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The Multi-Attribute Decision-Making Problem Using Single-Valued Neutrosophic Numbers

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P A P E R I N F O

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A B S T R A C T

In this paper, an extension of intuitionistic fuzzy numbers is presented.The researcher proposes single-valued triangular neutrosophic numbers (SVTNNs). These SVTNNs represent ordinary numbers but possess a level of uncertainty from a philosophical perspective. Additionally, the researcher introduces a modified operator termed the single-valued triangular neutrosophic weighted aggregation (SVTNWA) operator. This operator is utilized in multi-attribute decision-making (MADM) situations, enabling the management of many attribute to facilitate informed decisions. For this SVTNWA operator, examples are offered.

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1. INTRODUCTION

In everyday content, most of the issues involve imprecise concepts (Shahoodh, Ali, & Adwan, 2025). The traditional approach of set theory and numbers is inadequate to handle the imprecise idea and it must be expanded to include some additional concepts. The fuzzy concept is one of the concepts for this purpose.

Neutrosophic set theory is a mathematical framework that extends the concepts of classical set theory, fuzzy set theory, and intuitionistic fuzzy set theory. It was introduced by Smarandache in the 1990s as a way to incomplete, handle uncertain, and indeterminate information in a more flexible manner (Deli & Subas, 2014). Neutrosophic sets allow for the representation of three different types of membership degrees: truth, falsity, and indeterminacy. Unlike classical sets where an element is either a member or a non-member, and fuzzy sets where an element has a degree of membership between 0 and 1, neutrosophic sets recognize the existence of an indeterminate region where the membership status cannot be determined with certainty(Ansari, Biswas, & Aggarwal, 2013) (Ashbacher, 2014).

The multi-attribute decision-making (MADM) problem is a common challenge in various domains where decision-makers need to evaluate and compare alternatives based on multiple attribute. Conventional approaches to decision-making frequently take the attribute and their weights to be represented as clear-cut or fuzzy values. However, in practical situations, making decisions may involve ambiguity, insufficient information, and uncertainty(Taherdoost & Madanchian, 2023) (Bhole & Deshmukh, 2018). Current advances in MADM have progressively employed single-valued neutrosophic numbers (SVNNs) to address uncertainty and inaccuracy.

In (Xu & Zhao, 2025), the author presented a multi-attribute group decision-making technique that uses SVNNs in conjunction with extended power average operators and the Dombi operator. In (Liu, Shen, & Zhang, 2024), researchers presented a fresh distance metric for SVNNs, improving the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) approache to enhance decision-making accuracy. A more versatile foundation for MADM applications was also provided by the introduction of the idea of single-valued neutrosophic multiple sets (SVNMS) to expand standard SVNNs (Radhakrishnan & Thankachan, 2025). Notwithstanding these advancements, numerous current methodologies either concentrate on particular aggregation operators or lack holistic frameworks to address the intricacies of real-world decision-making

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contexts. In this paper, The single-valued triangular neutrosophic weighted aggregate (SVTNWA) is employed in multi-attribute decision-making (MADM) contexts, allowing for the management of several attribute to support informed decision-making.

1.1. Fuzzy Set (FS) FS theory is a mathematical framework that facilitates the description and management of uncertain or ambiguous notions (Hussein, 2024). Conversely, fuzzy set theory allows for varying degrees of membership, enabling components to partially belong to a set. The FSs are employed to represent and manage imprecise and uncertain information prevalent in real-world scenarios. They offer a robust instrument for addressing ambiguity and encapsulating the intrinsic vagueness in human reasoning (Yanar & Akyürek, 2006). FSs can convey nuances between full membership and non-membership by permitting incremental membership.

The membership values might vary from $0\ to\ 1$, where 0 indicates non-membership and 1 signifies full membership. Values ranging from $0\ to\ 1$ indicate partial membership. FS theory serves as a significant mathematical instrument, utilizing vagueness and uncertainty to create a framework for modeling and reasoning about imprecise concepts in a more adaptable and realistic way (Kahraman, 2008). In (Atanassov, 1988),the researcher suggested the Intuitionistic Fuzzy Set (IFS) as an extension of the fuzzy set within a universe A. The IFS includes a degree of non-membership $\nu_{X(a)} \in [0,1]$ in addition to the degree of membership $\mu_{X(a)} \in [0,1]$ for each element $a \in A$ belonging to a set X. To maintain this degree of non-membership, the following conditions must be met:

$$\forall\, a \in A, \quad \mu_{X(a)} + \nu_{X(a)} \leq 1 \qquad (1)$$

1.2. Neutrosophic Set (NS)

The NS concept was initially introduced by(Smarandache, 1998). Smarandache defined the degree of indeterminacy as an autonomous component. In an NS, every element within the universe of discourse is linked to three values: the truth (*T*), the indeterminacy (*I*), and the false (*F*). These values denote the membership, non-membership, and indeterminacy of an element within a specified set, respectively(Smarandache, 2019) in contrast to fuzzy sets, which have membership values confined to the interval $[0, 1]$, the NS permits membership, non-membership, and indeterminacy values to fluctuate within the range $[0, 1]$. The degree of truth (T) indicates the extent of an element's membership in a set, the degree of falsity (F) denotes the extent of an element's non-membership in a set, and the degree of indeterminacy (I) signifies the extent of uncertainty regarding an element's membership status (Dubois & Prade, 2012). Collectively, these three values offer more thorough ambiguous information and depiction of unclear.

When the available knowledge is either contradictory or inadequate, NSs serve as a valuable instrument. They can manage scenarios in which it is difficult to ascertain the exact membership or non-membership of components in a set due to ambiguity or uncertainty (Habib, Akram, & Kahraman, 2022). By incorporating the concept of indeterminacy, NSs allow for conflicting data or a more nuanced representation of incomple teness.

Assuming *A* is a universe of discourse and *a* represents a generic element in *A*, the NS set can be defined as an entity that takes on the following structure:

$$X = \{(a, (\mu_X(a), \omega_X(a), \vartheta_X(a)) : a \in A\} \qquad (2)$$

1.3. Multi-Attribute Decision Making

The approach of Multi-Attribute Decision Making (MADM) entails assessing and choosing the optimal alternative from a range of options based on various attribute or qualities. It is employed when decision-makers must evaluate and balance various factors concurrently to make informed and rational decisions. In MADM, each alternative is evaluated based on a set of pertinent traits or attribute relevant to the choice being made(Deli & Şubaş, 2017). These features may be quantifiable (e.g., cost, time, or performance measures) or qualitative (e.g., reputation, customer satisfaction, or environmental impact). The decision-maker allocates weights or significance values to each characteristic to represent their relative relevance.

2. SINGLE-VALUED TRIANGULAR NEUTROSOPHIC

Let a triangular neutrosophic number $\boldsymbol{\alpha}^{\sim}$ be defined as $\boldsymbol{\alpha}^{\sim} = ((\boldsymbol{x_1}, \boldsymbol{x_2}, \boldsymbol{x_3}), \boldsymbol{X_{\alpha^{\sim}}}), \ ((\boldsymbol{y_1}, \boldsymbol{y_2}, \boldsymbol{y_3}), \boldsymbol{Y_{\alpha^{\sim}}}), \ ((\boldsymbol{z_1}, \boldsymbol{z_2}, \boldsymbol{z_3}), \ \boldsymbol{Z_{\alpha^{\sim}}})$. An NS is defined on the real number set $\mathbb{R}$, with truth-membership, indeterminacy-membership, and false-membership functions. These functions are given by the following:

$$\mu_{\alpha^{\sim}}(\beta) = \begin{cases} (\beta - x_1)X_{\alpha^{\sim}} / (x_2 - x_1) & (x_1 \leq \beta < x_2) \\ X_{\alpha^{\sim}} & (\beta = x_2) \\ (x_3 - \beta)X_{\alpha^{\sim}} / (x_3 - x_2) & (x_2 \leq \beta \leq x_3) \\ 0 & otherwise \end{cases} \qquad (3)$$

$$v_{\alpha^{\sim}}(\beta) = \begin{cases} (y_2 - \beta + Y_{\alpha^{\sim}}(\beta - y_1))/(y_2 - y_1) & (y_1 \leq \beta < y_2 \\ Y_{\alpha^{\sim}} & (\beta = y_2) \\ (\beta - y_2 + Y_{\alpha^{\sim}}(y_3 - \beta))/(y_3 - y_2) & (y_2 \leq \beta < y_3 \\ 1 & otherwise \end{cases} \quad (4)$$

$$\lambda_{\alpha^{\sim}}(\beta) = \begin{cases} (z_2 - \beta + Z_{\alpha^{\sim}}(\beta - z_1))/(z_2 - z_1) & (z_1 \leq \beta < z_2 \\ Z_{\alpha^{\sim}} & (\beta = z_3\ ) \\ (\beta - z_2 + Z_{\alpha^{\sim}}(z_3 - \beta))/(z_3 - z_2) & (z_2 \leq \beta < z_3 \\ 1 & otherwise \end{cases} \quad (5)$$

If $x_1,\ y_1,\ z_1 \geq 0$ and at least $x_3\ , y_3\ , z_3 > 0$, then $\alpha^{\sim}$ is referred to as a positive Single-Valued Triangular Neutrosophic Number (SVTrNN), which is represented as $\alpha^{\sim} > 0$. Likewise, if $x_2\ , y_2\ , z_2 \leq 0$ and at least x_1, $y_1,\ z_1 < 0$, then $\alpha^{\sim}$ is referred to as a negative SVTrNN, which is represented as $\alpha^{\sim} < 0$. A triangular neutrosophic number denoted as $\alpha^{\sim} = ((x_1, x_2, x_3), X_{\alpha^{\sim}})$, $((y_1, y_2, y_3), Y_{\alpha^{\sim}})$, $((z_1, z_2, z_3),\ Z_{\alpha^{\sim}})$, can represent a vague or uncertain value related to the variable $\alpha^{\sim}$, which is approximately equivalent to $\alpha^{\sim}$.

3. TWO SINGLE-VALUED TRIANGULAR NEUTROSOPHIC NUMBERS

Let $\alpha^{\sim} = ((x_1, x_2, x_3), X_{\alpha^{\sim}})$, $((y_1, y_2, y_3), Y_{\alpha^{\sim}})$, $((z_1, z_2, z_3),\ Z_{\alpha^{\sim}})$ and $\beta^{\sim} = ((x_1, x_2, x_3), X_{\beta^{\sim}})$, $((y_1, y_2, y_3), Y_{\beta^{\sim}})$, $((z_1, z_2, z_3),\ Z_{\beta^{\sim}})$ be two SVTrNNs and $\eta \neq 0$, then

3.1. Addition

$$\alpha^{\sim} + \beta^{\sim} = ((x_1 + y_1,\ x_2 + y_2, x_3 + y_3\ )\ X_{\alpha^{\sim}}\ min\, X_{\beta^{\sim}}, Y_{\alpha^{\sim}}\ max\, Y_{\beta^{\sim}},\ Z_{\alpha^{\sim}} max\ Z_{\beta^{\sim}})$$

3.2. Subtraction

$$\alpha^{\sim} - \beta^{\sim} = ((x_1 - y_1,\ x_2 - y_2, x_3 - y_3\ )\ X_{\alpha^{\sim}}\ min\, X_{\beta^{\sim}}, Y_{\alpha^{\sim}}\ max\, Y_{\beta^{\sim}},\ Z_{\alpha^{\sim}} max\ Z_{\beta^{\sim}})$$

3.3. Multiplication

$$\alpha^{\sim}\beta^{\sim} = \begin{cases} ((x_1\, y_1,\ x_2 y_2, x_3 y_3);\ X_{\alpha^{\sim}}\ min\, X_{\beta^{\sim}}, Y_{\alpha^{\sim}}\ max\, Y_{\beta^{\sim}},\ Z_{\alpha^{\sim}} max\ Z_{\beta^{\sim}})(x_3 > 0, y_3 > 0) \\ ((x_1\, y_3,\ x_2 y_2, x_3 y_1);\ X_{\alpha^{\sim}}\ min\, X_{\beta^{\sim}}, Y_{\alpha^{\sim}}\ max\, Y_{\beta^{\sim}},\ Z_{\alpha^{\sim}} max\ Z_{\beta^{\sim}})(x_3 < 0, y_3 > 0) \\ ((\, x_3 y_3, x_2 y_2, x_1 y_1);\ X_{\alpha^{\sim}}\ min\, X_{\beta^{\sim}}, Y_{\alpha^{\sim}}\ max\, Y_{\beta^{\sim}},\ Z_{\alpha^{\sim}} max\ Z_{\beta^{\sim}})(x_3 < 0, y_3 < 0) \end{cases}$$

3.4. Division

$$\alpha^{\sim}/\beta^{\sim} = . \begin{cases} ((x_1\, /y_1,\ x_2/y_2, x_3/y_3);\ X_{\alpha^{\sim}}\ min\, X_{\beta^{\sim}}, Y_{\alpha^{\sim}}\ max\, Y_{\beta^{\sim}},\ Z_{\alpha^{\sim}} max\ Z_{\beta^{\sim}})(x_3 > 0, y_3 > 0) \\ ((x_1/\, y_3,\ x_2/y_2, x_3/y_1);\ X_{\alpha^{\sim}}\ min\, X_{\beta^{\sim}}, Y_{\alpha^{\sim}}\ max\, Y_{\beta^{\sim}},\ Z_{\alpha^{\sim}} max\ Z_{\beta^{\sim}})(x_3 < 0, y_3 > 0) \\ ((\, x_3/y_3, x_2/y_2, x_1/y_1);\ X_{\alpha^{\sim}}\ min\, X_{\beta^{\sim}}, Y_{\alpha^{\sim}}\ max\, Y_{\beta^{\sim}},\ Z_{\alpha^{\sim}} max\ Z_{\beta^{\sim}})(x_3 < 0, y_3 < 0) \end{cases}$$

3.5. Multiplication by a constant

$$\eta\alpha^{\sim} = \begin{cases} ((\eta x_1, \eta x_2, \eta x_3);\ X_{\alpha^{\sim}}, Y_{\alpha^{\sim}},\ Z_{\alpha^{\sim}})(\eta > 0) \\ ((\eta x_3, \eta x_2, \eta x_1);\ X_{\alpha^{\sim}}, Y_{\alpha^{\sim}},\ Z_{\alpha^{\sim}})(\eta < 0) \end{cases}$$

3.6. Inverse

$$\alpha^{\sim -1} = ((1/x_1, 1/x_2, 1/x_3);\ X_{\alpha^{\sim}}, Y_{\alpha^{\sim}},\ Z_{\alpha^{\sim}})\ (\alpha^{\sim} \neq 0)$$

It can be demonstrated that the outcomes derived from the multiplication and division operations involving two SVTrNNs do not consistently yield SVTrNNs. Nevertheless, it is common practice to utilize SVTrNNs as a means of approximating and expressing these computational findings.

3.7. Example

Let $\alpha^{\sim} = ((\ 3,4,6); 0.3,0.4,0.6\ )$ and $\beta^{\sim} = ((2,4,7); 0.5,0.6,0.7\ )$ represent two single-valued triangular neutrosophic numbers.

1. $\alpha^{\sim} + \beta^{\sim} = ((5,8,13); 0.3,0.6,0.7\ )$
2. $\alpha^{\sim} - \beta^{\sim} = ((1,0,-1); 0.3,0.6,0.7\ )$
3. $\alpha^{\sim}\beta^{\sim} = ((6,16,42); 0.3,0.6,0.7\ )$
4. $\alpha^{\sim}\backslash\beta^{\sim} = \left(\left(\frac{3}{7}, \frac{4}{4}, \frac{6}{2}\right); 0.3,0.6,0.7\right)$
5. $\alpha^{\sim -1} = \left(\left(\frac{1}{6}, \frac{1}{4}, \frac{1}{3}\right); 0.3,0.4,0.6\ \right)$
6. $3\alpha^{\sim} = ((9,12,18); 0.3,0.4,0.6\ )$

3.8. Remark

If $0 \leq X_{\alpha^{\sim}}, Y_{\alpha^{\sim}}, Z_{\alpha^{\sim}} \leq 1, 0 \leq X_{\alpha^{\sim}} + Y_{\alpha^{\sim}} + Z_{\alpha^{\sim}} \leq 1$, $Z_{\alpha^{\sim}} = 0$ and $0 \leq X_{\beta^{\sim}}, Y_{\beta^{\sim}}, Z_{\beta^{\sim}} \leq 1, 0 \leq X_{\beta^{\sim}} + Y_{\beta^{\sim}} + Z_{\beta^{\sim}} \leq 1$, $Z_{\beta^{\sim}} = 0$, then the SVTrNNs $\alpha^{\sim} = ((x_1, x_2, x_3), X_{\alpha^{\sim}})$, $((y_1, y_2, y_3), Y_{\alpha^{\sim}})$, $((z_1, z_2, z_3),\ Z_{\alpha^{\sim}})$ and $\beta^{\sim} = ((x_1, x_2, x_3), X_{\beta^{\sim}})$, $((y_1, y_2, y_3), Y_{\beta^{\sim}})$, $((z_1, z_2, z_3),\ Z_{\beta^{\sim}})$ The concept of degeneracy can be extended to the space of intuitionistic triangular fuzzy numbers $\alpha^{\sim} = ((x_1, x_2, x_3), X_{\alpha^{\sim}})$, $((y_1, y_2, y_3), Y_{\alpha^{\sim}})$, $(0\ )$ and $\beta^{\sim} = ((x_1, x_2, x_3), X_{\beta^{\sim}})$, $((y_1, y_2, y_3), Y_{\beta^{\sim}})$, $(0\ )$, respectively. As previously stated, the mathematical operations were developed to simplify them.

4. EXAMPLE OF EVALUATING TEACHING

The example we will focus on involves evaluating the quality of teaching and drawing inspiration from the application discussed. Suppose a government organization is seeking to fill a position, and they have

identified five candidates ($X = (x_1, x_2, x_3, x_4)$ for evaluation. The assessment process will be conducted by a panel of experts from Management Science, who will evaluate the candidates based on three specific aspects: teaching attitude (y_1), ability (y_2), and content (y_3).
The teaching attitude of the candidates holds a significant importance in this evaluation, as those who exhibit a positive attitude are likely to have a substantial impact when teaching. Evaluating teaching ability comprises assessing the candidates' professional knowledge and their practical experience in the field. Lastly, the content of their teaching is examined to ensure that it aligns closely with teaching guidance. To establish the relative importance of these attributes, a weight vector is assigned, with the values $(0.4, 0.4, 0.2)^T$, representing the respective weights for teaching attitude, ability, and content.

Step 1. The teachers were assessed by experts, and the outcomes of their evaluations are presented in Table 1.

	y_1	y_2	y_3
x_1	((0.2,0.3,0.4,0.6);0.6,0.5,0.1)	((0.1,0.2,0.4,0.5);0.4,0.2,0.6)	((0.1,0.3,0.6,0.7);0.8,0.1,0.4)
x_2	((0.3,0.6,0.7,0.9);0.9,0.3,0.5)	((0.3,0.5,0.6,0.8);0.2,0.3,0.4)	((0.3,0.4,0.7,0.7);0.6,0.4,0.8)
x_3	((0.3,0.5,0.7,0.7);0.7,0.3,0.1)	((0.3,0.6,0.7,0.9);0.3,0.6,0.8)	((0.3,0.5,0.5,0.4);0.7,0.3,0.6)
x_4	((0.4,0.5,0.6,0.8);0.8,0.2,0.4)	((0.2,0.4,0.7,0.9);0.8,0.9,0.6)	((0.5,0.6,0.8,0.7);0.4,0.3,0.2)

Step 2. For $\zeta = 1, 2, 3,$ and 4, the table displays the aggregated obtained by the SVTNWA.

	$\zeta = 1$	$\zeta = 2$
x_1	((0.140, 0.260, 0.440, 0.580);0.4, 0.5, 0.6)	((0.022, 0.070, 0.200, 0.342); 0.4, 0.5, 0.6)
x_2	((0.300, 0.520, 0.660, 0.820);0.2, 0.4,0.8)	((0.090, 0.276, 0.438, 0.678); 0.2,0.4,0.8)
x_3	((0.300, 0.540, 0.660, 0.720);0.3, 0.6,0.8)	((0.090, 0.294, 0.442, 0.552); 0.3,0.6,0.8)
x_4	((0.340, 0.480, 0.680, 0.820);0.4, 0.9,0.6)	((0.130, 0.236, 0.468, 0.678); 0.4,0.9,0.6)

	$\zeta = 3$	$\zeta = 4$
x_1	(0.004, 0.019, 0.094, 0.205); 0.4, 0.5, 0.6)	(0.001, 0.006, 0.046, 0.125); 0.4, 0.5, 0.6)
x_2	(0.027, 0.149, 0.292, 0.565); 0.2,0.4,0.8)	(0.008, 0.082, 0.196, 0.474); 0.2,0.4,0.8)
x_3	(0.027, 0.161, 0.299, 0.442); 0.3,0.6,0.8)	(0.008, 0.089, 0.205, 0.364); 0.3,0.6,0.8)
x_4	(0.054, 0.119, 0.326, 0.565); 0.4,0.9,0.6)	(0.023, 0.061, 0.230, 0.474); 0.4,0.9,0.6)

Step 3. The score values of the respective alternatives are shown in table.

	$S_1(x_1)$	$S_2(x_2)$	$S_3(x_3)$	$S_4(x_4)$
$\zeta = 1$	0.1846	0.1438	0.1248	0.1305
$\zeta = 2$	0.0514	0.0926	0.0774	0.0850
$\zeta = 3$	0.0262	0.0646	0.0522	0.0598
$\zeta = 4$	0.0144	0.0475	0.0374	0.0044

Step 4. The accuracy degrees of the respective alternatives are shown in table.

	$\boldsymbol{AC_1(x_1)}$	$\boldsymbol{AC_2(x_2)}$	$\boldsymbol{AC_3(x_3)}$	$\boldsymbol{AC_4(x_4)}$
$\zeta = 1$	0.2219	0.3738	0.3469	0.3045
$\zeta = 2$	0.0991	0.2408	0.2153	0.1985
$\zeta = 3$	0.0503	0.1679	0.1510	0.1397
$\zeta = 4$	0.0278	0.1235	0.1041	0.1034

Step 5. The alternatives are ranked based on these scores and their accuracy degrees.

	The score	**The accuracy degrees**
$\zeta = 1$	$x_1 > x_2 > x_4 > x_3$	$x_2 > x_3 > x_4 > x_1$
$\zeta = 2$	$x_2 > x_4 > x_3 > x_1$	$x_2 > x_3 > x_4 > x_1$
$\zeta = 3$	$x_2 > x_4 > x_3 > x_1$	$x_2 > x_3 > x_4 > x_1$
$\zeta = 4$	$x_2 > x_3 > x_1 > x_4$	$x_2 > x_3 > x_4 > x_1$

By determining the score and accuracy values, a comprehensive candidate ranking can be established. Aligning these scores and accuracy degrees enhances the effectiveness of candidate evaluations using MADM methods. It is easy to see that x_2 has the highest values of score and accuracy degrees. The alignment between our objective and the outcomes is readily discernible.

Our objective revolves around creating a versatile framework capable of accommodating diverse decision attribute, enabling decision-makers to effectively assess and prioritize factors based on their relative significance. The clarity achieved through this approach becomes evident in the results, as they vividly highlight the comprehensive representation, we aimed to provide for the decision problem. This alignment enhances the robustness and informed nature of the decision outcomes, reinforcing the purpose behind our efforts to ensure a more effective decision-making process.

The assessment of candidates based on their teaching attitude, ability, and content holds significant importance when considering weighted attribute. By increasing the value of ζ, the process of determining the highest-ranking candidate becomes more straightforward, as it enables a clearer distinction in terms of score and accuracy degrees.

In this context, evaluating candidates necessitates a comprehensive examination of various factors, such as their teaching attitude, ability, and content. Each of these attribute is assigned a weight to denote its relative importance in the overall assessment. The weight assigned to a criterion signifies the degree of significance it holds in the evaluation process.

We implemented this example using MATLAB to obtain the presented results as in Figure 1.

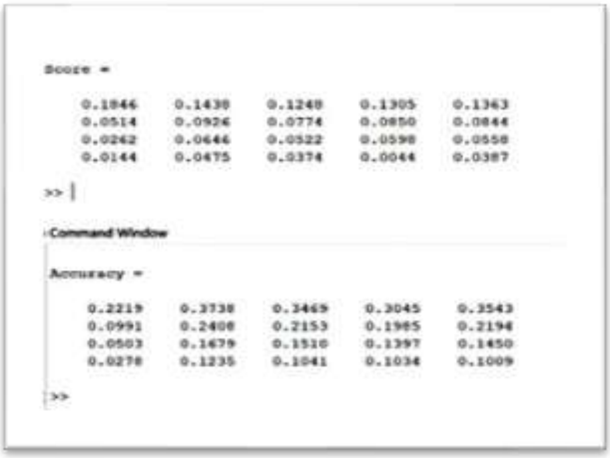

Figure 1. MATLAB results (example of evaluating teaching)

5. CONCLUSIONS

As a conclusion, the employment of SVTNWAs in multi-attribute decision-making has been demonstrated to be an effective method for handling decision problems that are characterized by uncertainty, vagueness, and indeterminacy. In this research, we have explored the theoretical foundations of SVTNWA and its application in MADM, particularly in the context of multiple attribute decision-making scenarios.

The SVTNWA operator-based MADM has been shown to be applicable in a real-world context through the use of the practical example that has been offered in this scientific investigation. The example demonstrated how decision-makers can utilize SVTNWA to assess options, gain significant insights into complicated decision-making circumstances, and make educated choices. The SVTNWA can also be used to have more sophisticated decision-making scenarios in the real world that involve large-scale or dynamic data.

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