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Neutrosophic HyperSoft Set (NHSS) for Teaching Quality Assessment in University Interior Design Courses

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Abstract: Teaching quality evaluation in university interior design courses have different criteria and values. So, we used the multi-criteria decision making (MCDM) approach to deal with various criteria. Two MCDM methods are used such as Entropy to compute the criteria weights and RAFSI method to rank the alternatives. Two MCDM methods are used under the neutrosophic-Z number (NZN) to deal with uncertain and vague information. This study uses the neutrosophic HyperSoft set (NHSS) to find the relationship between different criteria. Seven criteria and eight alternatives are used in this study. An empirical application is applied to show the validation of the proposed approach. The sensitivity analysis is conducted to show the stability of the ranks of the alternatives.

Keywords: HyperSoft Set; Neutrosophic-Z-Number (NZN); University Interior Design Courses; Uncertainty Information; Evaluation Problem.

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1. Introduction and Literature Review

Interior design is a multidisciplinary field that blends art, architecture, technology, and human psychology to create functional and aesthetically pleasing indoor environments. University interior design courses aim to equip students with knowledge in design principles, materials, space planning, sustainability, lighting, digital modeling, and user experience. The quality of teaching in these courses directly impacts students' creativity, technical expertise, and industry readiness. Thus, a systematic evaluation of teaching quality is essential to maintain academic standards, improve curricula, and enhance learning outcomes[1], [2]. There are various aims of the Teaching Quality

- Ensures high educational standards and alignment with industry needs.
- Identifies strengths and weaknesses in teaching methods, course structure, and student engagement.
- Helps in faculty development and curriculum enhancement.

- Improves student satisfaction and learning experience.
- Guides policymakers, accreditation bodies, and university administrations in decision-making[3], [4].

However, teaching quality in interior design courses is difficult to measure due to its subjective, creative, and technical nature. A structured Multi-Criteria Decision-Making (MCDM) approach can provide a more objective, data-driven, and comprehensive evaluation system[5].

It is well recognized that Zadeh's fuzzy sets are crucial to modern scientific and technological applications. The notion of Z-numbers was further established by Zadeh in 2011 to characterize the reliability and constraint of the evaluation by an order pair of fuzzy numbers in uncertain scenarios. This concept is broader and closely tied to dependability than the traditional fuzzy number. As a result, the Z-number suggests a greater capacity to characterize human knowledge and judgments using an order pair of fuzzy numbers that correlate to reliability and limitation. It has received a lot of attention since then[6], [7].

The truth, falsity, and indeterminacy membership degrees independently characterize neutrosophic sets in an indeterminate and inconsistent environment, yet the Z-numbers discussed above are unable to represent them. Neutrosophic sets have since been used in a variety of fields. Nevertheless, the reliability measures associated with the truth, falsity, and indeterminacy membership degrees are absent from the neutrosophic set. The hybrid information mixing the truth, falsity, and indeterminacy degrees with their associated reliability degrees may be described by three order pairs of fuzzy numbers if the Z-number concept is extended to the neutrosophic set[8], [9]. Information expressions and decision-making techniques are essential study subjects in MCDM challenges.

The Z-number, which Zadeh presented as an extension of the conventional fuzzy number, has more capacity to represent human knowledge and judgments of dependability and restraint as an order pair of fuzzy numbers. The truth, falsity, and indeterminacy degrees define a neutrosophic set in an indeterminate and inconsistent environment, but they do not include reliability-related metrics. As a generalization of the Z-number and the neutrosophic set, Du et al.[10] first introduced the idea of a neutrosophic Z-number (NZN) set, which is a new framework of neutrosophic values combined with the neutrosophic measures of reliability, to describe the hybrid information of combining the truth, falsity, and indeterminacy degrees with their corresponding reliability degrees.

They proposed a scoring function for grading neutrosophic Z-numbers (NZNs) and their operations. To aggregate NZN information and examine its features, we then introduce NZN weighted arithmetic averaging. In the NZN environment, MCDM strategy is created by NZN operators and the score function. The relevance and efficacy of the established MCDM technique in the NZN scenario are finally illustrated with an example pertaining to the business partner selection problem.

The following are the article's primary contributions for the first study:

(a) In indeterminate and inconsistent scenarios, the suggested NZN set may resolve the information expression problem of the truth, falsity, and indeterminacy values together with their associated reliability measures by the three order pairs of fuzzy numbers.

(b) The score function of NZN is used to rank NZNs, which offer helpful mathematical tools for MCDM problems in NZN settings.

(c) In addition to improving MCDM dependability, the proposed MCDM strategy offers a fresh, practical solution for MCDM issues in the NZN context.

(d) Two MCDM methods are applied such as Entropy to compute the criteria weights and the RAFSI method to rank the alternatives. These methods are used under the hypersoft set to deal with various criteria values.

(f) The sensitivity analysis is conducted to show the stability of the ranks under different cases.

The following structures make up the study's organization. The concept of a NZN set, operations of NZNs, and a scoring function of NZN for comparing NZNs are introduced in section 2. The section 3 shows the steps of the proposed approach to compute the criteria weights and ranking the alternatives. Section 4 shows the results of the proposed approach. Section 5 shows the conclusion of this study.

2. Neutrosophic Z-number set (NZN)

An order pair of fuzzy numbers, Z = (V, R), associated with a real-valued uncertain variable X, was originally described by Zadeh in 2011. The first component, V, is a fuzzy constraint on the values that X can take, while the second component, R, is a measure of reliability for V[10].

Definition 1

Set X as a universe set, then the NZN can be defined as:

$$S_Z = \{(x, T(V,R)x, I(V,R)x, F(V,R)x) | x \in X\} \quad (1)$$

$$T(V,R)x = \left(T_V(x), T_R(x)\right), I(V,R)x = \left(I_V(x), I_R(x)\right), F(V,R)x = \left(F_V(x), F_R(x)\right) \quad (2)$$

$$0 \leq T_V(x) + I_V(x) + F_V(x) \leq 3 \quad (3)$$

$$0 \leq T_R(x) + I_R(x) + F_R(x) \leq 3 \quad (4)$$

Definition 2

Let $s_{Z_1} = \left(T_1(V,R), I_1(V,R), F_1(V,R)\right) = \left(\left(T_{V_1}(x), T_{R_1}(x)\right), \left(I_{V_1}(x), I_{R_1}(x)\right), \left(F_{V_1}(x), F_{R_1}(x)\right)\right)$

$s_{Z_2} = \left(T_2(V,R), I_2(V,R), F_2(V,R)\right) = \left(\left(T_{V_2}(x), T_{R_2}(x)\right), \left(I_{V_2}(x), I_{R_2}(x)\right), \left(F_{V_2}(x), F_{R_2}(x)\right)\right)$, two NZNs and their operations as:

$$s_{Z_1} \supseteq s_{Z_2} \Leftrightarrow T_{V_1}(x) \geq T_{V_2}(x), T_{R_1}(x) \geq T_{R_2}(x), I_{V_1}(x) \leq I_{V_2}(x), I_{R_1}(x) \leq I_{R_2}(x), F_{V_1}(x) \leq F_{V_2}(x), F_{R_1}(x) \leq F_{R_2}(x) \tag{5}$$

$$s_{Z_1} = s_{Z_2} \Leftrightarrow s_{Z_1} \supseteq s_{Z_2} \; and \; s_{Z_2} \supseteq s_{Z_1} \tag{6}$$

$$s_{Z_1} \cup s_{Z_2} = \begin{pmatrix} \left(T_{V_1}(x) \vee T_{V_2}(x), T_{R_1}(x) \vee T_{R_2}(x)\right), \\ \left(I_{V_1}(x) \wedge I_{V_2}(x), I_{R_1}(x) \wedge I_{R_2}(x)\right), \\ \left(F_{V_1}(x) \wedge F_{V_2}(x), F_{R_1}(x) \wedge F_{R_1}(x)\right) \end{pmatrix} \tag{7}$$

$$s_{Z_1} \cap s_{Z_2} = \begin{pmatrix} \left(T_{V_1}(x) \wedge T_{V_2}(x), T_{R_1}(x) \wedge T_{R_2}(x)\right), \\ \left(I_{V_1}(x) \vee I_{V_2}(x), I_{R_1}(x) \vee I_{R_2}(x)\right), \\ \left(F_{V_1}(x) \vee F_{V_2}(x), F_{R_1}(x) \vee F_{R_1}(x)\right) \end{pmatrix} \tag{8}$$

$$\left(s_{Z_1}\right)^C = \left(\left(F_{V_1}(x), F_{R_1}(x)\right), \left(1 - I_{V_1}(x), 1 - I_{R_1}(x)\right), \left(T_{V_1}(x), T_{R_1}(x)\right)\right) \tag{9}$$

$$s_{Z_1} \oplus s_{Z_2} = \begin{pmatrix} \left(T_{V_1}(x) + T_{V_2}(x) - T_{V_1}(x)T_{V_2}(x), T_{R_1}(x) + T_{R_2}(x) - T_{R_1}(x)T_{R_2}(x)\right), \\ \left(I_{V_1}(x)I_{V_2}(x), I_{R_1}(x)I_{R_2}(x)\right), \\ \left(F_{V_1}(x)F_{V_2}(x), F_{R_1}(x)F_{R_2}(x)\right) \end{pmatrix} \tag{10}$$

$$s_{Z_1} \otimes s_{Z_2} = \begin{pmatrix} \left(T_{V_1}(x)T_{V_2}(x), T_{R_1}(x)T_{R_2}(x)\right), \\ \left(I_{V_1}(x) + I_{V_2}(x) - I_{V_1}(x)I_{V_2}(x), I_{R_1}(x) + I_{R_2}(x) - I_{R_1}(x)I_{R_2}(x)\right), \\ \left(F_{V_1}(x) + F_{V_2}(x) - F_{V_1}(x)F_{V_2}(x), F_{R_1}(x) + F_{R_2}(x) - F_{R_1}(x)F_{R_2}(x)\right) \end{pmatrix} \tag{11}$$

$$\lambda s_{Z_1} = \begin{pmatrix} \left(1 - \left(1 - T_{V_1}(x)\right)^{\lambda}, 1 - \left(1 - T_{R_1}(x)\right)^{\lambda}\right), \\ \left(\left(I_{V_1}(x)\right)^{\lambda}, \left(I_{R_1}(x)\right)^{\lambda}\right), \\ \left(\left(F_{V_1}(x)\right)^{\lambda}, \left(F_{R_1}(x)\right)^{\lambda}\right) \end{pmatrix} \tag{12}$$

$$\left(s_{Z_1}\right)^{\lambda} = \begin{pmatrix} \left(\left(T_{V_1}(x)\right)^{\lambda}, \left(T_{R_1}(x)\right)^{\lambda}\right), \\ \left(1 - \left(1 - I_{V_1}(x)\right)^{\lambda}, 1 - \left(1 - I_{R_1}(x)\right)^{\lambda}\right), \\ \left(1 - \left(1 - I_{V_1}(x)\right)^{\lambda}, 1 - \left(1 - I_{R_1}(x)\right)^{\lambda}\right) \end{pmatrix} \tag{13}$$

Definition 3

The score function can be computed such as:

$$A\left(s_{Z_1}\right)=\frac{2+T_{V_1}(x)T_{R_1}(x)-I_{V_1}(x)I_{R_1}(x)-F_{V_1}(x)F_{R_1}(x)}{3} \tag{14}$$

Definition 4 (HyperSoft Set (HSS))[11]

Let U be the universal set and P(U) is the power set of U. Let $C^1, C^2, C^3, \dots C^n$ be a set of attributes for $n \geq 1$and the corresponding values are $L^1, L^2, L^3, \dots L^n$, $L^i \cap L^j = \emptyset \; for \; i \neq j$.

A pair $(F, L^1 \times L^2 \times L^3 \dots . L^n)$ is a HSS over U where F is a mapping with $F\colon L^1 \times L^2 \times L^3 \dots L^n \rightarrow P(U)$.

Definition 5 (Neutrosophic HyperSoft Set (NHSS))[12], [13]

Let U be the universal set and P(U) is the power set of U. Let $C^1, C^2, C^3, \dots C^n$ be a set of attributes for $n \geq 1$and the corresponding values are $L^1, L^2, L^3, \dots L^n$, $L^i \cap L^j = \emptyset \; for \; i \neq j$ and the relation $L^1 \times L^2 \times L^3 \dots . L^n = S$

A pair (F, S) is a NHSS over U where $(F, L^1 \times L^2 \times L^3 \dots . L^n) = L^1 \times L^2 \times L^3 \dots . L^n \rightarrow P(U)$ with $F(L^1 \times L^2 \times L^3 \dots . L^n) = \{T(F(S)), I(F(S)), F(F(S)), x \in U\}$ where T,I, and F refer to truth, indeterminacy, and falsity functions.

3. NZN-Entropy-RAFSI

This section shows the steps of the proposed approach. We used the Entropy method to compute the criteria weights. We used the RAFSI method to rank the alternatives. We used the NZN to deal with vague and uncertainty information.

A new decision-making technique called Ranking of Alternatives by Functional mapping of criteria sub-intervals into Single Intervals (RAFSI) was initially put out by Žižović et al. The aim of this approach is to solve the rank reversal problem. They identified three specific advantages of the suggested approach. First, it facilitates the resolution of challenging real-world decision-making issues. Second, it has a novel data normalization process. Thirdly, it can get rid of problems with rank reversal. The values of the initial decision-making matrix are mapped and transferred by the RAFSI algorithm using a criterion interval. Different formats of decision-making values must be standardized into a criterion interval that includes values between 0 and 1[14], [15]. An overview of the original RAFSI method's computing process is provided below.

NZN-Entropy Method

- Build the decision matrix.

We used the NZN to evaluate the criteria and alternatives.

- Normalize the decision matrix

$$r_{ij}=\frac{a_{ij}}{\sum_{i=1}^{m} a_{ij}}; i=1,\dots,m; j=1,\dots,n \tag{15}$$

a_{ij} refers to the value in the decision matrix.

- Compute entropy value

$$e_j = -h\sum_{i=1}^{m} r_{ij} \ln r_{ij} \tag{16}$$

$$h = \frac{1}{\ln(m)} \tag{17}$$

- Compute the criteria weights.

$$W_j = \frac{1-e_j}{\sum_{j=1}^{n}(1-e_j)} \tag{18}$$

NZN-RAFSI-Method

- Compute the ideal $(a_j)^I$ and non-ideal $(a_j)^N$ values.

Each criterion must have two values defined by the expert, with the requirement that the ideal value for the maximum criteria type be larger than the non-ideal value, and vice versa for the lowest criteria type.

- Create criterion intervals for each entry in the main decision-making matrix. The following is the design of the criterion intervals: There are two types of intervals: (i) for maximum criterion and (ii) for minimum criteria. Next, all the criteria in the decision matrix must be constructed equally using the RAFSI approach and converted into the essential interval. It is truly the case that the procedure creates a series of numbers with intervals and locations inside the gap in between. The approach separated two interval mappings since the criterion had two kinds. First, it converts the lowest value into the maximum criteria and the highest value into the minimum criteria. Second, the value is mapped into both the minimal criterion and the value. Additionally, it is advised to provide. $a_1 = 0.1, a_{2_c} = 0.9$

$$g_m(a_{ij}) = \frac{a_{2_c} - a_1}{(a_j)^I - (a_j)^N} a_{ij} + \frac{(a_j)^I a_1 - a_{2_c}(a_j)^N}{(a_j)^I - (a_j)^N} \tag{19}$$

- Compute the harmonic and arithmetic means for the minim and maximum values

$$H = \frac{2}{\frac{1}{a_1} + \frac{1}{a_{2_c}}} \tag{20}$$

$$H = \frac{a_1 + a_{2_c}}{2} \tag{21}$$

- Normalize the decision matrix

$$Y_{ij} = \frac{a_{ij}}{2A} \tag{22}$$

$$Y_{ij} = \frac{H}{2a_{ij}} \tag{23}$$

- Compute the criteria function

$$V(A_i) = \sum_{j=1}^{n} w_j Y_{ij} \tag{24}$$

4. On Construction of NHSS-Entropy- RAFSI for MCDM Problem using NZN

This section shows the results of the proposed approach to compute the criteria weights and ranking the alternatives. Three experts are evaluated the criteria and alternatives under the neutrosophic sets to deal with uncertainty and vague information. This study uses seven criteria and eight alternatives to be evaluated.

The criteria of this study are technology integration, assessment and feedback mechanism, curriculum relevance, creativity, project-based learning, faculty expertise, and industry collaboration.

The alternatives of this study are flipped classroom model, design thinking and problem-solving, competency-based learning, blended learning, traditional lecture-based teaching, technology-driven education, project-based learning, industry-engaged learning

NZN-Entropy Method

- We Build the decision matrix using the NZN between the criteria and alternatives as shown in Table 1. Then we applied the score function to obtain one value. Then we combined these matrixes.

- We normalize the decision matrix using Eq. (15).

- Then we compute entropy value using Eq. (16) and Eq. (17).

- Then we compute the criteria weights such as W1 = 0.13893117, W2 = 0.130143474, W2 = 0.187458982, W4 = 0.137317575, W5 = 0.142512891, W6 = 0.157670497, W7 = 0.105965411. We show the criterion 3 is the best and the criterion 7 is the worst.

Table 1. The NZN numbers.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.7,0.6),(0.2,0.7),(0.3,0.8))	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.7,0.6),(0.2,0.7),(0.3,0.8))
A_2	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.8,0.8),(0.4,0.7),(0.2,0.8))
A_3	((0.7,0.6),(0.2,0.7),(0.3,0.8))	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.7,0.6),(0.2,0.7),(0.3,0.8))	((0.7,0.6),(0.2,0.7),(0.3,0.8))	((0.7,0.8),(0.1,0.7),(0.1,0.7))
A_4	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.6),(0.2,0.6),(0.1,0.7))
A_5	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.7,0.6),(0.2,0.7),(0.3,0.8))	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.7,0.6),(0.2,0.7),(0.3,0.8))	((0.6,0.7),(0.1,0.7),(0.2,0.7))
A_6	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.7,0.6),(0.2,0.7),(0.3,0.8))
A_7	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.6,0.7),(0.1,0.7),(0.2,0.7))
A_8	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.6,0.6),(0.2,0.6),(0.1,0.7))
	C_1	C_2	C_3	C_4	C_5	C_6	C_7

A_1	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.7,0.6),(0.2,0.7),(0.3,0.8))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.7,0.6),(0.2,0.7),(0.3,0.8))
A_2	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.7,0.6),(0.2,0.7),(0.3,0.8))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.8,0.8),(0.4,0.7),(0.2,0.8))
A_3	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.6),(0.2,0.7),(0.3,0.8))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.7,0.6),(0.2,0.7),(0.3,0.8))	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.8,0.8),(0.4,0.7),(0.2,0.8))
A_4	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.6,0.6),(0.2,0.6),(0.1,0.7))
A_5	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.7,0.6),(0.2,0.7),(0.3,0.8))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.6,0.7),(0.1,0.7),(0.2,0.7))
A_6	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.7,0.6),(0.2,0.7),(0.3,0.8))
A_7	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.6,0.6),(0.2,0.6),(0.1,0.7))
A_8	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))
	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.7,0.6),(0.2,0.7),(0.3,0.8))
A_2	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.8,0.8),(0.4,0.7),(0.2,0.8))
A_3	((0.6,0.8),(0.1,0.7),(0.2,0.8))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))
A_4	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.6,0.6),(0.2,0.6),(0.1,0.7))
A_5	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.8,0.7),(0.1,0.8),(0.2,0.6))
A_6	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.8),(0.4,0.7),(0.2,0.8))	((0.7,0.6),(0.2,0.7),(0.3,0.8))
A_7	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.7),(0.1,0.8),(0.2,0.6))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.8),(0.1,0.7),(0.1,0.7))	((0.8,0.7),(0.1,0.8),(0.2,0.6))
A_8	((0.7,0.6),(0.2,0.7),(0.3,0.8))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.7,0.6),(0.2,0.7),(0.3,0.8))	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.6,0.7),(0.1,0.7),(0.2,0.7))	((0.6,0.6),(0.2,0.6),(0.1,0.7))	((0.6,0.6),(0.2,0.6),(0.1,0.7))

NZN-RAFSI-Method

- In the NHSS, experts put three values of each criterion such as lower bound, middle value, and upper bound. We chose the best value of each criterion such as: $C_{1-3}, C_{2-3}, C_{3-3}, C_{4-3}, C_{5-3}, C_{6-3}, C_{7-3}$.

- We Compute the ideal $(a_j)^I$ and non-ideal $(a_j)^N$ values.

- We create criterion intervals for each entry in the main decision-making matrix using Eq. (19).

- then we compute the harmonic and arithmetic means for the minim and maximum values using Eq. (21)

- Then we normalize the decision matrix using Eq. (22) as shown in Table 2 and the weighted normalized decision matrix in Table 3.

- Then we compute the criteria function using Eq. (24) as shown in Fig 1. Then we ranked the alternatives as shown in Fig 2.

Table 2. Normalized matrix using the RAFSI method.

	C_{1-3}	C_{2-3}	C_{3-3}	C_{4-3}	C_{5-3}	C_{6-3}	C_{7-3}
A_1	0.149138	0.032692	0.225	0.058846	0.030941	0.188636	0.025
A_2	0.135345	0.025	0.18	0.031154	0.225	0.038636	0.129348
A_3	0.025	0.109615	0.225	0.058846	0.025	0.088636	0.225
A_4	0.149138	0.178846	0.045	0.160385	0.145792	0.102273	0.109783
A_5	0.225	0.028846	0.115	0.025	0.12797	0.025	0.168478
A_6	0.042241	0.071154	0.12	0.225	0.133911	0.211364	0.025
A_7	0.135345	0.225	0.14	0.055769	0.12599	0.125	0.159783
A_8	0.052586	0.128846	0.025	0.129615	0.139851	0.225	0.16413

Table 3. The weighted normalize values.

	C_{1-3}	C_{2-3}	C_{3-3}	C_{4-3}	C_{5-3}	C_{6-3}	C_{7-3}
A_1	0.02072	0.004255	0.042178	0.008081	0.004409	0.029742	0.002649
A_2	0.018804	0.003254	0.033743	0.004278	0.032065	0.006092	0.013706
A_3	0.003473	0.014266	0.042178	0.008081	0.003563	0.013975	0.023842
A_4	0.02072	0.023276	0.008436	0.022024	0.020777	0.016125	0.011633
A_5	0.03126	0.003754	0.021558	0.003433	0.018237	0.003942	0.017853
A_6	0.005869	0.00926	0.022495	0.030896	0.019084	0.033326	0.002649
A_7	0.018804	0.029282	0.026244	0.007658	0.017955	0.019709	0.016931
A_8	0.007306	0.016768	0.004686	0.017798	0.019931	0.035476	0.017392

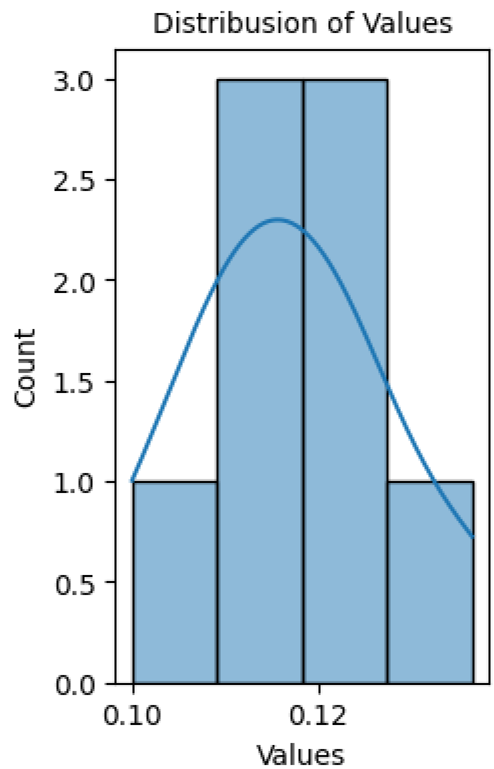

Fig 1. The values of criteria function.

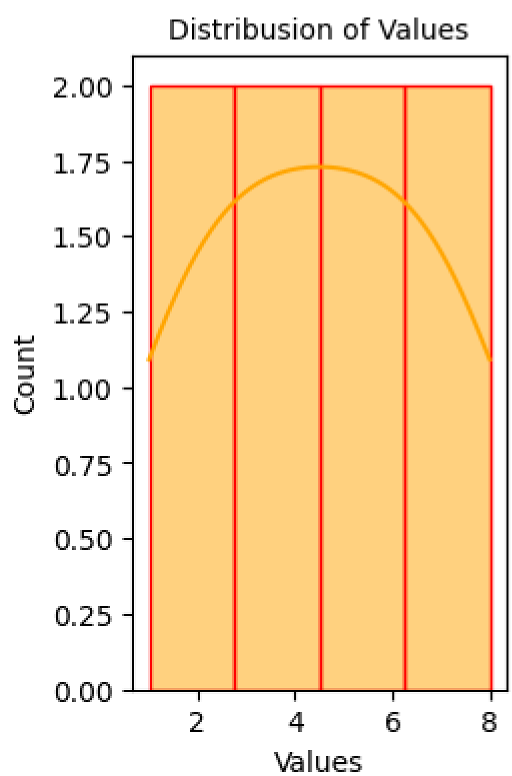

Fig 2. The rank of alternatives.

Sensitivity analysis

In this section, we change the proposed approach parameters then we ranked the alternatives under new parameters values to show different ranks. The aim of the sensitivity analysis is to show the stability of the ranks of the proposed approach. In this section, we use the criteria weights of the Entropy method to compute the criteria weights. We build the decision matrix using the NZN between the criteria and alternatives. Then we compute the entropy values of each criterion. Then we compute the criteria weights.

Then we ranked the alternatives under the Entropy method. We change value of the A parameters value between 0 and 1. Then we ranked the alternatives. In each case, we compute ethe value of criteria function under the ranking method as shown in Fig 3. Then we ranked the alternatives under the new values as shown in Fig 4. The results show the ranks of alternatives are stable under different values. The results show the alternative 6 is the best and alternative 5 is the worst in all cases.

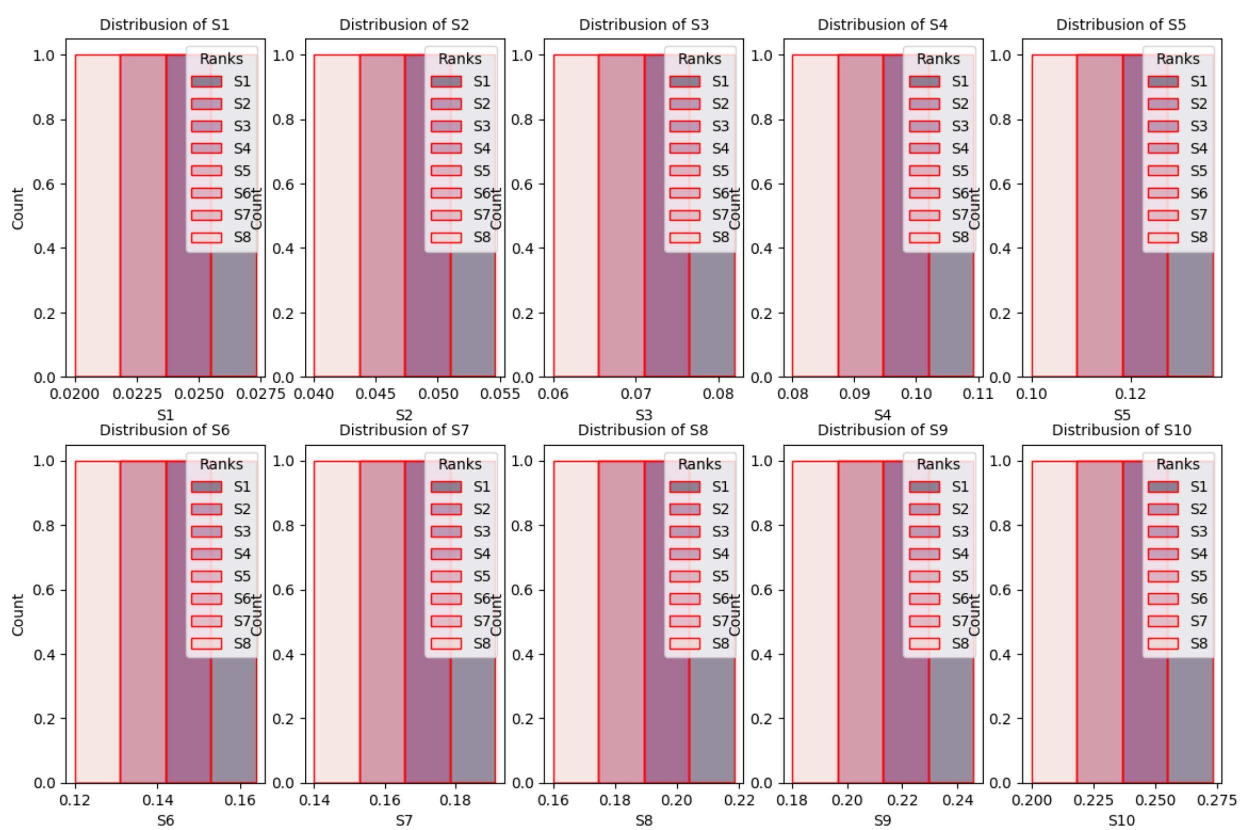

Fig 3. The different values of criteria function.

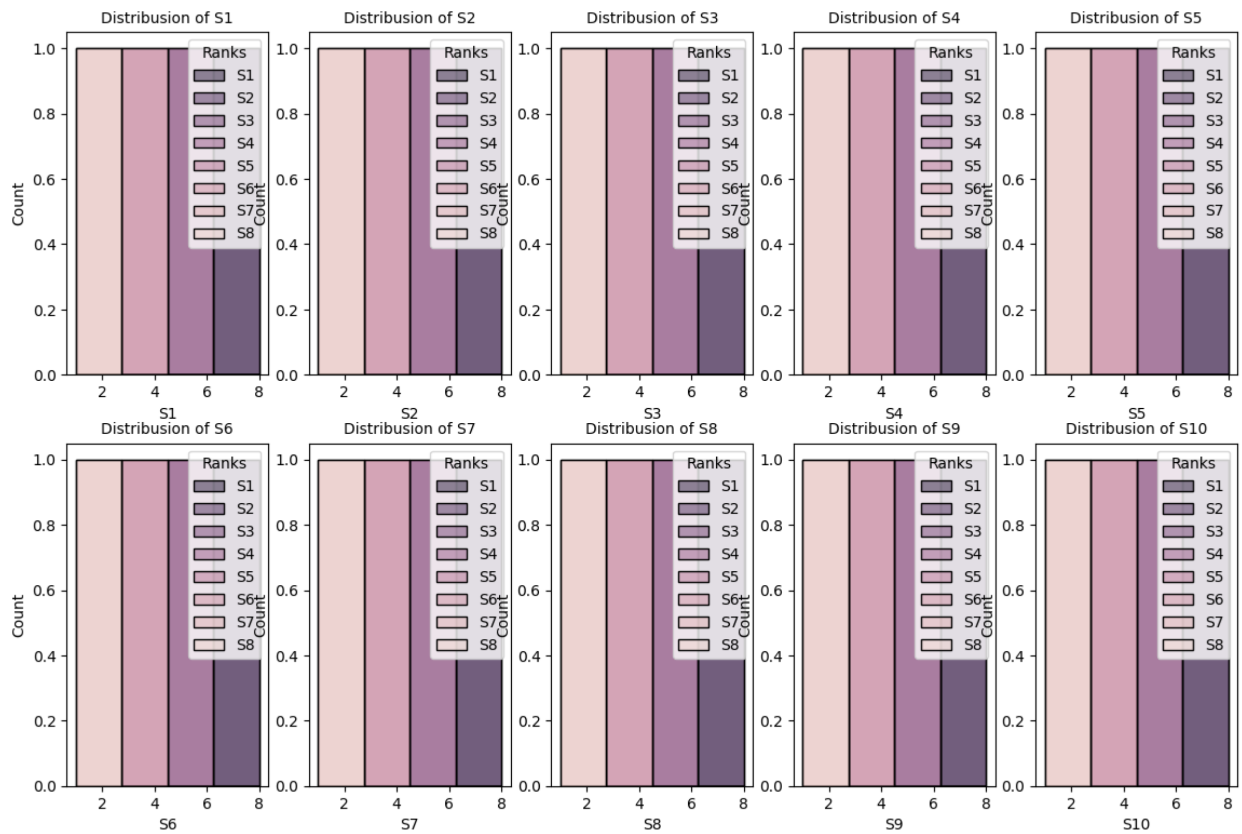

Fig 4. The different values of ranks of alternatives.

5. Conclusions and Future Works

Two MCDM methods are used in this study such as Entropy method to compute the criteria weights and RAFSI method to rank the alternatives. These methods are used under the neutrosophic-z number to deal with uncertainty data. We used the neutrosophic HyperSoft set to show the relationship between the criteria and values. Three experts are evaluated the criteria and alternatives. Seven criteria and eight alternatives are used in this study. We show alternative 6 and alternative 5. Sensitivity analysis results show the ranks of alternatives are stable under different cases.

In the future works, the proposed approach can be used in different MCDM problems to compute the criteria weights by the Entropy method and ranking the alternatives by the RAFSI method. These methods can be used under the uncertainty models to overcome the vague and uncertain information.

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