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Abstract
To avoid any conflict toward a previous work [1], we clarify certain parts that need explanation and suggest some modifications that will enhance the performance of the suggested algorithm. We enhance the algorithm by making it work in any environment and under various conditions without the occurrence of any warnings. Moreover, we suggest various future directions that will help researchers in the application of neutrosophic analytic hierarchy process. Given that scientific research is always renewed and developed, we always strive to reach the best methods and solutions. Thus, we present this study as a good guide for researchers in their future works.

Keywords: Neutrosophic Set; Analytic Hierarchy Process; Triangular Neutrosophic Number.

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1. Introduction

The analytic hierarchy process (AHP) is one of the most important multicriteria decision-making techniques [1-2]; thus, it is applied in various fields. However, as traditional AHP fails to consider imprecise and incomplete information, it needs to be developed. For example, Saaty's AHP produces rank reversal; thus, in 2015, Smarandache proposed a new procedure called "alpha-discounting method for multicriteria decision making" [4-7].

In view of the important role of neutrosophic theory in various fields and applications, we are the first to present the analytic hierarch process in the neutrosophic environment [1]. Generally, scientific research is always evolving, and new discoveries are made every day, which might change the usual rules or methods. Thus, we must present the latest developments to guide researchers toward the right path.

In this study, we present an accurate version of the score function, which was presented in [1] and has never been presented in the literature. We also present some modifications of the proposed method that researchers can use in their future works.

The remaining parts of this paper are organized as follows. In Section 2, we present a suggested modification of the score function and neutrosophic scaling of AHP. Section 3 discusses the managerial implications and benefits of the suggested modifications. Section 4 presents the conclusion and future work suggestions.

2. Suggested Modifications

In this section, some modifications of the presented score function in [1] are introduced, and a new neutrosophic scaling for the comparison matrices of AHP is presented.

2.1 Modification of the Existing Score Function

In Section 3 "Methodology, " especially in Step 4, if we have a single-value triangular neutrosophic number $\tilde{a} = \left((a_1, a_2, a_3); \alpha_{\tilde{a}}, \theta_{\tilde{a}}, \beta_{\tilde{a}}\right)$, then the score function for converting it to its crisp value is as follows:

$$S(\tilde{a}) = \frac{a_1+a_2+a_3}{9} * (2 + \alpha_{\tilde{a}} - \theta_{\tilde{a}} - \beta_{\tilde{a}}). \quad (1)$$

The accuracy function is

$$A(\tilde{a}) = \frac{a_1+a_2+a_3}{9} * (2 + \alpha_{\tilde{a}} - \theta_{\tilde{a}} + \beta_{\tilde{a}}). \quad (2)$$

2.2 Modification of the Illustrative Example

By solving the presented example in [1] for evaluating job applicants, the neutrosophic pairwise comparison matrix of the criteria, which is presented in Table 4 in [1], is exactly as presented in Table 1 in the present work.

Table 1. Neutrosophic pairwise comparison matrix of criteria

	Presentable	**Years of experience**	**Age**
Presentable	$\tilde{1}$	$\tilde{2}$	$\tilde{6}$
Years of experience	$\tilde{2}^{-1}$	$\tilde{1}$	$\tilde{7}$
Age	$\tilde{6}^{-1}$	$\tilde{7}^{-1}$	$\tilde{1}$

Notes: $\tilde{1} = (0.5,1,3); (0.5,0.2,0.3)$, $\tilde{2} = (0,2,3); (0.3,0.7,0.7)$, $\tilde{6} = (3,6,12); (0.1,0.3,0.5)$, $\tilde{7} = (2,7,15); (0.4,0.4,0.5)$.

By using a modified score function (i.e., Eq. (1)), we obtain the same data as in Table 5 in [1]. For the modified neutrosophic pairwise comparisons of the applicants according to a presentable criterion, which was presented in Table 7 in [2], $\tilde{1} = (0.5,1,3); (0.5,0.2,0.3)$, $\tilde{2} = (0,2,3); (0.6,0.2,0.3)$, $\tilde{3} = (0,3,9); (0.3,0.5,0.6)$, $\tilde{4} = (2,4,6); (0.2,0.5,0.6)$, $\tilde{5} = (3,5,15); (0.4,0.5,0.6)$, $\tilde{6} = (0,6,12); (0.4,0.5,0.6)$, $\tilde{7} = (2,7,11); (0.1,0.2,0.5)$, and $\tilde{9} = (4,9,20); (0.2,0.5,0.6)$.

By applying the modified score function using the suggested steps in [1] and correcting the typographical errors to be $\tilde{1} = (0.5,1,3); (0.5,0.2,0.3)$, $\tilde{2} = (0,2,3); (0.6,0.2,0.3)$, $\tilde{3} = (0,3,9); (0.3,0.5,0.6)$, $\tilde{4} = (2,4,6); (0.2,0.5,0.6)$, $\tilde{5} = (3,5,15); (0.4,0.5,0.6)$, $\tilde{6} = (0,6,12); (0.4,0.5,0.6)$, $\tilde{7} = (2,7,11); (0.1,0.2,0.5)$, $\tilde{9} = (4,9,20); (0.2,0.5,0.6)$, we set Tables 7 and 8 in [1] as Tables 2 and 3 here, respectively.

Table 2. Neutrosophic pairwise comparison matrix of alternatives regarding presentable criterion

	A1	**A2**	**A3**	**A4**	**A5**
A1	$\tilde{1}$	$\tilde{1}$	$\tilde{3}$	$\tilde{1}$	$\tilde{9}$
A2		$\tilde{1}$	$\tilde{1}$	$\tilde{3}$	$\tilde{7}$
A3			$\tilde{1}$	$\tilde{4}$	$\tilde{9}$
A4				$\tilde{1}$	$\tilde{5}$
A5					$\tilde{1}$

Table 3. Crisp pairwise comparison matrix of alternatives regarding presentable criterion

	A1	A2	A3	A4	A5
A1	1	1	1.60	1	4.03
A2	1	1	1	1.60	3.11
A3	0.62	1	1	1.46	4.03
A4	1	0.62	0.68	1	3.32
A5	0.25	0.32	0.25	0.30	1

The weights of the alternatives are as follows: $A1 = 0.26, A2 = 0.24, A3 = 0.23, A4 = 0.19,$ and $A5 = 0.06$.
Moreover, Table 13 in [1] is set as Table 4 here.

Table 4. Neutrosophic pairwise comparison matrix of alternatives regarding age

	A1	A2	A3	A4	A5
A1	$\tilde{1}$	$\tilde{3}$	$\tilde{7}$	$\tilde{6}$	$\tilde{7}$
A2		$\tilde{1}$	$\tilde{4}$	$\tilde{7}$	$\tilde{5}$
A3			$\tilde{1}$	$\tilde{3}$	$\tilde{6}$
A4				$\tilde{1}$	$\tilde{9}$
A5					$\tilde{1}$

The weights of the alternatives regarding to age are as follows: $A1 = 0.36, A2 = 0.26, A3 = 0.16, A4 = 0.14,$ and $A5 = 0.07$.

Furthermore, all the elements in the comparison matrix are positive, and the upper value of the triangular neutrosophic number is greater than zero.

2.3 Modification of the Methodology

This subsection presents a modified approach for solving neutrosophic AHP. Table 5 presents a new ranking scale for the alternatives and criteria.
The steps for solving the neutrosophic AHP are as follows.
Step 1. Same as in [1].
Step 2. Same as in [1]. However, for constructing the neutrosophic pairwise comparison matrix, use the scale presented in Table 5.
Steps 3 and 4. Same as in [1]. However, for converting the neutrosophic pairwise comparison matrix, use Eq. (1) instead of Eq. (4) in [1].
Steps 5 and 6. Same as in [1].

Table 5. Linguistic variables for ranking the alternatives and criteria for neutrosophic AHP

Neutrosophic scale of Saaty	Linguistic terms	Lower, median, and upper values of the triangular number	Degree of certainty of expert opinion
$\tilde{1}$	Equally important	$\langle(1,1,1)\rangle$	Absolutely uncertain (0, 0, 1)
$\tilde{3}$	Slightly important	$\langle(2,3,4)\rangle$	Uncertain (0.25 ,0.75, 0.75)
$\tilde{5}$	Strongly important	$\langle(4,5,6)\rangle$	Slightly certain (0.45, 0.60, 0.60)
$\tilde{7}$	Very strongly important	$\langle(6,7,8)\rangle$	Median certainty (0.50, 0.50, 0.50)
$\tilde{9}$	Absolutely important	$\langle(9,9,9)\rangle$	Certain (0.75, 0.20, 0.20)
$\tilde{2}$	Sporadic values among two close scales	$\langle(1,2,3)\rangle$	Strongly certain (0.85, 0.15, 0.15)
$\tilde{4}$		$\langle(3,4,5)\rangle$	Very strongly certain (0.90, 0.10, 0.10)
$\tilde{6}$		$\langle(5,6,7)\rangle$	Absolutely certain (1.00, 0.00, 0.0)
$\tilde{8}$		$\langle(7,8,9)\rangle$	

2.4 Illustrative Example

For illustrating how the suggested method works, let us solve a simple example.

If we need to purchase an MP3 player and *i* have three criteria for buying, namely, storage, availability, and color [3], then we have four available alternatives A, B, C, and D. We want to evaluate the four available alternatives to select the best one.
The hierarchy for evaluating the available alternatives of MP3 players is shown in Fig. 1.

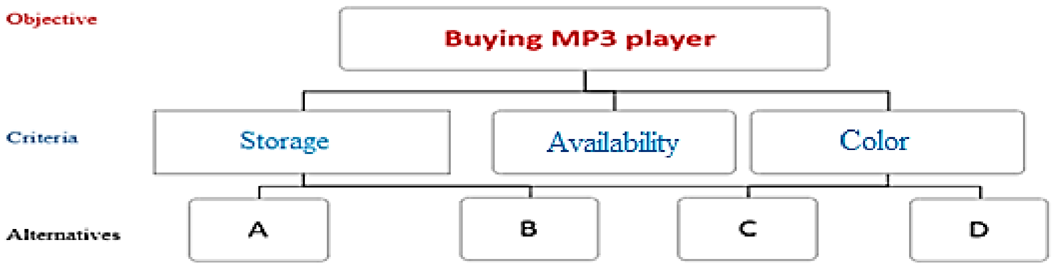

Fig. 1. Hierarchy tree for evaluating various types of MP3 player

Table 6 shows the neutrosophic pairwise comparison matrix of criteria using the suggested scale.

Table 6. Neutrosophic pairwise comparison matrix of criteria

	Storage	Availability	Color
Storage	$\langle(1,1,1);\ (1,0,0)\rangle$	$\langle(2,3,4);\ (0.85,0.15,0.15)\rangle$	$\langle(4,5,6);\ (0.9,0.1,0.1)\rangle$
Availability		$\langle(1,1,1);\ (1,0,0)\rangle$	$\langle(2,3,4);\ (0.85,0.15,0.15)\rangle$
Color			$\langle(1,1,1);\ (1,0,0)\rangle$

By using Eq. (1), the crisp form of the neutrosophic pairwise comparison matrix of the criteria are shown in Table 7.

Table 7. Crisp pairwise comparison matrix of criteria

	Storage	Availability	Color
Storage	1	2.55	4.5
Availability	0.39	1	2.55
Color	0.22	0.39	1

The weights for the criteria are as follows: weight of storage = 0.61, weight of availability = 0.27, and weight of color = 0.12.

Table 8 shows the neutrosophic pairwise comparison matrix of the alternatives regarding storage using the suggested scale.

Table 8. Neutrosophic pairwise comparison matrix of alternatives regarding storage criterion

Storage	A	B	C	D
A	$\langle(1,1,1);\ (1,0,0)\rangle$	$\langle(4,5,6);\ (0.9,0.1,0.1)\rangle$	$\langle(4,5,6);\ (0.9,0.1,0.1)\rangle$	$\langle(4,5,6);\ (0.9,0.1,0.1)\rangle$
B		$\langle(1,1,1);\ (1,0,0)\rangle$	$\langle(2,3,4);\ (0.85,0.15,0.15)\rangle$	$\langle(4,5,6);\ (0.9,0.1,0.1)\rangle$
C			$\langle(1,1,1);\ (1,0,0)\rangle$	$\langle(4,5,6);\ (0.9,0.1,0.1)\rangle$
D				$\langle(1,1,1);\ (1,0,0)\rangle$

By using Eq. (1), the crisp form of the neutrosophic pairwise comparison matrix of the alternatives regarding storage criterion is shown in Table 9.

Table 9. Crisp pairwise comparison matrix of alternatives regarding storage criterion

Storage	A	B	C	D
A	1	4.5	4.5	4.5
B	0.22	1	2.55	4.5
C	0.22	0.39	1	4.5
D	0.22	0.22	0.22	1

The weights for the alternatives are as follows: weight of A = 0.55, weight of B = 0.23, weight of C = 0.16, and weight of D = 0.07.

Table 10 presents the neutrosophic pairwise comparison matrix of the alternatives regarding availability using the suggested scale.

Table 10. Neutrosophic pairwise comparison matrix of alternatives regarding availability criterion

Availability	A	B	C	D
A	$\langle(1,1,1);\ (1,0,0)\rangle$	$\langle(7,8,9);\ (0.85,0.15,0.15)\rangle$	$\langle(7,8,9);\ (0.85,0.15,0.15)\rangle$	$\langle(7,8,9);\ (0.85,0.15,0.15)\rangle$
B		$\langle(1,1,1);\ (1,0,0)\rangle$	$\langle(2,3,4);\ (0.85,0.15,0.15)\rangle$	$\langle(2,3,4);\ (0.85,0.15,0.15)\rangle$
C			$\langle(1,1,1);\ (1,0,0)\rangle$	$\langle(2,3,4);\ (0.85,0.15,0.15)\rangle$
D				$\langle(1,1,1);\ (1,0,0)\rangle$

By using Eq. (1), the crisp form of the neutrosophic pairwise comparison matrix of the alternatives regarding availability criterion is shown in Table 11.

Table 11. Crisp pairwise comparison matrix of alternatives regarding availability criterion

Availability	A	B	C	D
A	1	6.8	6.8	6.8
B	0.15	1	2.55	2.55
C	0.15	0.39	1	2.55
D	0.15	0.39	0.39	1

The weights for the alternatives are as follows: weight of A = 0.661, weight of B = 0.163, weight of C = 0.109, and weight of D = 0.065.

The neutrosophic pairwise comparison matrix of the alternatives regarding color using the suggested scale is presented in Table 12.

Table 12. Neutrosophic pairwise comparison matrix of alternatives regarding color criterion

Color	A	B	C	D
A	$\langle(1,1,1);\ (1,0,0)\rangle$	$\langle(1,2,3);\ (1,0,0)\rangle$	$\langle(3,4,5);\ (1,0,0)\rangle$	$\langle(7,8,9);\ (1,0,0)\rangle$
B		$\langle(1,1,1);\ (1,0,0)\rangle$	$\langle(1,2,3);\ (1,0,0)\rangle$	$\langle(3,4,5);\ (1,0,0)\rangle$
C			$\langle(1,1,1);\ (1,0,0)\rangle$	$\langle(2,3,4);\ (1,0,0)\rangle$
D				$\langle(1,1,1);\ (1,0,0)\rangle$

By using Eq. (1), the crisp form of the neutrosophic pairwise comparison matrix of the alternatives regarding color criterion is shown in Table 13.

Table 13. Crisp pairwise comparison matrix of alternatives regarding color criterion

Color	A	B	C	D
A	1	2	4	8
B		1	2	4
C			1	3
D				1

The weights for the alternatives are as follows: weight of A = 0.529, weight of B = 0.264, weight of C = 0.147, and weight of D = 0.06.

Then, the relative scores for the alternatives are as follows:

$$\begin{bmatrix} 0.55 & 0.66 & 0.53 \\ 0.23 & 0.16 & 0.26 \\ 0.16 & 0.11 & 0.15 \\ 0.07 & 0.06 & 0.06 \end{bmatrix} \times \begin{bmatrix} 0.61 \\ 0.27 \\ 0.12 \end{bmatrix} = \begin{bmatrix} 0.57 \\ 0.21 \\ 0.14 \\ 0.07 \end{bmatrix}.$$

Findings show that Alternative A is the best one.

3. Managerial Implications

Selecting suitable alternatives requires a ranking method that usually contains several selection scopes. Habitually, there exist several conflicting criteria that makes the selection process difficult. The suggested neutrosophic AHP displays its applicability to handle vague and imprecise information, which exists usually in reality. Then, we can reach robust decisions by using the suggested method. The suggested neutrosophic AHP has the same benefits with the classical AHP besides the following advantages: offers user with a richer structural framework than the classical, fuzzy, and intuitionistic fuzzy AHP; defines the preference judgment values of the decision maker efficiently; and considers three degrees, namely, membership, indeterminacy, and non-membership degrees, which simulate natural human thinking. Generally, the suggested method in this study can be extended to diverse decisions related to other problems. The proposed method can be utilized as a reference guide for researchers to produce precise decisions about any problem in any organization. Governments can also use the proposed method to make precise decisions about any social, economic, and environmental problems.

4. Conclusions and Future Directions

Clarifications and modifications of the suggested score function and method for neutrosophic AHP are illustrated here to avoid any conflict among researchers and help them in future application of neutrosophic AHP in various fields. By using the suggested score function and the suggested scale for neutrosophic AHP, researchers can overcome various problems that they may face in the future application of neutrosophic AHP.

In the future, we recommend researchers to use the proposed scale for rating criteria and alternatives of neutrosophic AHP and use the presented score function in various case studies for its benefits and applicability. Moreover, we recommend researchers to propose novel methods to enhance the degree of consistency instead of repeating the exercise in cases of obtaining inconsistent comparison matrices.

Conflict of interest

We do not have any commercial or associative interest that signifies a conflict of interest in submitting our work.

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