic Road Traffic Accidents

Introduction

In recent trends many researchers are mainly concentrating their theory towards the path of obtaining suitable decision to reduce cost cutting and to opt for best decision with desirable alternatives. When a person is given a many number of options do choose for best alternative against criteria it becomes a difficult task. When decision not taken at correct time will leads to dangerous consequences. It is one's duty to take correct decision at correct spot with consideration of all preference against criteria carefully before taking a healthy decision.

On Early days, literature dealt with Bi -Logic system of acceptance(TRUE) or rejection(FALSE) but nowadays the system has becomes more complex in nature as it cannot be grouped only through Bi-Logic as it steps on towards the birth of multiple logic system .For this professor , L.A. Zadeh (1965) [2] introduced a new concept of multi-logic values varies linguistically from the caption of WORST FALSE to BEST TRUE graded with different membership named as Fuzzy logic system. Whose presence of elements in the sets are decided by the means of membership function varies in between the closed interval minimum zero to maximum one. But it fails to give the value for absence of elements in the set. Later, Krasimira Atanasova (1982) [3] created a new theory of membership to Intuitionistic fuzzy sets by promoting membership(presence) and non-membership(absence) with degree of hesitation margin as its neutral values which also varies from 0 to 1. Brans and Vincke[4] in 1985 has developed a special type of tool for multiple criterion decision making[13] for out ranking preference function and named it as PROMTHEE of different kinds namely PROMETHEE- I for partial ordering of decision alternative to PROMTHEE-VI. In this article the authors use PROMETHEE II which is completeness ranking of alternatives[5] to establish the relation between alternatives against criteria and to derive the causes and effects of the problem related to road traffic accidents.

2. Theoretical Background

Fuzzy Set[6]:

Let X be a set, denumerable or not and let x be an element of X Then the fuzzy subset A of X is a set of ordered pairs given by

$$A = \{(x, \mu_A(x)) : x \in X\}$$

where $\mu_A(x): X \to [0,1]$ is called membership function or grade of membership function $xinA$

Distance Measure for Fuzzy Sets:[13]

Consider for any two fuzzy subsets A and B of $X = (x_1, x_2 \dots \dots x_n)$ then

Euclidean Distance : $e(A,B) = \sqrt{\sum_{i=1}^{n} |\mu_A(x_i) - \mu_B(x_i)|^2}$

Normalized Euclidean Distance : $\in (A,B) = \frac{1}{\sqrt{n}} \sqrt{\sum_{i=1}^{n} |\mu_A(x_i) - \mu_B(x_i)|^2}$

where $\mu_A(x_i), \mu_B(x_i) \in [0,1]$,$0 \leq e(A,B) \leq 1$ and $0 \leq \in (A,B) \leq \sqrt{n}$

Intuitionistic Fuzzy Sets[2]

For the set x of objects an intuitionistic fuzzy set (IFS) for A is a set of ordered triples

$$A = \{(x \mid \mu_A(x), v_A(x)) : x \in X\}$$

Where$\mu_A(x): X \to [0,1]$; $v_A(x): X \to [0,1]$ denotes a grade of membership and non-membership respectively of $x \ in \ A$ such that $0 \leq \mu_A(x) + v_A(x) \leq 1$

Hesitation Margin of Intuitionistic Fuzzy Sets[15]

The hesitation margin for an intuitionistic fuzzy index of $x \in A$ is given by $\pi_A(x) = 1 - \mu_A(x) - v_A(x)$

Where $0 \leq \pi_A(x) \leq 1$ for each $x \in X$. On the other hand, it is defined as a triplet is given by $A = \{(x \mid \mu_A(x), \pi_A(x), v_A(x)) : x \in X\}$

as membership, hesitation margin and non-membership values of a set.

Distance Measure for Intuitionistic Fuzzy Sets[12]

Consider for any two fuzzy subsets A and B of $X = (x_1, x_2 \dots \dots x_n)$ then

Euclidean Distance[13]

$$e(A,B) = \sqrt{\sum_{i=1}^{n} |\mu_A(x_i) - \mu_B(x_i)|^2 + |v_A(x_i) - v_B(x_i)|^2 + |\pi_A(x_i) - \pi_B(x_i)|^2}$$

Normalized Euclidean Distance[13]

$$\in (A,B) = \frac{1}{\sqrt{2n}} \sqrt{\sum_{i=1}^{n} |\mu_A(x_i) - \mu_B(x_i)|^2 + |v_A(x_i) - v_B(x_i)|^2 + |\pi_A(x_i) - \pi_B(x_i)|^2}$$

Where $\mu_A(x_i), \mu_B(x_i) \in [0,1]$; $0 \leq e(A,B) \leq 1$, and $0 \leq \in (A,B) \leq \sqrt{n}$

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3. Euclidean Distance Intuitionistic Fuzzy Valued With POMETHE-II Ranking Method (EDIFV-PII)

An Adjacency matrix for a causal relationship between preferences(alternative)

as $(PA_1, PA_2 \ldots\ldots PA_m)$ as the nodes of the neuron PA_x and $(QG_1\ , QG_2\ \ldots\ldots QG_n\ )$ be the nodes of the neuron QG_j.The values are recorded in between the closed interval ranging from [0,1] in the form of ordered doublet consisting of (membership ,non-membership) function typically known as intuitionistic fuzzy values by opinion of 'k' number of experts are framed.

It is represented as vectors $r_1=(a_{ij}^1)$, $r_2=(a_{ij}^2)\ldots$ $r_k=(a_{ij}^K)$ for i=1,2,…m and j=1,2,…n. The opinion of different experts are collected and formed as a new adjacency matrix denoted by M_{IFVMN}. The format is given below

$$M_{IVFMN} = \begin{bmatrix} |a_{11}(\mathcal{E}), a_{11}(\mathfrak{z}),| & |a_{12}(\mathcal{E}), a_{12}(\mathfrak{z}),| & |a_{13}(\mathcal{E}), a_{13}(\mathfrak{z}),| & \ldots. & |a_{1n}(\mathcal{E}), a_{1n}(\mathfrak{z}),| \\ |a_{21}(\mathcal{E}), a_{21}(\mathfrak{z}),| & |a_{22}(\mathcal{E}), a_{22}(\mathfrak{z}),| & |a_{23}(\mathcal{E}), a_{23}(\mathfrak{z}),| & \ldots.. & |a_{2n}(\mathcal{E}), a_{2n}(\mathfrak{z}),| \\ |a_{31}(c), a_{31}(\mathfrak{z}),| & |a_{32}(\mathcal{E}), a_{32}(\mathfrak{z}),| & |a_{33}(\mathcal{E}), a_{33}(\mathfrak{z}),| & \ldots.. & |a_{3n}(\mathcal{E}), a_{3n}(\mathfrak{z}),| \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ |a_{m1}(\mathcal{E}), a_{m1}(\mathfrak{z}),| & |a_{m2}(\mathcal{E}), a_{m2}(\mathfrak{z}),| & |a_{m3}(\mathcal{E}), a_{m3}(\mathfrak{z}),| & \ldots\ldots & |a_{mn}(\mathcal{E}), a_{mn}(\mathfrak{z}),| \end{bmatrix}$$

where $a_{pq}(\mathcal{E})$ *is the grade of Membership function and* $a_{pq}(\mathfrak{z})$ *is the* grade of Non-Membership Function of intuitionistic fuzzy set values. The opinion of different 'k' number of experts are grouped together to form one combined synaptic connection matrix with the relation

$$\alpha_{pq}(\mathcal{E}, \mathfrak{z}) = \{Max(a_{pq}(\mathcal{E}), Min(a_{pq}(\mathfrak{z})\}$$

$$\beta_{pq}(\mathcal{E}, \mathfrak{z}) = \{Min(a_{pq}(\mathcal{E}), Max(a_{pq}(\mathfrak{z})\}$$

for $1 \le p \le m\ \ and\ 1 \le q \le n$

with hesitation margin given by

$$H_{pq}(\gamma) = 1 - Max(\alpha_{pq}(\mathcal{E}) - Min(\alpha_{pq}(\mathfrak{z})\}$$

$$H_{pq}(\delta) = 1 - Max(\beta_{pq}(\mathcal{E}) - Min(\beta_{pq}(\mathfrak{z})\}$$

We use the Euclidean distance formula for intuitionistic sets to normalize the given matrix into a single connection synaptic matrix by the formula given below

represented as $IFVED$

$$IVFED = \frac{1}{\sqrt{2n}} \sqrt{\sum_{i=1}^{n} \sum_{j=1}^{m} \left[\left|\alpha_{pq}(\mathcal{E}) - \beta_{pq}(\mathcal{E})\right|^2 + \left|\alpha_{pq}(\mathfrak{z}) - \beta_{pq}(\mathfrak{z})\right|^2 + \left|H_{pq}(\gamma) - H_{pq}(\delta)\right|^2 \right]}$$

We obtain the values in the form of matrix given by

$$M_{IFVEDPII} = \begin{bmatrix} |\eta_{11}| & |\eta_{12}| & |\eta_{13}| & \ldots. & |\eta_{1n}| \\ |\eta_{21}| & |\eta_{22}| & |\eta_{23}| & \ldots.. & |\eta_{2n}| \\ |\eta_{31}| & |\eta_{32}| & |\eta_{33}| & \ldots.. & |\eta_{3n}| \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ |\eta_{m1}| & |\eta_{m2}| & |\eta_{m3}| & \ldots\ldots & |\eta_{mn}| \end{bmatrix}$$

1. **Procedure : Proposed Methodology:**

Step:1: After obtaining the matrix $M_{IFVEDPII}$ with the values of the criteria against the

set of all possible attributes

Step 2: Determine the weights W_j of criteria such that $\sum_{j=1}^{k} Wj = 1$ where the weights are assigned by the experts

Step 3: We normalize the decision matrix $M_{IFVEDPII}$ using benefit criteria formula

$R_{ij} = \frac{[X_{ij} - Min(X_{ij})]}{[Max(X_{ij}) - Min(X_{ij})]}$ X_{ij} is value got by evaluation of Euclidean formula

$1 \leq i \leq n$ $1 \leq j \leq n$

Step 4: Finding of deviation through pairwise comparison

$D_j(x,y) = g_j(x) - g_j(y)$ $D_j(x,y)$ denotes the change between the estimations of x and y on each of criteria.

Step 5: Calculating Preference Function $P_j(x,y) = F_j[Dj(x,y)]$

Where Pj(x,y)represents the function of the changes between the evaluation of alternate regarding alternative y on each column into degree ranging between the closed interval [0,1]

Step 6: Determining multi criteria preference index $\Omega(x,y) = \sum_{j=1}^{k} P(x,y) W_j$

Step 7: Finding the Leaving and Entering flows

Leaving Ranking Flow $\Upsilon^{+}(x) = \frac{1}{n-1} \sum_{a \in A} \Omega(x,a)$

Entering Ranking Flow $\Upsilon^{-}(x) = \frac{1}{n-1} \sum_{a \in A} \Omega(a,x)$

Step-8: Calculate the net flow values and rank accordingly[12]

$$\Upsilon(a) = \Upsilon^{+}(a) - \Upsilon^{-}(a) = \frac{1}{n-1} \sum_{j=1}^{k} \sum_{x \in A} [P_j(a,x) - P_j(x,a)] W_j$$

5. Numerical Example of Adaptation to the Problem to EDIFVPIIRM(Euclidean Distance Intuitionistic Fuzzy Values Promethee=II Ranking Method)

The adaptation to this Euclidean Distance Intuitionistic Fuzzy Valued Promethee-II model is an expert tool towards multi attribute decision making consisting of m-sets of alternatives against n-sets of criteria. The numerical illustration of the above model is carried out for safety measures on roads. With set of six attributes $(PA_1, PA_2 \ldots\ldots PA_6)$ against $(QG_1, QG_2 \ldots\ldots QG_6)$ as six attributes related to Well-being and Mistakes while travelling on roads respectively. The scale of variables obtained using unsupervised method constituting of linguistic variant with intuitionistic fuzzy value in an around local areas in Chennai region. The Attributes are given in tabular form as

Table 1: Common Well-being Problem on roads as domain space

Attribute	
PA_1	Lack of Sleep
PA_2	Blurred Vision
PA_3	Frightening
PA_4	Body Pain /Headache
PA_5	Stress /Tension
PA_6	Drowsiness / Tiredness

Table 2: Common Mistakes on roads as range space

Attribute	
QG_1	Distraction while driving
QG_2	Winking Eyes Recurrently
QG_3	Gaping Repeatedly
QG_4	Slow Response
QG_5	Errors in Judging
QG_6	Moving track without indication

The opinion polling of different experts are obtained in linguistic scale valued ranges between [0,1] and tabulated as an doublet comprising of membership and non-membership as we list three sets of expert opinion as an causal adjacency matrix $(V_{1,}V_2,V_3)$

The relational connection matrix given by different experts are

$$V_1 = \begin{bmatrix} [0.5,0.4] & [0.6,0.2] & [0.6,0.4] & [0.7,0.3] & [0.3,0.3] & [0.7,0.3] \\ [0.4,0.3] & [0.4,0.2] & [0.4,0.1] & [0.3,0.1] & [0.4,0.2] & [0.5,0.2] \\ [0.6,0.2] & [0.6,0.1] & [0.8.0.1] & [0.7,0.2] & [0.7,0.3] & [0.6,0.2] \\ [0.6,0.3] & [0.7,0.2] & [0.6,0.3] & [0.7,0.3] & [0.4,0.2] & [0.8,0.1] \\ [0.7,0.3] & [0.5,0.3] & [0.7,0.2] & [0.6,0.2] & [0.5,0.3] & [0.5,0.2] \\ [0.5,0.1] & [0.7,0.2] & [0.8,0.2] & [0.7,0.2] & [0.5,0.3] & [0.6,0.1] \end{bmatrix}$$

$$V_2 = \begin{bmatrix} [0.5,0.4] & [0.7,0.2] & [0.8,0.1] & [0.6,0.4] & [0.6,0.1] & [0.2,0.2] \\ [0.7,0.1] & [0.3,0.2] & [0.2,0.3] & [0.8,0.2] & [0.7,0.2] & [0.2,0.3] \\ [0.8,0.1] & [0.5,0.1] & [0.5.0.4] & [0.7,0.2] & [0.7,0.3] & [0.3,0.1] \\ [0.6,0.2] & [0.2,0.5] & [0.2,0.3] & [0.5,0.2] & [0.6,0.3] & [0.8,0.2] \\ [0.7,0.1] & [0.2,0.3] & [0.2,0.2] & [0.5,0.5] & [0.5,0.5] & [0.3,0.2] \\ [0.8,0.1] & [06,0.1] & [02,0.3] & [0.60.2] & [0.7,0.3] & [0.5,0.1] \end{bmatrix}$$

$$V_3 = \begin{bmatrix} [0.8,0.1] & [0.3,0.2] & [0.7,0.1] & [0.7,0.2] & [0.5,0.1] & [0.6,0.2] \\ [0.6,0.2] & [0.3,0.3] & [0.2,0.2] & [0.7,0.1] & [0.6,0.1] & [0.7,0.2] \\ [0.5,0.2] & [0.2,0.2] & [0.4.0.1] & [0.5,0.2] & [0.4,0.3] & [0.6,0.3] \\ [0.5,0.5] & [0.2,0.6] & [0.3,0.6] & [0.5,0.5] & [0.4,0.3] & [0.3,0.5] \\ [0.8,0.2] & [0.3,0.5] & [0.5,0.5] & [0.7,0.3] & [0.7,0.2] & [0.4,0.5] \\ [0.8,0.1] & [09,0.1] & [02,0.8] & [0.6,0.1] & [0.5,0.1] & [0.5,0.3] \end{bmatrix}$$

Relational Matrix with {Max,Min} intuitionistic values

$$\alpha = \begin{bmatrix} [0.8,0.1] & [0.7,0.2] & [0.8,0.1] & [0.7,0.2] & [0.6,0.1] & [0.7,0.2] \\ [0.7,0.1] & [0.4,0.2] & [0.4,0.3] & [0.8,0.2] & [0.7,0.2] & [0.7,0.3] \\ [0.8,0.1] & [0.6,0.1] & [0.8.0.1] & [0.7,0.2] & [0.7,0.3] & [0.6,0.1] \\ [0.6,0.2] & [0.7,0.2] & [0.6,0.3] & [0.7,0.2] & [0.6,0.2] & [0.8,0.1] \\ [0.8,0.1] & [0.5,0.3] & [0.7,0.2] & [0.7,0.2] & [0.7,0.2] & [0.5,0.2] \\ [0.8,0.1] & [0.9,0.1] & [0.8,0.2] & [0.7,0.1] & [0.6,0.1] & [0.6,0.1] \end{bmatrix}$$

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Relational Matrix with {Min,Max} intuitionistic values

$$\beta = \begin{bmatrix} [0.6,0.4] & [0.3,0.2] & [0.5,0.4] & [0.4,0.4] & [0.3,0.3] & [0.2,0.3] \\ [0.4,0.3] & [0.3,0.3] & [0.2,0.3] & [0.3,0.2] & [0.4,0.2] & [0.2,0.3] \\ [0.5,0.2] & [0.2,0.2] & [0.4.0.4] & [0.5,0.2] & [0.4,0.3] & [0.3,0.3] \\ [0.5,0.5] & [0.2,0.6] & [0.2,0.6] & [0.5,0.5] & [0.4,0.3] & [0.3,0.5] \\ [0.7,0.3] & [0.2,0.5] & [0.2,0.5] & [0.5,0.5] & [0.5,0.5] & [0.3,0.5] \\ [0.5,0.1] & [0.6,0.2] & [0.2,0.8] & [0.6,0.2] & [0.5,0.3] & [0.5,0.3] \end{bmatrix}$$

Table 3: Intuitionistic fuzzy Euclidean Distance with hesitation values

	QG_1	QG_2	QG_3	QG_4	QG_5	QG_6
PA_1	0.153	0.267	0.17	0.13	0.13	0.304
PA_2	0.13	0.037	0.093	0.304	0.13	0.304
PA_3	0.13	0.207	0.207	0.093	0.17	0.13
PA_4	0.157	0.304	0.207	0.153	0.073	0.304
PA_5	0.077	0.13	0.264	0.153	0.153	0.153
PA_6	0.17	0.13	0.52	0.037	0.093	0.077

Table-4: Normalize Decision Matrix $M_{IFVEDPII}$ using Benefit Criteria

	QG_1	QG_2	QG_3	QG_4	QG_5	QG_6
PA_1	0.1938776	0.141818	0.818391	0.643636	0.40404	0
PA_2	0.4081633	1	1	0	0.40404	0
PA_3	0.4081633	0.36	0.731034	0.785455	0	0.753191
PA_4	0.1836735	0	0.731034	0.567273	1	0
PA_5	1	0.643636	0.595402	0.567273	0.191919	0.66383
PA_6	0	0.643636	0	1	0.79798	1

Table-5: Deviation through pairwise comparison

Weights	0.1	0.2	0.2	0.1	0.2	0.2
/ Attrib	QG1	QG2	QG3	QG4	QG5	QG6
De_{12}	0	0	0	0.0643	0	0
De_{13}	0	0	0.0174	0	0.0808	0
De_{14}	0.0010	0.0283	0.0174	0.0076	0	0
De_{15}	0	0	0.0445	0.0076	0.0424	0
De_{16}	0.0193	0	0.1636	0	0	0
De_{21}	0.0214	0.1716	0.0363	0	0	0

De_{23}	0	0.128	0.0537	0	0.0808	0
De_{24}	0.0224	0.2	0.0537	0	0	0
De_{25}	0	0.0712	0.0809	0	0.0424	0
De_{26}	0.0408	0.0712	0.2	0	0	0
De_{31}	0.0214	0.0436	0	0.0141	0	0.1506
De_{32}	0	0	0	0.0785	0	0.1506
De_{34}	0.0224	0.072	0	0.0218	0	0.1506
De_{35}	0	0	0.0271	0.0218	0	0.0178
De_{36}	0.0408	0	0.1462	0	0	0
De_{41}	0	0	0	0	0.1191	0
De_{42}	0	0	0	0.0567	0.1191	0
De_{43}	0	0	0	0	0.2	0
De_{45}	0	0	0.0271	0	0.1616	0
De_{46}	0.0183	0	0.1462	0	0.0404	0
De_{51}	0.0806	0.1003	0	0	0	0.1327
De_{52}	0.0591	0	0	0.0567	0	0.1327
De_{53}	0.0591	0.0567	0	0	0.0383	0
De_{54}	0.0816	0.1287	0	0	0	0.1327
De_{56}	0.1	0	0.1190	0	0	0
De_{61}	0	0.1003	0	0.0356	0.0787	0.2
De_{62}	0	0	0	0.1	0.0787	0.2
De_{63}	0	0.0567	0	0.0214	0.1595	0.0493
De_{64}	0	0.1287	0	0.0432	0	0.2
De_{65}	0	0	0	0.0432	0.1212	0.0672

Table-6: Preference function

	PA_1	PA_2	PA_3	PA_4	PA_5	PA_6
PA_1	0	0.0643	0.0982	0.0544	0.0946	0.1830
PA_2	0.2293	0	0.2626	0.2762	0.1946	0.3120
PA_3	0.2298	0.2291	0	0.2669	0.0668	0.1870
PA_4	0.1191	0.1759	0.2	0	0.1887	0.2049
PA_5	0.3137	0.2486	0.1542	0.3431	0	0.2190
PA_6	0.4147	0.3787	0.2871	0.372	0.2317	0

Table-7: Ranking of Preference Function with Leaving and Entry Flow

	Leaving Flow	Entry Flow	Net Flow
PA_1	0.0989	0.2613	-0.1624
PA_2	0.2549	0.2193	0.0356
PA_3	0.1959	0.2004	-0.0045
PA_4	0.1777	0.2625	-0.0847
PA_5	0.2557	0.1553	0.1004
PA_6	0.3368	0.2212	0.1156

Results and Conclusion:

This article has given the preference in choosing the best attribute in road safety process. We further checked by adapting a methodology of keeping one to raise and other to be uniform in our model the attributes keep on changing when weightages varied that we could establish the following results as an output. As we can see through the table when all the criteria are kept at same with membership value 0.1 except one with maximum membership of 0.5 which when sums up to the weightage equal to 1 has given different ranking among the alternatives. It is given in the table below

Table-8: Ranking Position of Attributes with different weightage for criteria

Maximum Weightage Factor	Ranking Positions of Attributes					
(0.5) value	1	2	3	4	5	6
PA_1	PA_5	PA_3	PA_2	PA_4	PA_6	PA_1
PA_2	PA_2	PA_5	PA_6	PA_3	PA_1	PA_4
PA_3	PA_2	PA_5	PA_3	PA_1	PA_4	PA_6
PA_4	PA_6	PA_3	PA_5	PA_1	PA_4	PA_2
PA_5	PA_6	PA_4	PA_5	PA_2	PA_1	PA_3
PA_6	PA_6	PA_5	PA_3	PA_2	PA_4	PA_6

So the study finally concludes that the attribute PA_5(Stress /Tension) and PA_6(Drowsiness / Tiredness) are the major contributers for road traffic collision. Further, the arrangement of sequential order of preference of net flow ranking indicates the greater affinity of highest attribute provokes the rest of the attributes can be easily identified. Its sequential flow PA6>PA5>PA2>PA3>PA4>PA1 is been validated.

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