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Neutrosophic in Multi-Criteria Decision Making for Location Selection

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Abstract: Neutrosophic set (NS) theory has a diverse nature in dealing with impreciseness of real life events and has a wider range of applications in logic, algebra, topology, operation research, pattern recognition, artificial intelligence, neural networks and several other fields.In this paper, we combine single valued neutrosophic with we use the score and accuracy function and hybrid score accuracy function of single- valued neutrosophic number and ranking method for single- valued neutrosophic numbers to model logistics center location problem . The combined values of each alternative have been ordered with the help of score function to find the best attributes. Finally, an illustrative example has been provided to validate the proposed approach for multi attribute decision making problem.

Keywords: Neutrosophic Logic; decision making ; Interval Valued Neutrosophic Set.

1. Introduction

The concept of fuzzy sets (FS) was introduced by L.Zaheh(1965), where each element had degree of membership. Since the fuzzy sets and fuzzy logic have been applied in many real life problems in uncertain and ambiguous environment. The traditional fuzzy sets is characterized by the membership value and the grade of membership value. the concept of interval valued fuzzy sets was proposed by Turksen(1986) to capture the uncertain of grade of membership value. Neither the fuzzy sets nor the interval valued fuzzy sets is appropriate for such a situation. A tool which represents the partnership or relationship function is called a Fuzzy Set (FS) and handles the real world problems in which generally some type of uncertainty exists. This concept was generalized by Atanassov to intuitionistic fuzzy set (IFS) which is determined in terms of membership (MS) and non-membership (NMS) functions, the characteristic functions of the set. Intuitionistic fuzzy sets (IFS) introduced by Atanassov(1986) as a generalization of FS, where besides the degree of membership $\mu_A(x)\epsilon[0,1]$ for each element $x\epsilon X$ to a set A there was considered a degree of non-membership$\vartheta_A(x)\epsilon[0,1]$, such that$\forall x \in X, \mu_A(x) + \vartheta_A(x) \leq 1$ the neutrosophic set (NS) was introduced by F.Smarandache who introduced the degree of indeterminacy(I) as independent component in 1998. In this paper, we combine single valued neutrosophic with we use the score and accuracy function and hybrid score accuracy function of single- valued neutrosophic number and ranking method for single- valued neutrosophic numbers to model logistics center location problem The combined values of each alternative have been ordered with the help of score function to find the best attributes. Finally, an an illustrative example has been provided to validate the proposed approach for multi attribute decision making problem.

Multi-criteria decision-making (MCDM) is a common offshoot of decision-making science. There are a huge number of MCDM techniques which assist individuals in constructing and solving decision problems that concern multiple criteria. Each technique has its own physiognomies and no single one is the best. The proper MCDM technique should be designated consistent with the problem structure. It is recognized that without integrating preference information, no unique optimal solution to an MCDM problem can be acquired. Regardless of the chosen MCDM technique for the problem we are dealing with, the significant phase is to achieve the decision factor weights. Either the subjective or objective method can regulate the criteria weights in MCDM techniques.

2. Review of Literature

The author in, [1] analyzed Spatially explicit seasonal forecasting using fuzzy spatiotemporal clustering of long-term daily rainfall and temperature data. And the authors of, [2] analyzed Ambient Atmospheric Temperature Prediction Using Fuzzy Knowledge –Rule Base for Inland Cities in India. [3] Analysis a new Approach and Applications, International Journal of Research in Computer and Communication Technology. [4] examined Project Schedule Uncertainty Analysis Using Fuzzy Logic, Project Management Institute. [5] Analyzed the Power Flow Analysis Using Fuzzy Logic [6] proposed Types of Neutrosophic Graphs and neutrosophic Algebraic Structures together with their Applications in Technology. [7] proposed a new approach for Single Valued Neutrosophic Graphs. [8] Proposed a method for On Bipolar Single Valued Neutrosophic

[1] Graph. [9] Proposed various types of Interval Valued Neutrosophic Graphs.[10] proposed Isolated Single Valued Neutrosophic Graphs [11] examined bipolar single valued neutrosophic graphs. [12] Proposed Single-Valued Neutrosophic Minimum Spanning Tree and Its Clustering Method. [13] proposed Fuzzy based approach for weather advisory system. [14] provided Weather Forecasting using Fuzzy Neural Network (FNN) and Hierarchy Particle Swarm Optimization

Algorithm (HPSO). [15] proposed Spanning Tree Problem with Neutrosophic Edge Weigh. [16] A new algorithm for finding minimum spanning trees with undirected neutrosophic graphs. [17] The role of single valued neutrosophic sets and rough sets in smart city: imperfect and incomplete information systems. [18] Review on Neutrosophic Set and Its Development. [19] proposed Long-Term Weather Elements Prediction in Jordan using Adaptive Neuro-Fuzzy Inference System (ANFIS) with GIS Techniques [20] Neutrosophic Sets: An Overview . [21] proposed a new A new perspective ontraffic control management using triangular interval type-2 fuzzy sets and interval neutrosophic sets. [22] analyzed Minimum Spanning Tree Problem with Single-Valued Trapezoidal Neutrosophic Number [23] Single Valued Neutrosophic Graphs: Degree. [24] Concept of a application of Dijkstra algorithm for solving interval valued neutrosophic shortest path problem. [25] Analysed Minimum Spanning Tree in Trapezoidal Fuzzy Neutrosophic Environment. [26] proposed a methodology Shortest Path problem by minimal spanning tree algorithm using bipolar neutrosophic numbers. [27] A new concept of matrix algorithm for MST in undirected interval valued neutrosophic graph.[28] Analysis about the Logistics Center Location Selection approach Based on Neutrosophic Multi-Criteria Decision Making

3. Preliminaries

3.1 Neutrosophic set

Neutrosophy is a branch of philosophy identified by Florentin Smarandache in 1980.

Definition 1:

Assume that X be an universe o discourse.then a neutrosophic sets N can be dehined as follows;

$$N = \{< x: T_N(x), I_N(x), F_N(x) >/ \ x \in X\} \qquad (1)$$

Here the functions T, I, F define respectively the membership degree, indeterminacy degree and the non-membership degree of the element $x \in X$ to the set N. the three functions T, I and F satisfy the following the conditions:

T, I, F:X $\rightarrow]0^-, 1^+[$

$$0^- \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+ \qquad (2)$$

For two neutrosophic sets

$M = \{< x: T_M(x), I_M(x), F_M(x) >/ \ x \in X\}$ and $N = \{< x: T_N(x), I_N(x), F_N(x) >/ \ x \in X\}$ the two relations are defined as follows:

$M \subseteq N$ if and only if $T_M(x) \leq T_N(x), I_M(x) \geq I_N(x), F_M(x) \geq F_N(x)$

$M = N$ if and only if $T_M(x) = T_N(x), I_M(x) = I_N(x), F_M(x) = F_N(x)$

Definition 2:

Complement of neutrosophic sets:

For any set $M = \{< x: T_M(x), I_M(x), F_M(x) >/ \ x \in X\}$,then

$M' = \{< x: F_M(x), 1 - I_M(x), T_M(x) >/ \ x \in X\}$ (3)

Definition 3:

Single valued neutrosophic number (SVNN)

Let X be a universe of discourse with generic element in X denoted by x. A SVNS M in X is characterized by a truth-membership function $T_M(x)$, a indeterminacy-membership function $I_M(x)$ and a falsity-membership function $F_M(x)$. Then, a SVNS M can be written as follows:

$M = \{< x: T_M(x), I_M(x), F_M(x) >/ \ x \in X\}$ where $T_M(x), I_M(x), F_M(x) \in [0,1]$ for each point x in X. Since no restriction is imposed in the sum of t M (p), i M (p) and f M (p),

it satisfies $0^- \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+$. For a SVNS M in the triple $< T_M(x), I_M(x), F_M(x) >$ is called single valued neutrosophic number (SVNN).

4. MCGDM method based on hybrid – score accuracy functions under single valued neutrosophic environment

Assume that B = {B_1, …, B_n }(n ≥ 2) be the set of logistics centers, K = {K_1, K_2, ..., Kq } (q≥2) be the set of criteria and E = {E_1, E_2, ..., E_m} (m ≥ 2) be the set of decision makers or experts.

The weights of the decision makers and criteria are not previously assigned, where the information about the weights of the decision- makers is completely unknown and information about the weights of the criteria is incompletely known in the group decision making problem. In such a case, we develop a method based on the hybrid score – accuracy function for MCDM problem with unknown weights under single-valued neutrosophic environment using linguistic variables. The steps for solving MCGDM by proposed approach have been presented below is discussed

Algorithm

Step 1:

Formation of the decision matrix

Step 2:

Calculate hybrid score accuracy matrix

Step 3:

Calculate the average matrix

Step 4:

Determination of decision maker's weights

Step 5:

Calculate collective hybrid score accuracy matrix

Step 6:

Weight model for criteria

Step 7:

Ranking of alternatives

Step 8:

End

5. Methodology:

The following illustration is suppose that a state government wants to construct tan eco-tourism park for the development of state tourism and especially for the mental refreshment of children. After initial screening three potential spots namely spot-1 (P_1), spot-2 (P_2), spot-3 (P_3). A team of three decision makers namely D_1,D_2,D_3 has been constructed a neutrosophic sets for selecting the most suitable spot with respect to the following attributes:

Ecology (C_1)
Cost (C_2)
Technical facility (C_3)
Transport (C_4)
Risk factors (C_5)

Assume that a new modern logistic center is required in a town. There are three spot P_1 , P_2 ,P_3 . A committee of four decision makers or experts namely, D_1 , D_2 , D_3 has been formed to select the most appropriate location on the basis of five criteria adopted from the study [6] namely, C_1,C_2,C_3,C_4,C_5.Thus the three decision makers use linguistic variables to rate the alternatives with respect to the criterion and construct the decision matrices as follows:
Step 1:

Formation of the decision matrix

D_1	C_1	C_2	C_3	C_4	C_5
P_1	(0.7,0.4,0.4)	(0.7,0.4,0.3)	(0.8,0.1,0.1)	(0.7,0.2,0.1)	(0.6,0.5,0.5)
P_2	(0.4,0.3,0.6)	(0.5,0.2,0.5)	(0.6,0.2,0.2)	(0.7,0.3,0.3)	(0.4,0.3,0.4)
P_3	(0.4,0.2,0.3)	(0.8,0.1,0.3)	(0.5,0.4,0.4)	(0.5,0.2,0.2)	(0.7,0.3,0.2)

D_2	C_1	C_2	C_3	C_4	C_5
P_1	(0.5,0.2,0.3)	(0.7,,0.4,0.4)	(0.8,0.2,0.2)	(0.5,0.2,0.2)	(0.5,0.5,0.4)
P_2	(0.5,0.4,0.4)	(0.5,0.2,0.4)	(0.5,0.3,0.3)	(0.8,0.3,0.3)	(0.4,0.1,0.4)
P_3	(0.4,0.2,0.5)	(0.8,0.2,0.2)	(0.5,0.3,0.3)	(0.7,0.2,0.2)	(0.7,0.4,0.2)

D_3	C_1	C_2	C_3	C_4	C_5
P_1	(0.7,0.4,0.3)	(0.8,0.2,0.1)	(0.6,0.3,0.3)	(0.7,0.2,0.5)	(0.5,0.6,0.5)
P_2	(0.6,0.2,0.3)	(0.5,0.1,0.3)	(0.7,0.4,0.4)	(0.5,0.3,0.4)	(0.3,0.4,0.4)

P_3	(0.6,0.2,0.3)	(0.6,0.4,0.2)	(0.5,0.3,0.3)	(0.7,0.4,0.2)	(0.5,0.6,0.4)

Step 2:

Calculate hybrid score accuracy matrix

Now we use the above method for single valued neutrophic group decision making to choice appropriate location. We take α= 0.5 for demonstrating the computing procedure

Calculate hybrid score – accuracy matrix

Hybrid score- accuracy matrix can be obtained from above decision matrix using equation

$$h_{ij}^{s} = \frac{1}{2}\alpha(1 + t_{ij}^{s} - f_{ij}^{s}) + \frac{1}{3}(1-\alpha)(2 + t_{ij}^{s} - i_{ij}^{s} - f_{ij}^{s})$$

are given below respectively.

HYBRID SCORE MATRIX FOR D_1

H_1

	C_1	C_2	C_3	C_4	C_5
P_1	0.6417	0.6833	0.8583	0.8000	0.5417
P_2	0.4500	0.5500	0.7167	0.7000	0.5333
P_3	0.5917	0.7750	0.5583	0.6750	0.7417

HYBRID SCORE MATRIX FOR D_2

H_2

	C_1	C_2	C_3	C_4	C_5
P_1	0.6333	0.6417	0.8000	0.6750	0.5417
P_2	0.5583	0.5917	0.6167	0.7417	0.5667
P_3	0.5083	0.8000	0.6167	0.7583	0.7250

HYBRID SCORE MATRIX FOR D_3

H_3

	C_1	C_2	C_3	C_4	C_5
P_1	0.6833	0.8417	0.6583	0.6333	0.4833
P_2	0.6750	0.6500	0.6417	0.5750	0.4750
P_3	0.6750	0.6833	0.6167	0.7250	0.5250

Step 3:

Calculate the average matrix . Form the above hybrid score-accuracy matrix by using equation $h_{ij}^{*} = \frac{1}{m}\sum_{s=1}^{m}(h_{ij}^{s})$.

We form the average matrix H*

The average matrix

H*	0.6528	0.7222	0.7722	0.7028	0.5222
	0.5611	0.5972	0.6583	0.6722	0.5250
	0.5917	0.7528	0.5972	0.7194	0.6639

The collective correlation co-efficient between H^{s} and H* express follows by equation

$$\Omega_{s} = \sum_{i=1}^{n} \frac{\sum_{j=i}^{\rho} h_{ij}^{s} h_{ij}^{*}}{\sqrt{\sum_{j=1}^{\rho}\left(h_{ij}^{s}\right)^{2}}} \frac{1}{\sqrt{\sum_{j=1}^{\rho}\left(h_{ij}^{*}\right)^{2}}}$$

Here s={1,2,3}

To find Ω_1,

H_1 x H*					$\sum_{j=i}^{\rho} h_{ij}^{1} h_{ij}^{*}$	$\sqrt{\sum_{j=1}^{\rho}\left(h_{ij}^{1}\right)^{2}}$	$\sqrt{\sum_{j=1}^{\rho}\left(h_{ij}^{*}\right)^{2}}$
0.4189	0.4935	0.6628	0.5622	0.2829	2.4203	1.5965	1.5201
0.2525	0.3285	0.4718	0.4706	0.2800	1.8033	1.3391	1.3537
0.3501	0.5834	0.3334	0.4856	0.4924	2.2449	1.5060	1.4939

$$\Omega_1 = \frac{2.4203}{1.5965 \times 1.5201} + \frac{1.8033}{1.3391 \times 1.3537} + \frac{2.2449}{1.3391 \times 1.4939} = 0.4278$$

$\Omega_2 = 2.9937$

$\Omega_3 = 2.9781$

Step – 4

Determination decision maker's weights

$$\gamma_s = \frac{\Omega_s}{\sum_{s=1}^{m}\Omega_s}, 0 \leq \gamma_s \leq 1 \, for \; s = 1,2,3,\ldots,m$$

From the equation we determine the weight of the four decision makers as follows :-

$$\Omega_1 + \Omega_2 + \Omega_3 = 6.3996$$

$\gamma_1 = \frac{\Omega_1}{\Omega_1+\Omega_2+\Omega_3} = \frac{0.4278}{6.3996} = 0.0669$

$\gamma_2 = 0.4678$

$\gamma_3 = 0.4654$

Step 5:

Calculate collective hybrid score – accuracy matrix

Hence the hybrid score-accuracy values of the different decision makers choice are aggregated by equation $\mathcal{H} = (\mathrm{h_{ij}})\mathrm{n} \times \mathrm{p} = \sum_{\mathrm{s}=1}^{\mathrm{m}} \gamma_{\mathrm{s}} \mathrm{h}_{\mathrm{ij}}^{\mathrm{s}}$ and the collective hybrid score-accuracy matrix can be formulated as follows:

$\gamma_1 \times \mathrm{H}_1$

0.0327	0.0349	0.0438	0.0408	0.0276
0.0230	0.0281	0.0366	0.0357	0.0272
0.0302	0.0395	0.0285	0.0344	0.0378

$\gamma_2 \times \mathrm{H}_2$

0.3008	0.3048	0.3800	0.3206		0.2573
	0.2652	0.2810	0.2929	0.3523	0.2692
	0.2415	0.3800	0.2929	0.3602	0.3444

$\gamma_3 \times \mathrm{H}_3$

0.3239	0.3990	0.312	0.3002		0.2291
	0.3200	0.3081	0.3042	0.2726	0.2252
	0.3200	0.3239	0.2923	0.3437	0.2489

By adding all the above

$\mathcal{H} =$

0.657	0.739	0.736	0.662	0.514
0.608	0.617	0.634	0.661	0.522
0.592	0.743	0.614	0.738	0.631

Step 6

Weight model for criteria

Assume that the information about criteria weights is incompletely known given as follows: weight vectors, Using the linear programming model $\mathrm{Max}\,\omega = \frac{1}{n}\sum_{j=1}^{\rho}\omega_j h_{ij}$, we obtain the weight vector of the criteria as ω =[0.1, 0.1, 0.25, 0.2, 0.15].

Step 7

Ranking of alternatives

Using equation $\psi(P_i) = \sum_{j=1}^{\rho}\omega^i h^{ij}$ we calculate the over all hybrid score-accuracy values $\psi(P_i)$ (i = 1, 2, 3):

$\psi(P_1)$=0.533

$\psi(P_2)$=0.491

$\psi(P_3)$=0.529

Based on the above values of $\psi(P_i)$ (i = 1, 2, 3,) the ranking order of the locations are as follows:

$P_1 > P_3 > P_2$

Therefore the location P_1 is the best location.

6. Conclusions

In this paper, the concept of single valued Neutrosophic set used with location problem tested with the help of score function. A possible application has been tackled through the usage of SVNS which will not only prove useful by itself but will help out keen researchers to solve other problems of uncertainties through similar procedures. The following paper demonstrated a new solution procedure to solve neutrosophic fuzzy sets with the contraction value based on real life decision making problems. This procedure proves quite feasible in many real life scenarios where else of decision making is the goal in mind.

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