Selection of Agricultural Aircraft in Bipolar Neutrosophic Environment using Bipolar - TOPSIS method

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Abstract

The neutrosophic set has numerous uses in a variety of industries. There are more advantages to use the Bipolar Neutrosophic set than other sets for elucidating a multi-criteria decision-making problem. The bipolar-neutrosophic set addresses both the positive and negative facets of the issue, improving the probability of a successful resolution. By implementing the removal area method, the de-bipolarization of the bipolar neutrosophic number with eleven parameters is formulated. The proposed Neutrosophic number is used to solve the selection of agricultural aircraft using given criteria and the linguistic variables by the TOPSIS approach. A comparative study has been conducted to determine its robustness. Also, the multi-criteria decision-making problem (MCDM) is solved using the TOPSIS approach with MATLAB programming.

Keywords: Neutrosophic set; De-bipolarization; Removal area; TOPSIS Method; MATLAB

1. Introduction

The production of crops is crucial for a nation's development nowadays, making agricultural aircraft a great necessity. The aircraft is used to spray insecticide seeds, irrigate fields, provide fertilizer, etc. Countries like Brazil, China, the United States, New Zealand, and Australia effectively cultivate using agricultural aircraft. In order to overcome uncertainty, Zadeh [20] introduced the fuzzy concept in 1965, which deals with the membership function based on linguistic variables. This concept deals with the membership function and addresses the absurd and uncertain nature of choosing an agricultural aircraft based on performance. Fuzzy doesn't deal with non-membership and indeterminacy, which excludes using expert judgement to get over this restriction. Neutrosophic theory, which can deal with membership, non-membership, and indeterminate membership functions and has all the potential expert opinions, was introduced by Florentin Smarandache.Since it can handle indeterminacy and all the membership functions are independent of one another, Numerous domains, such as optimisation, neural networks, modelling, decision theory, and engineering challenges, have utilised the neutrosophic environment.

2. Review of literature

An integrated strategy utilising the neutrosophic analytical hierarchy process (N-AHP) was proposed by Mohamad Adel-Basset. The objective of neutrosophic technology is to measure supply chain hazards. The optimal answer (N-TOPSIS) is to be as close as possible to the order preference match. [1] The model put forth by Abdel-Basset, M. effectively addresses multi-criteria decision-making (MCDM) issues with numerous competing principles and options. The viability of the suggested methodology is verified using an exemplary case that takes ten dangers associated with self-driving cars into account. When compared to cutting-edge methods for handling and modelling vagueness and partial hazard evidence using neutrosophic sets, the proposed model is believed to

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be reliable and consistent. [2] Ali, A., and Warren, D., analysed the body of research on cloud computing from the perspective of business innovation. Also, they created an integrated model for risk management during the innovation of cloud-based commercial services by fusing this thorough literature study with pertinent theory. The model identifies four categories of resolutions (stakeholder involvement, skill growth, invention development, and innovation controller) and three kinds of hazards (hazards related to facilities, skill, and processes). The methodology aids managers in determining the general risk profile of their organization and connecting that profile to a particular arrangement of solutions. [3]Kocherlakota Satya Pritam proposed a new method for beginning investors to build portfolios applying multi-criteria decision-making methods in a uncertain situation. Two non-dimensional factors were introduced for classifying hazardous and non-risky assets based on the results of these methodologies. Three perception portfolios were created using the specified non-dimensional constraints and the slight lion grouping technique. An example application in equity portfolio selection is presented to illustrate the suggested methodology.[4] Dutta, A., described in this article, intend to analyses potential hazards that businesses may experience during the deployment of cloud calculating, as well as evaluate and prioritise these hazards. A collection of 295 extremely skilled IT experts tangled in creating and executing cloud-based solutions were given a questionnaire, and 39 (13.2%) of their responses were gathered and examined. 39 cloud computing dangers were discovered, and they were centered around various operational, organizational, technical, and legal issues. The existing legal and technological complexity, limitations, and lack of planning and preparedness connected with cloud computing were deemed to be the most significant top 10 hazards that IT specialists recognized.[5]

To address the consequent MAGDM problem, Abazar Keikha put forward a fresh approach based on aggregation operators. An example using numbers, including analysis of the outcomes.[7] To assess the effectiveness of instructors' instruction, Xueping Lu developed an better standing method according to the maximisation of deviations concept and TOPSIS for the SNIS technique. The maximising deviation approach is used to get attribute weights, Following that, the TOPSIS concept -based decision-making typical is used. Finally, a MADM model has been created for a TQE example, and it has been compared to other relevant representations to show the viability and logic of the anticipated prototypical with unfamiliar characteristic masses in the SNIE. [8] The students received advice from Saima Mustafa on how to select the finest university and assess the variables that influence admission. Additionally, merged bipolar fuzzy and soft expert sets were analyzed to provide a multicriteria method for decision-making that resolves problems that may come up when making decisions. Additionally, structural hierarchical parameter models were built, and soft expert sets were put into practice in order to introduce a novel algorithm that would greatly improve the decision-making process.[9] Reverse-order triangular fuzzy numbers were defined by Pathinathan, T. Using triangular fuzzy numbers, create a pentagonal fuzzy number. Also defined trapezoidal fuzzy numbers to reverse the order of the numbers. Additionally, it supported basic mathematical operations including addition, subtraction, and reverse-order trapezoidal and triangular fuzzy numbers. [10] Nathan Stalin offered a novel approach for determining the best way to use pesticides to promote healthy farming. Additionally, a ranking approach using triangular single-valued Neutrosophic numbers was offered as a better method for choosing agricultural aeroplanes. [11] With examples and rationale for rank preservation and relative measurement inversion, R. W. SAATY suggested concentrating on departure from reliability, measuring it, and using both complete and comparative measurements. [12] An innovative system to rate agricultural aeroplanes based on linguistic analyses of their characteristics was proposed by Gabriel Scherer Schwening. In order to achieve this, an algorithm based on the Method of Demand of Predilection by Comparation to the Perfect Resolution (TOPSIS) and the Logical Hierarchy Procedure (AHP) process is utilised. Using triangular fuzzy numbers, language is parameterized. The technique can also be applied to other selection issues and during the conceptual design phase to pick aircraft configurations. [13] To tackle fuzzy multicriteria problems with inconsistent and unreasonable measures, Serafim Opricovic created a novel fuzzy VIKOR approach. This approach resolves issues in situations where the principles and masses may both be uncertain sets. When there are conflicting criteria, VIKOR emphases on rating and choosing recommending compromise options (one or more) from a range of potential outcomes. An analysis of trade-offs is added to it. An application of the proposed procedure to learn the construction of a lake scheme for the stowage of superficial movements of the Mlava River and its branches for provincial water source is illustrated by a numerical example. [14] A conceptual framework for classifying and evaluating cyber risks was put out by Sheehan, B. Its goal was to quantify the risk and show how important preventative and corrective measures are in limiting a company's exposure to cyber risk. In order to deliver a evaluation according to the likelihood of a cyberthreat, this approach combines a hazard matrix and a bow-tie concept to assess the likelihood of an event happening and the possible sternness of the significances. To assess the pressures, blocks, and stairways for the context, the model can take into account both antique data, professional view, and earlier recognized outlines.[15] For demand response applications in the SG, Sianaki, O. A., proposed an intelligent home energy management system (HEMS). The suggested technique is then implemented in the industrial sector to aid operations managers in making decisions regarding whether to admit claim retort programmes with or without gaining electricity from dispersed energy possessions or reject the claim retort programmes .[16] To provide a thorough grasp of the safety necessities in

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the haze situation, Swathy Akshaya, M., offered a classification of haze safety outbreaks and a prospective hazard valuation. According to a review, not all areas of hazard valuation and safety outbreaks have been covered in earlier articles. The risk components that weren't covered in depth in previous studies are also listed, categorised, and quantified. [17] The important masses of the assessment standards were considered using the uncertain multi-criteria decision-making (MCDM) process by Wang, T. C., who then combined the assessments of the aspirant airplane. The evaluations' attitudes towards partiality were combined, and TOPSIS was used to get a clear complete demonstration value for individual option before a selection was made. [18] The original VIKOR technique was extended by G. Wang to 2TLNNs, and the 2TLNNs-based VIKOR method calculation steps are now anticipated. The anticipated approach takes conflicting criteria into account in a more logical and scientific way. In order to further emphasise the advantages of the new approach, comparisons have also been made, and a case study for selecting green suppliers has been offered. [19] E-VIKOR and TOPSIS methods were created by N. Zhang to address MCDM issues, including hesitant fuzzy set material. First, the essential components of the VIKOR technique are presented, together with the hesitant uncertain set evidence and associated notions. The ideas and methods of the suggested E-VIKOR method and TOPSIS approach are then offered, followed by a description of the problem of several characteristic decision making. The implementation of the EVIKOR approach is demonstrated numerically, and the outcome obtained using the TOPSIS method is contrasted.[21]

3. Preliminaries

Definition 3.1. Bipolar Fuzzy Set

Let M be a nonempty set. A BFS $\tilde{S}$ in M is an object of the form

$$\tilde{S} = \left(\eta_{\tilde{S}}^{P}, \eta_{\tilde{S}}^{N}\right) = \{(x, \eta_{\tilde{S}}^{P}(z), \eta_{\tilde{S}}^{N}(z))z \in M\}$$

where $\eta_{\tilde{S}}^{P}(z): M \to [0,1]$ and $\eta_{\tilde{S}}^{N}(z): M \to [-1,0]$ are mappings. The terms $\eta_{\tilde{S}}^{P}(z), \eta_{\tilde{S}}^{N}(z)$ indicate the degree of truth that a component has with a particular characteristic that belongs to the bipolar fuzzy set "S" and the degree of truth that the element has with a certain counter-property.

Definition 3.2. Single Valued Neutrosophic Set

A single-valued Neutrosophic set N in P is represented by a combination of truth membership function $T_N(p): P \to [0,1]$ an indeterminacy membership function $I_N(p): P \to [0,1]$ and falsity membership function $F_N(p): P \to [0,1]$. if S is a universal set with a generic component a in S.

The single-valued Neutrosophic set N is described below:

$$N = \{p, < T_N(p), I_N(p), F_N(p) > | p \in P\}$$

Where $T_N(p), I_N(p), F_N(p) \in [0,1]$ and $0 \le T_N(p), I_N(p), F_N(p) \le 3$.

Definition 3.3. Bipolar Neutrosophic Set

A bipolar Neutrosophic set B in a universal set S is defined by the positive membership degrees $T_B^+(s), I_B^+(s), F_B^+(s)$ where $T_B^+(s): S \to [0,1]$ is a truth membership function, $I_B^+(s): S \to [0,1]$ is a indeterminate membership function and $F_B^+(s): S \to [0,1]$ is a falsity membership function and the negative membership degree where $T_B^-(s): S \to [-1,0]$ is a truth membership function, $I_B^-(s): S \to [-1,0]$ is a indeterminacy membership function and $F_B^-(s): S \to [-1,0]$ is a falsity membership function. It is possible to express the Bipolar Neutrosophic set B as an entity of the form,

$$B = \{s, < T_B^+(s), I_B^+(s), F_B^+(s), T_B^-(s), I_B^-(s), F_B^-(s) > | s \in S\}$$

Where $T_B^+(s), I_B^+(s), F_B^+(s) \in [0,1]$ and $T_B^-(s), I_B^-(s), F_B^-(s) \in [-1,0]$.

Definition 3.4. Single Valued Bipolar Hendecagonal Neutrosophic Number (SVBHeNN)

Linear Bipolar Hendecagonal Neutrosophic Number is defined as

$$\text{SV}\widetilde{\text{BHe}}\text{NN} = < \begin{pmatrix} \eta_1, \eta_2, \eta_3, \eta_4, \eta_5, \eta_6, \eta_7, \eta_8, \eta_9, \eta_{10}, \eta_{11}; \\ \varphi_1, \varphi_2, \varphi_3, \varphi_4, \varphi_5, \varphi_6, \varphi_7, \varphi_8, \varphi_9, \varphi_{10}, \varphi_{11}; \\ \vartheta_1, \vartheta_2, \vartheta_3, \vartheta_4, \vartheta_5, \vartheta_6, \vartheta_7, \vartheta_8, \vartheta_9, \vartheta_{10}, \vartheta_{11} \end{pmatrix}$$

$$\begin{pmatrix} -\eta_1, -\eta_2, -\eta_3, -\eta_4, -\eta_5, -\eta_6, -\eta_7, -\eta_8, -\eta_9, -\eta_{10}, -\eta_{11}; \\ -\varphi_1, -\varphi_2, -\varphi_3, -\varphi_4, -\varphi_5, -\varphi_6, -\varphi_7, -\varphi_8, -\varphi_9, -\varphi_{10}, -\varphi_{11}; \\ -\vartheta_1, -\vartheta_2, -\vartheta_3, -\vartheta_4, -\vartheta_5, -\vartheta_6, -\vartheta_7, -\vartheta_8, -\vartheta_9, -\vartheta_{10}, -\vartheta_{11} \end{pmatrix} >$$

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Truth membership function
$T^{+}_{\widetilde{\text{SVBHeNN}}}(x): X \to [0,1]$
$T^{-}_{\widetilde{\text{SVBHeNN}}}(x): X \to [-1,0]$
$where$ X is a universal set.
$-1 \le \sup\{T^{+}_{\widetilde{\text{SVBHeNN}}}(x)\} + \sup\{T^{-}_{\widetilde{\text{SVBHeNN}}}(x)\} \le 1$

$$T^{+}_{\widetilde{\text{SVBHeNN}}}(x) = \begin{cases} \left(\frac{x-\eta_1}{\eta_2-\eta_1}\right) & if\ \eta_1 \le x \le \eta_2 \\ \left(\frac{x-\eta_2}{\eta_3-\eta_2}\right) & if\ \eta_2 \le x \le \eta_3 \\ \left(\frac{x-\eta_3}{\eta_4-\eta_3}\right) & if\ \eta_3 \le x \le \eta_4 \\ \left(\frac{x-\eta_4}{\eta_5-\eta_4}\right) & if\ \eta_4 \le x \le \eta_5 \\ \left(\frac{x-\eta_5}{\eta_6-\eta_5}\right) & if\ \eta_5 \le x \le \eta_6 \\ 1 & if\ x = \eta_6 \\ \left(\frac{\eta_7-x}{\eta_7-\eta_6}\right) & if\ \eta_6 \le x \le \eta_7 \\ \left(\frac{\eta_8-x}{\eta_8-\eta_7}\right) & if\ \eta_7 \le x \le \eta_8 \\ \left(\frac{\eta_9-x}{\eta_9-\eta_8}\right) & if\ \eta_8 \le x \le \eta_9 \\ \left(\frac{\eta_{10}-x}{\eta_{10}-\eta_9}\right) & if\ \eta_9 \le x \le \eta_{10} \\ \left(\frac{\eta_{11}-x}{\eta_{11}-\eta_{10}}\right) & if\ \eta_{10} \le x \le \eta_{11} \\ 0 & otherwise \end{cases}$$

$$T^{-}_{\widetilde{\text{SVBHeNN}}}(x) = \begin{cases} \left(\frac{\eta_2-x}{\eta_2-\eta_1}\right) & if\ \eta_1 \le x \le \eta_2 \\ \left(\frac{\eta_3-x}{\eta_3-\eta_2}\right) & if\ \eta_2 \le x \le \eta_3 \\ \left(\frac{\eta_4-x}{\eta_4-\eta_3}\right) & if\ \eta_3 \le x \le \eta_4 \\ \left(\frac{\eta_5-x}{\eta_5-\eta_4}\right) & if\ \eta_4 \le x \le \eta_5 \\ \left(\frac{\eta_6-x}{\eta_6-\eta_5}\right) & if\ \eta_5 \le x \le \eta_6 \\ -1 & if\ x = \eta_6 \\ \left(\frac{x-\eta_7}{\eta_7-\eta_6}\right) & if\ \eta_6 \le x \le \eta_7 \\ \left(\frac{x-\eta_8}{\eta_8-\eta_7}\right) & if\ \eta_7 \le x \le \eta_8 \\ \left(\frac{x-\eta_9}{\eta_9-\eta_8}\right) & if\ \eta_8 \le x \le \eta_9 \\ \left(\frac{x-\eta_{10}}{\eta_{10}-\eta_9}\right) & if\ \eta_9 \le x \le \eta_{10} \\ \left(\frac{x-\eta_{11}}{\eta_{11}-\eta_{10}}\right) & if\ \eta_{10} \le x \le \eta_{11} \\ 0 & otherwise \end{cases}$$

Indeterminacy membership function
$I^{+}_{\widetilde{\text{SVBHeNN}}}(x): X \to [0,1]$
$I^{-}_{\widetilde{\text{SVBHeNN}}}(x): X \to [-1,0]$
$where$ X is a universal set
$-1 \le \sup\{I^{+}_{\widetilde{\text{SVBHeNN}}}(x)\} + \sup\{I^{-}_{\widetilde{\text{SVBHeNN}}}(x)\} \le 1$

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$$I^{+}_{\mathrm{SVB\widetilde{He}NN}}(x) = \begin{cases} \left(\frac{\varphi_2 - x}{\varphi_2 - \varphi_1}\right) & if\ \varphi_1 \le x \le \varphi_2 \\ \left(\frac{\varphi_3 - x}{\varphi_3 - \varphi_2}\right) & if\ \varphi_2 \le x \le \varphi_3 \\ \left(\frac{\varphi_4 - x}{\varphi_4 - \varphi_3}\right) & if\ \varphi_3 \le x \le \varphi_4 \\ \left(\frac{\varphi_5 - x}{\varphi_5 - \varphi_4}\right) & if\ \varphi_4 \le x \le \varphi_5 \\ \left(\frac{\varphi_6 - x}{\varphi_6 - \varphi_5}\right) & if\ \varphi_5 \le x \le \varphi_6 \\ 0 & if\ x = \varphi_6 \\ \left(\frac{x - \varphi_7}{\varphi_7 - \varphi_6}\right) & if\ \varphi_6 \le x \le \varphi_7 \\ \left(\frac{x - \varphi_8}{\varphi_8 - \varphi_7}\right) & if\ \varphi_7 \le x \le \varphi_8 \\ \left(\frac{x - \varphi_9}{\varphi_9 - \varphi_8}\right) & if\ \varphi_8 \le x \le \varphi_9 \\ \left(\frac{x - \varphi_{10}}{\varphi_{10} - \varphi_9}\right) & if\ \varphi_9 \le x \le \varphi_{10} \\ \left(\frac{x - \varphi_{11}}{\varphi_{11} - \varphi_{10}}\right) & if\ \varphi_{10} \le x \le \varphi_{11} \\ 1 & otherwise \end{cases}$$

$$I^{-}_{\mathrm{SVB\widetilde{He}NN}}(x) = \begin{cases} \left(\frac{x - \varphi_1}{\varphi_2 - \varphi_1}\right) & if\ \varphi_1 \le x \le \varphi_2 \\ \left(\frac{x - \varphi_2}{\varphi_3 - \varphi_2}\right) & if\ \varphi_2 \le x \le \varphi_3 \\ \left(\frac{x - \varphi_3}{\varphi_4 - \varphi_3}\right) & if\ \varphi_3 \le x \le \varphi_4 \\ \left(\frac{x - \varphi_4}{\varphi_5 - \varphi_4}\right) & if\ \varphi_4 \le x \le \varphi_5 \\ \left(\frac{x - \varphi_5}{\varphi_6 - \varphi_5}\right) & if\ \varphi_5 \le x \le \varphi_6 \\ 0 & if\ x = \varphi_6 \\ \left(\frac{\varphi_7 - x}{\varphi_7 - \varphi_6}\right) & if\ \varphi_6 \le x \le \varphi_7 \\ \left(\frac{\varphi_8 - x}{\varphi_8 - \varphi_7}\right) & if\ \varphi_7 \le x \le \varphi_8 \\ \left(\frac{\varphi_9 - x}{\varphi_9 - \varphi_8}\right) & if\ \varphi_8 \le x \le \varphi_9 \\ \left(\frac{\varphi_{10} - x}{\varphi_{10} - \varphi_9}\right) & if\ \varphi_9 \le x \le \varphi_{10} \\ \left(\frac{\varphi_{11} - x}{\varphi_{11} - \varphi_{10}}\right) & if\ \varphi_{10} \le x \le \varphi_{11} \\ -1 & otherwise \end{cases}$$

Falsity membership function

$F^{+}_{\mathrm{SVB\widetilde{He}NN}}(x): X \rightarrow [0,1]$

$F^{-}_{\mathrm{SVB\widetilde{He}NN}}(x): X \rightarrow [-1,0]$

where X is a universe of discourse

$-1 \le \sup\{F^{+}_{\mathrm{SVB\widetilde{He}NN}}(x)\} + \sup\{F^{-}_{\mathrm{SVB\widetilde{He}NN}}(x)\} \le 1$

$$F^{+}_{\mathrm{SVB\widetilde{He}NN}}(x) = \begin{cases} \left(\frac{\vartheta_2 - x}{\vartheta_2 - \vartheta_1}\right) & if\ \vartheta_1 \le x \le \vartheta_2 \\ \left(\frac{\vartheta_3 - x}{\vartheta_3 - \vartheta_2}\right) & if\ \vartheta_2 \le x \le \vartheta_3 \\ \left(\frac{\vartheta_4 - x}{\vartheta_4 - \vartheta_3}\right) & if\ \vartheta_3 \le x \le \vartheta_4 \\ \left(\frac{\vartheta_5 - x}{\vartheta_5 - \vartheta_4}\right) & if\ \vartheta_4 \le x \le \vartheta_5 \\ \left(\frac{\vartheta_6 - x}{\vartheta_6 - \vartheta_5}\right) & if\ \vartheta_5 \le x \le \vartheta_6 \\ 0 & if\ x = \vartheta_6 \\ \left(\frac{x - \vartheta_7}{\vartheta_7 - \vartheta_6}\right) & if\ \vartheta_6 \le x \le \vartheta_7 \\ \left(\frac{x - \vartheta_8}{\vartheta_8 - \vartheta_7}\right) & if\ \vartheta_7 \le x \le \vartheta_8 \\ \left(\frac{x - \vartheta_9}{\vartheta_9 - \vartheta_8}\right) & if\ \vartheta_8 \le x \le \vartheta_9 \\ \left(\frac{x - \vartheta_{10}}{\vartheta_{10} - \vartheta_9}\right) & if\ \vartheta_9 \le x \le \vartheta_{10} \\ \left(\frac{x - \vartheta_{11}}{\vartheta_{11} - \vartheta_{10}}\right) & if\ \vartheta_{10} \le x \le \vartheta_{11} \\ 1 & otherwise \end{cases}$$

$$F^{-}_{\mathrm{SVB\widetilde{He}NN}}(x) = \begin{cases} \left(\frac{x - \vartheta_1}{\vartheta_2 - \vartheta_1}\right) & if\ \vartheta_1 \le x \le \vartheta_2 \\ \left(\frac{x - \vartheta_2}{\vartheta_3 - \vartheta_2}\right) & if\ \vartheta_2 \le x \le \vartheta_3 \\ \left(\frac{x - \vartheta_3}{\vartheta_4 - \vartheta_3}\right) & if\ \vartheta_3 \le x \le \vartheta_4 \\ \left(\frac{x - \vartheta_4}{\vartheta_5 - \vartheta_4}\right) & if\ \vartheta_4 \le x \le \vartheta_5 \\ \left(\frac{x - \vartheta_5}{\vartheta_6 - \vartheta_5}\right) & if\ \vartheta_5 \le x \le \vartheta_6 \\ 0 & if\ x = \vartheta_6 \\ \left(\frac{\vartheta_7 - x}{\vartheta_7 - \vartheta_6}\right) & if\ \vartheta_6 \le x \le \vartheta_7 \\ \left(\frac{\vartheta_8 - x}{\vartheta_8 - \vartheta_7}\right) & if\ \vartheta_7 \le x \le \vartheta_8 \\ \left(\frac{\vartheta_9 - x}{\vartheta_9 - \vartheta_8}\right) & if\ \vartheta_8 \le x \le \vartheta_9 \\ \left(\frac{\vartheta_{10} - x}{\vartheta_{10} - \vartheta_9}\right) & if\ \vartheta_9 \le x \le \vartheta_{10} \\ \left(\frac{\vartheta_{11} - x}{\vartheta_{11} - \vartheta_{10}}\right) & if\ \vartheta_{10} \le x \le \vartheta_{11} \\ -1 & otherwise \end{cases}$$

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$$where\ ^{-}3 \leq T_{\mathrm{SVB\widetilde{He}NN}}(x) + I_{\mathrm{SVB\widetilde{He}NN}}(x) + F_{\mathrm{SVB\widetilde{He}NN}}(x) \leq 3^{+}$$

Graphical Representation of SVBHeNN

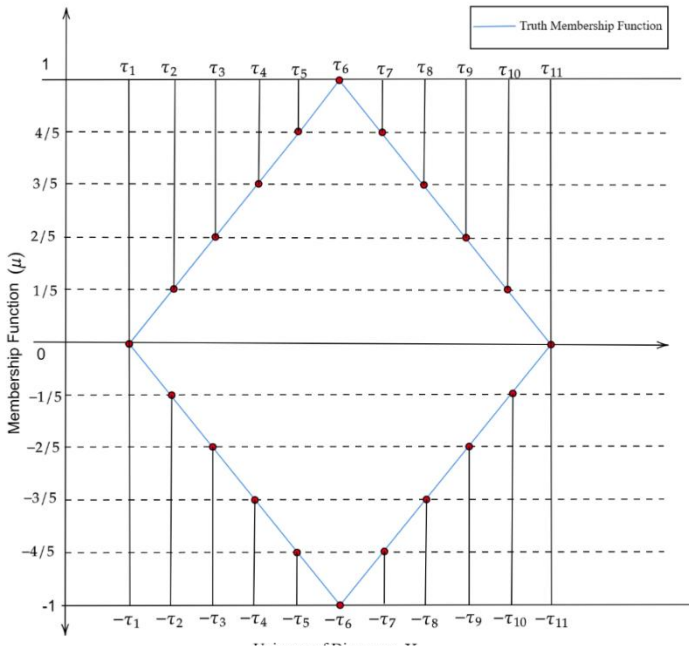

Figure 1: Truth membership function

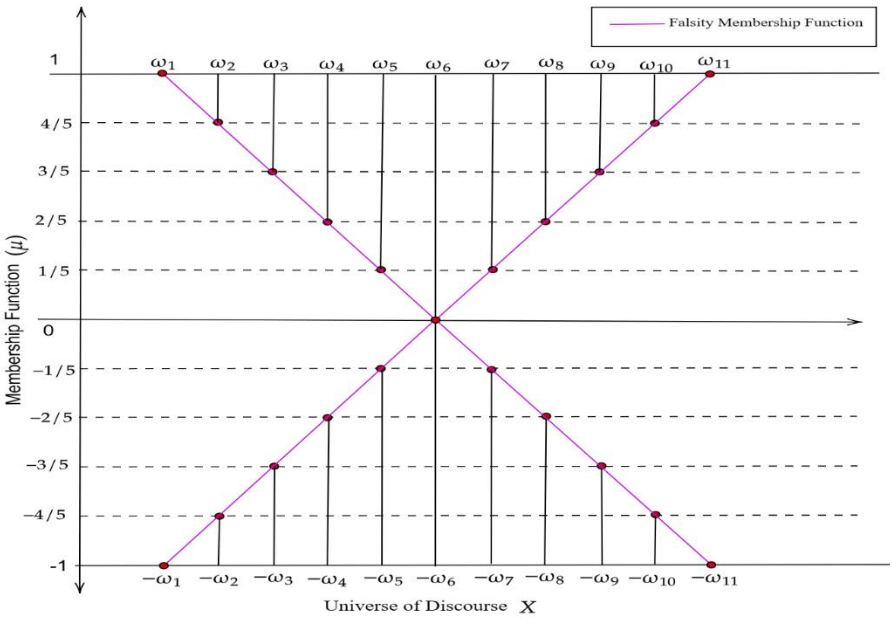

Figure 2: Falsity membership function

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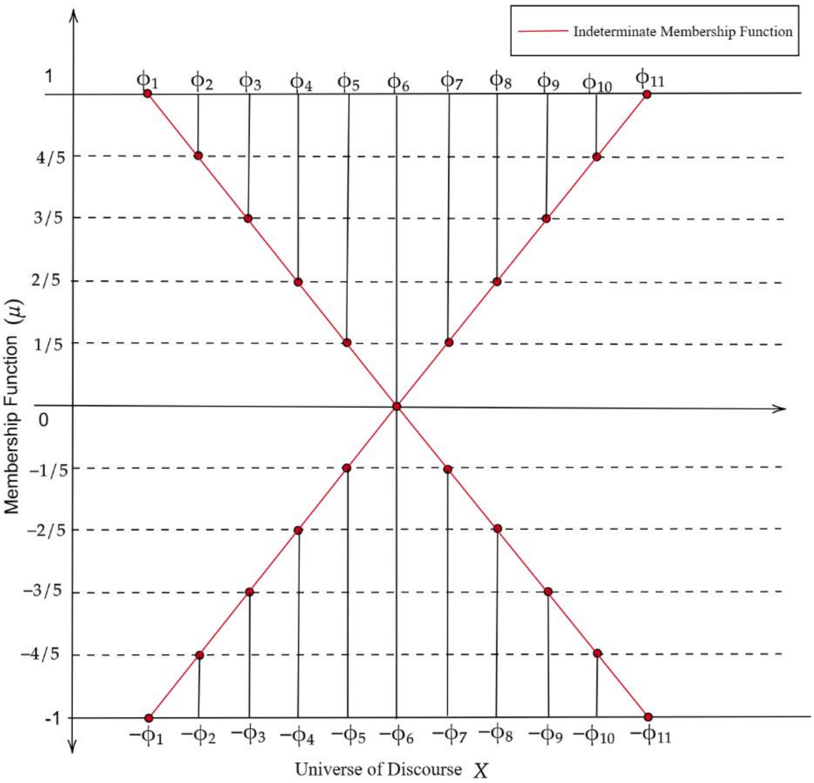

Figure 3: Indeterminate membership function

4. De-bipolarization of the proposed number

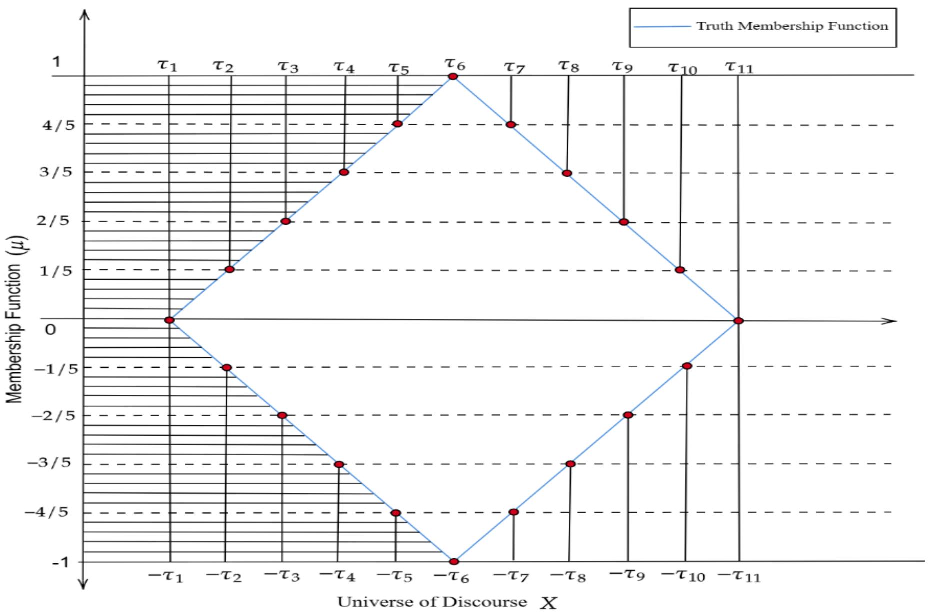

Figure 4: Area Removal of Truth membership function (Left)

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The De-Bipolarization of Hendecagonal Neutrosophic number for truth membership function

$$= \frac{\eta_2-\eta_1}{2}\left(\frac{1}{5}\right)+\frac{\eta_3-\eta_2}{2}\left(\frac{2}{5}\right)+\frac{\eta_4-\eta_3}{2}\left(\frac{3}{5}\right)+\frac{\eta_5-\eta_4}{2}\left(\frac{4}{5}\right)+\frac{\eta_6-\eta_5}{2}(1)$$

$$= \frac{(\eta_2-\eta_1+2\eta_3-2\eta_2+3\eta_4-3\eta_3+4\eta_5-4\eta_4)}{10}+\frac{(\eta_6-\eta_5)}{2}$$

$$= \frac{(-\eta_1-\eta_2-\eta_3-\eta_4+4\eta_5)}{10}+\frac{(\eta_6-\eta_5)}{2}$$

$$= -\frac{(\eta_1+\eta_2+\eta_3+\eta_4+\eta_5-5\eta_6)}{10} \quad (1)$$

$$= \frac{\eta_7-\eta_6}{2}(1)+\frac{\eta_8-\eta_7}{2}\left(\frac{4}{5}\right)+\frac{\eta_9-\eta_8}{2}\left(\frac{3}{5}\right)+\frac{\eta_{10}-\eta_9}{2}\left(\frac{2}{5}\right)+\frac{\eta_{11}-\eta_{10}}{2}\left(\frac{1}{5}\right)$$

$$= \frac{(4\eta_8-4\eta_7+3\eta_9-3\eta_8+2\eta_{10}-2\eta_9)}{10}+\frac{(\eta_7-\eta_6)}{2}$$

$$= \frac{(5\eta_7-5\eta_6+\eta_8-4\eta_7+\eta_9+\eta_{10}+\eta_{11})}{10}$$

$$= \frac{(-5\eta_6+\eta_7+\eta_8+\eta_9+\eta_{10}+\eta_{11})}{10} \quad (2)$$

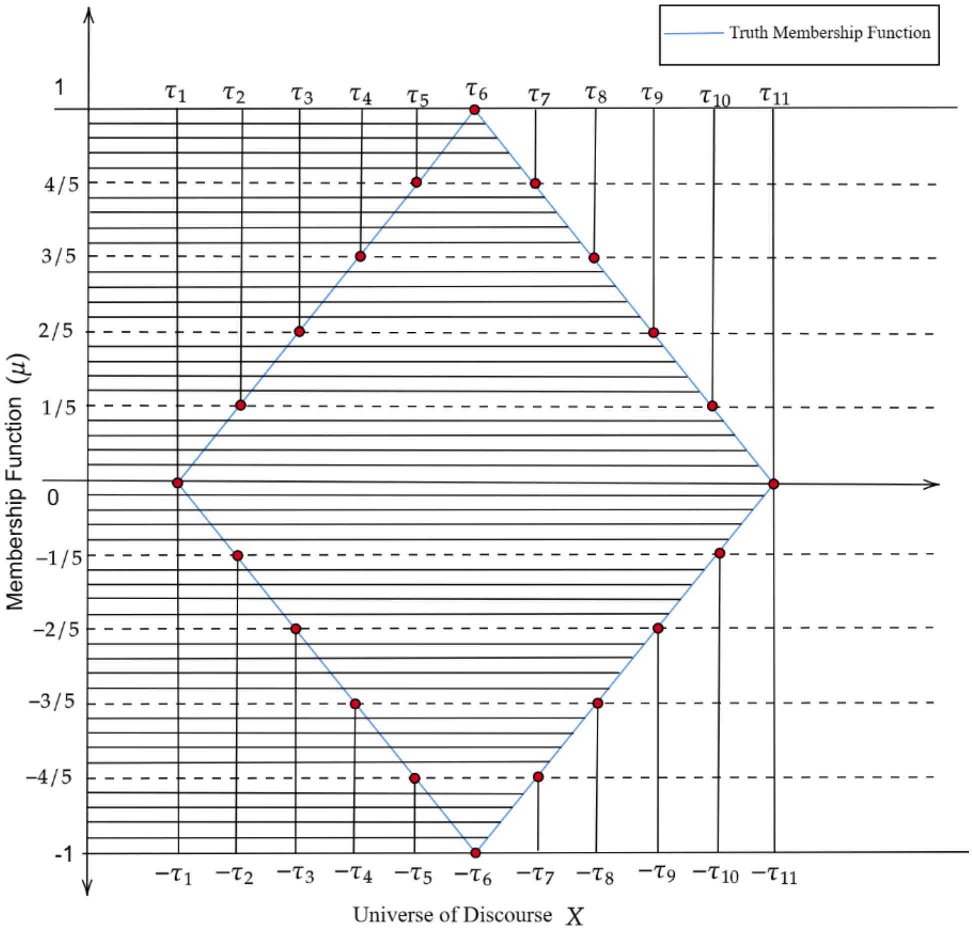

Figure 5: Area Removal of Truth membership function (Right)

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Adding the two equations (1) and (2) we obtain the result of the de-bipolarization of truth membership function

$$= -\frac{(\eta_1 + \eta_2 + \eta_3 + \eta_4 + \eta_5 - 5\eta_6)}{10} + \frac{(-5\eta_6 + \eta_7 + \eta_8 + \eta_9 + \eta_{10} + \eta_{11})}{10}$$

$$= \frac{-\boldsymbol{\tau_1} - \boldsymbol{\tau_2} - \boldsymbol{\tau_3} - \boldsymbol{\tau_4} - \boldsymbol{\tau_5} + \boldsymbol{\tau_7} + \boldsymbol{\tau_8} + \boldsymbol{\tau_9} + \boldsymbol{\tau_{10}} + \boldsymbol{\tau_{11}}}{\mathbf{10}}$$

(2)

$$= \frac{\eta_2-\eta_1}{2}\left(-\frac{1}{5}\right) + \frac{\eta_3-\eta_2}{2}\left(-\frac{2}{5}\right) + \frac{\eta_4-\eta_3}{2}\left(-\frac{3}{5}\right) + \frac{\eta_5-\eta_4}{2}\left(-\frac{4}{5}\right) + \frac{\eta_6-\eta_5}{2}(-1)$$

$$= \frac{(-\eta_2 + \eta_1 - 2\eta_3 + 2\eta_2 - 3\eta_4 + 3\eta_3 - 4\eta_5 + 4\eta_4)}{10} + \frac{(-\eta_6 + \eta_5)}{2}$$

$$= \frac{(\eta_1 + \eta_2 + \eta_3 + \eta_4 - 4\eta_5)}{10} + \frac{(-\eta_6 + \eta_5)}{2}$$

$$= \frac{(\eta_1 + \eta_2 + \eta_3 + \eta_4 + \eta_5 - 5\eta_6)}{10}$$

(3)

$$= \frac{\eta_7 - \eta_6}{2}(-1) + \frac{\eta_8 - \eta_7}{2}\left(-\frac{4}{5}\right) + \frac{\eta_9 - \eta_8}{2}\left(-\frac{3}{5}\right) + \frac{\eta_{10} - \eta_9}{2}\left(-\frac{2}{5}\right) + \frac{\eta_{11} - \eta_{10}}{2}\left(-\frac{1}{5}\right)$$

$$= \frac{(-4\eta_8 + 4\eta_7 - 3\eta_9 + 3\eta_8 - 2\eta_{10} + 2\eta_9)}{10} + \frac{(-\eta_7 + \eta_6)}{2}$$

$$= \frac{(-5\eta_7 + 5\eta_6 - \eta_8 + 4\eta_7 - \eta_9 - \eta_{10} - \eta_{11})}{10}$$

$$= \frac{(5\eta_6 - \eta_7 - \eta_8 - \eta_9 - \eta_{10} - \eta_{11})}{10}$$

(4)

$$= \frac{(\eta_1 + \eta_2 + \eta_3 + \eta_4 + \eta_5 - 5\eta_6)}{10} + \frac{(5\eta_6 - \eta_7 - \eta_8 - \eta_9 - \eta_{10} - \eta_{11})}{10}$$

$$= \frac{\boldsymbol{\tau_1} + \boldsymbol{\tau_2} + \boldsymbol{\tau_3} + \boldsymbol{\tau_4} + \boldsymbol{\tau_5} - \boldsymbol{\tau_7} - \boldsymbol{\tau_8} - \boldsymbol{\tau_9} - \boldsymbol{\tau_{10}} - \boldsymbol{\tau_{11}}}{\mathbf{10}}$$

(5)

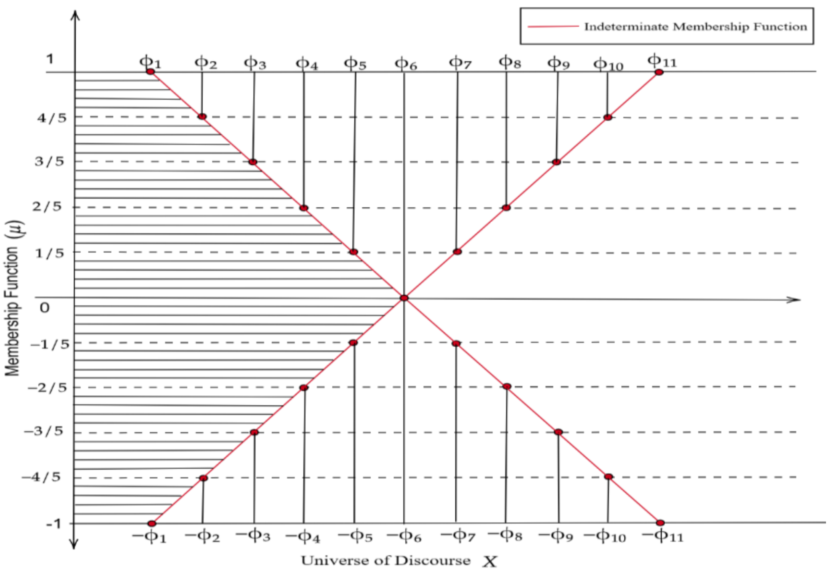

Figure 6: Area Removal of Indeterminate membership function (Left)

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Indeterminate membership function

$$= \left(\frac{\varphi_2-\varphi_1}{2}\right)(1)+\left(\frac{\varphi_3-\varphi_2}{2}\right)\left(\frac{4}{5}\right)+\left(\frac{\varphi_4-\varphi_3}{2}\right)\left(\frac{3}{5}\right)+\left(\frac{\varphi_5-\varphi_4}{2}\right)\left(\frac{2}{5}\right)+\left(\frac{\varphi_6-\varphi_5}{2}\right)\left(\frac{1}{5}\right)$$

$$= \left(\frac{\varphi_2-\varphi_1}{2}\right)+\frac{-4\varphi_2+4\varphi_3-3\varphi_3+3\varphi_4-2\varphi_4+2\varphi_5-\varphi_5+\varphi_6}{10}$$

$$= \left(\frac{\varphi_2-\varphi_1}{2}\right)+\frac{-4\varphi_2+\varphi_3+\varphi_4+\varphi_5+\varphi_6}{10}$$

$$= \frac{5\varphi_2-5\varphi_1-4\varphi_2+\varphi_3+\varphi_4+\varphi_5+\varphi_6}{10}$$

$$= \frac{-5\varphi_1+\varphi_2+\varphi_3+\varphi_4+\varphi_5+\varphi_6}{10} \tag{6}$$

$$= \left(\frac{\varphi_7-\varphi_6}{2}\right)\left(\frac{1}{5}\right)+\left(\frac{\varphi_8-\varphi_7}{2}\right)\left(\frac{2}{5}\right)+\left(\frac{\varphi_9-\varphi_8}{2}\right)\left(\frac{3}{5}\right)+\left(\frac{\varphi_{10}-\varphi_9}{2}\right)\left(\frac{4}{5}\right)+\left(\frac{\varphi_{11}-\varphi_{10}}{2}\right)(1)$$

$$= \frac{-\varphi_6+\varphi_7-2\varphi_7+2\varphi_8-3\varphi_8+3\varphi_9-4\varphi_9+4\varphi_{10}}{10}+\left(\frac{-\varphi_{10}+\varphi_{11}}{2}\right)$$

$$= \frac{-\varphi_6-\varphi_7-\varphi_8-\varphi_9+4\varphi_{10}-5\varphi_{10}+5\varphi_{11}}{10}$$

$$= \frac{-(\varphi_6+\varphi_7+\varphi_8+\varphi_9+\varphi_{10}-5\varphi_{11})}{10} \tag{7}$$

Adding both the equations we get

$$= \frac{-5\varphi_1+\varphi_2+\varphi_3+\varphi_4+\varphi_5+\varphi_6}{10}+\frac{-(\varphi_6+\varphi_7+\varphi_8+\varphi_9+\varphi_{10}-5\varphi_{11})}{10}$$

$$= \boldsymbol{\frac{-5\varphi_1+\varphi_2+\varphi_3+\varphi_4+\varphi_5-\varphi_7-\varphi_8-\varphi_9-\varphi_{10}-5\varphi_{11}}{10}} \tag{8}$$

$$= \left(\frac{\varphi_2-\varphi_1}{2}\right)(-1)+\left(\frac{\varphi_3-\varphi_2}{2}\right)\left(-\frac{4}{5}\right)+\left(\frac{\varphi_4-\varphi_3}{2}\right)\left(-\frac{3}{5}\right)+\left(\frac{\varphi_5-\varphi_4}{2}\right)\left(-\frac{2}{5}\right)+\left(\frac{\varphi_6-\varphi_5}{2}\right)\left(-\frac{1}{5}\right)$$

$$= \left(\frac{\varphi_1-\varphi_2}{2}\right)+\frac{4\varphi_2-4\varphi_3+3\varphi_3-3\varphi_4+2\varphi_4-2\varphi_5+\varphi_5-\varphi_6}{10}$$

$$= \left(\frac{\varphi_1-\varphi_2}{2}\right)+\frac{4\varphi_2-\varphi_3-\varphi_4-\varphi_5-\varphi_6}{10}$$

$$= \frac{5\varphi_1-5\varphi_2+4\varphi_2-\varphi_3-\varphi_4-\varphi_5-\varphi_6}{10}$$

$$= \frac{5\varphi_1-\varphi_2-\varphi_3-\varphi_4-\varphi_5-\varphi_6}{10} \tag{9}$$

$$= \left(\frac{\varphi_7-\varphi_6}{2}\right)\left(-\frac{1}{5}\right)+\left(\frac{\varphi_8-\varphi_7}{2}\right)\left(-\frac{2}{5}\right)+\left(\frac{\varphi_9-\varphi_8}{2}\right)\left(-\frac{3}{5}\right)+\left(\frac{\varphi_{10}-\varphi_9}{2}\right)\left(-\frac{4}{5}\right)+\left(\frac{\varphi_{11}-\varphi_{10}}{2}\right)(-1)$$

$$= \frac{\varphi_6-\varphi_7+2\varphi_7-2\varphi_8+3\varphi_8-3\varphi_9+4\varphi_9-4\varphi_{10}}{10}+\left(\frac{\varphi_{10}-\varphi_{11}}{2}\right)$$

$$= \frac{\varphi_6+\varphi_7+\varphi_8+\varphi_9+\varphi_{10}-5\varphi_{11}}{10}$$

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(10)

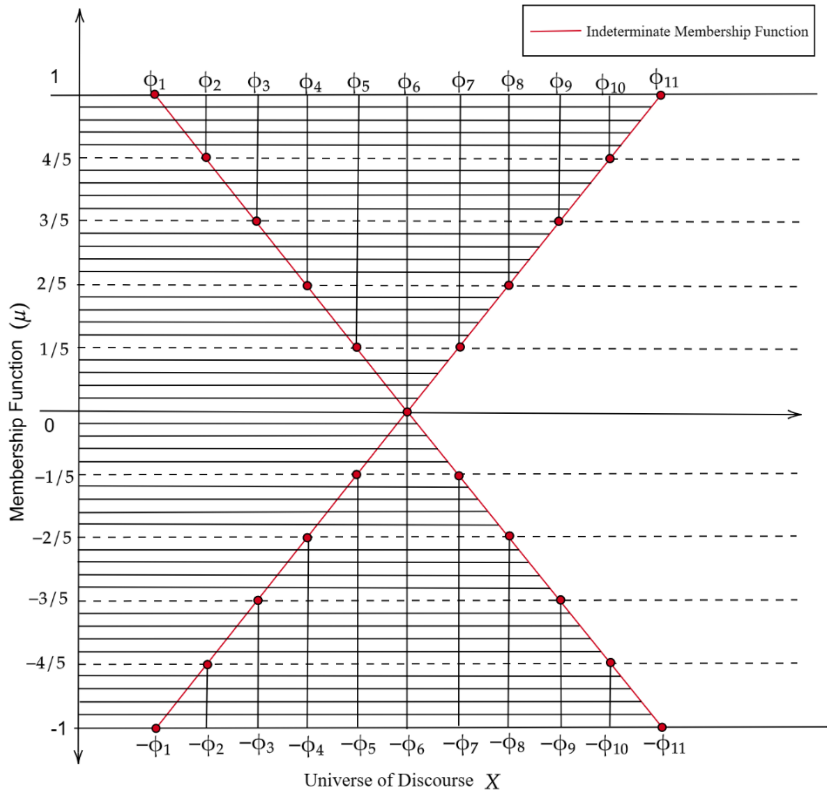

Figure 7: Area Removal of Indeterminate membership function (Right)

Adding both the equations we get

$$= \frac{5\varphi_1 - \varphi_2 - \varphi_3 - \varphi_4 - \varphi_5 - \varphi_6}{10} + \frac{\varphi_6 + \varphi_7 + \varphi_8 + \varphi_9 + \varphi_{10} - 5\varphi_{11}}{10}$$

$$= \boldsymbol{\frac{5\varphi_1 - \varphi_2 - \varphi_3 - \varphi_4 - \varphi_5 + \varphi_7 + \varphi_8 + \varphi_9 + \varphi_{10} - 5\varphi_{11}}{10}}$$

(11)

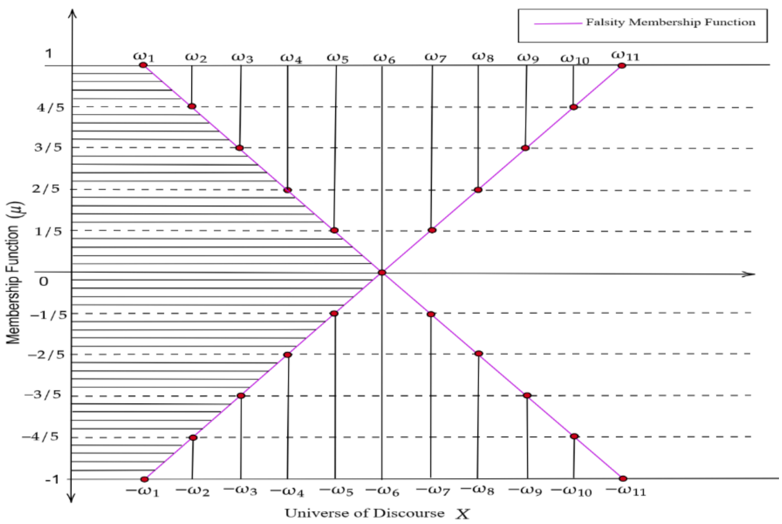

Figure 8: Area Removal of Falsity membership function (Left)

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Falsity membership function

$$= \left(\frac{\omega_2 - \omega_1}{2}\right)(1) + \left(\frac{\omega_3 - \omega_2}{2}\right)\left(\frac{4}{5}\right) + \left(\frac{\omega_4 - \omega_3}{2}\right)\left(\frac{3}{5}\right) + \left(\frac{\omega_5 - \omega_4}{2}\right)\left(\frac{2}{5}\right) + \left(\frac{\omega_6 - \omega_5}{2}\right)\left(\frac{1}{5}\right)$$

$$= \left(\frac{\omega_2 - \omega_1}{2}\right) + \frac{-4\omega_2 + 4\omega_3 - 3\omega_3 + 3\omega_4 - 2\omega_4 + 2\omega_5 - \omega_5 + \omega_6}{10}$$

$$= \left(\frac{\omega_2 - \omega_1}{2}\right) + \frac{-4\omega_2 + \omega_3 + \omega_4 + \omega_5 + \omega_6}{10}$$

$$= \frac{5\omega_2 - 5\omega_1 - 4\omega_2 + \omega_3 + \omega_4 + \omega_5 + \omega_6}{10}$$

$$= \frac{-5\vartheta_1 + \vartheta_2 + \vartheta_3 + \vartheta_4 + \vartheta_5 + \vartheta_6}{10} \tag{12}$$

$$= \left(\frac{\omega_7 - \omega_6}{2}\right)\left(\frac{1}{5}\right) + \left(\frac{\omega_8 - \omega_7}{2}\right)\left(\frac{2}{5}\right) + \left(\frac{\omega_9 - \omega_8}{2}\right)\left(\frac{3}{5}\right) + \left(\frac{\omega_{10} - \omega_9}{2}\right)\left(\frac{4}{5}\right) + \left(\frac{\omega_{11} - \omega_{10}}{2}\right)(1)$$

$$= \frac{-\omega_6 + \omega_7 - 2\omega_7 + 2\omega_8 - 3\omega_8 + 3\omega_9 - 4\omega_9 + 4\omega_{10}}{10} + \left(\frac{-\omega_{10} + \omega_{11}}{2}\right)$$

$$= \frac{-\omega_6 - \omega_7 - \omega_8 - \omega_9 + 4\omega_{10} - 5\omega_{10} + 5\omega_{11}}{10}$$

$$= \frac{-(\vartheta_6 + \vartheta_7 + \vartheta_8 + \vartheta_9 + \vartheta_{10} - 5\vartheta_{11})}{10} \tag{13}$$

Adding both the equations we get

$$= \frac{-5\omega_1 + \omega_2 + \omega_3 + \omega_4 + \omega_5 + \omega_6}{10} + \frac{-(\omega_6 + \omega_7 + \omega_8 + \omega_9 + \omega_{10} - 5\omega_{11})}{10}$$

$$= \boldsymbol{\frac{-5\omega_1 + \omega_2 + \omega_3 + \omega_4 + \omega_5 - \omega_7 - \omega_8 - \omega_9 - \omega_{10} - 5\omega_{11}}{10}} \tag{14}$$

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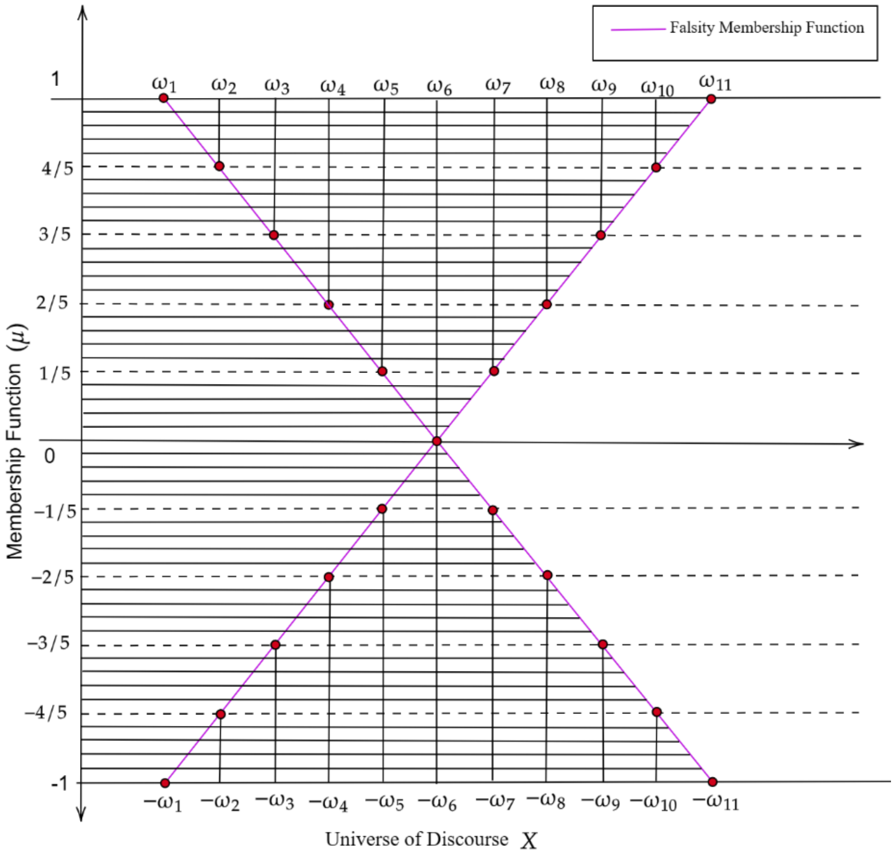

Figure 9: Area Removal of Falsity membership function (Right)

$$= \left(\frac{\omega_2 - \omega_1}{2}\right)(-1) + \left(\frac{\omega_3 - \omega_2}{2}\right)\left(-\frac{4}{5}\right) + \left(\frac{\omega_4 - \omega_3}{2}\right)\left(-\frac{3}{5}\right) + \left(\frac{\omega_5 - \omega_4}{2}\right)\left(-\frac{2}{5}\right) + \left(\frac{\omega_6 - \omega_5}{2}\right)\left(-\frac{1}{5}\right)$$

$$= \left(\frac{\omega_1 - \omega_2}{2}\right) + \frac{4\omega_2 - 4\omega_3 + 3\omega_3 - 3\omega_4 + 2\omega_4 - 2\omega_5 + \omega_5 - \omega_6}{10}$$

$$= \left(\frac{\omega_1 - \omega_2}{2}\right) + \frac{4\omega_2 - \omega_3 - \omega_4 - \omega_5 - \omega_6}{10}$$

$$= \frac{5\omega_1 - 5\omega_2 + 4\omega_2 - \omega_3 - \omega_4 - \omega_5 - \omega_6}{10}$$

$$= \frac{5\vartheta_1 - \vartheta_2 - \vartheta_3 - \vartheta_4 - \vartheta_5 - \vartheta_6}{10} \tag{15}$$

$$= \left(\frac{\omega_7 - \omega_6}{2}\right)\left(-\frac{1}{5}\right) + \left(\frac{\omega_8 - \omega_7}{2}\right)\left(-\frac{2}{5}\right) + \left(\frac{\omega_9 - \omega_8}{2}\right)\left(-\frac{3}{5}\right) + \left(\frac{\omega_{10} - \omega_9}{2}\right)\left(-\frac{4}{5}\right) + \left(\frac{\omega_{11} - \omega_{10}}{2}\right)(-1)$$

$$= \frac{\omega_6 - \omega_7 + 2\omega_7 - 2\omega_8 + 3\omega_8 - 3\omega_9 + 4\omega_9 - 4\omega_{10}}{10} + \left(\frac{\omega_{10} - \omega_{11}}{2}\right)$$

$$= \frac{\omega_6 + \omega_7 + \omega_8 + \omega_9 + \omega_{10} - 5\omega_{11}}{10}$$

Adding both the equations we get

$$= \frac{5\omega_1 - \omega_2 - \omega_3 - \omega_4 - \omega_5 - \omega_6}{10} + \frac{\omega_6 + \omega_7 + \omega_8 + \omega_9 + \omega_{10} - 5\omega_{11}}{10}$$

$$= \boldsymbol{\frac{5\omega_1 - \omega_2 - \omega_3 - \omega_4 - \omega_5 + \omega_7 + \omega_8 + \omega_9 + \omega_{10} - 5\omega_{11}}{10}}$$

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(16)

5. Selection of Agricultural Aircraft in Bipolar Neutrosophic Environment using TOPSIS method

Linguistic variables are represented in terms of the single valued linear Bipolar hendecagonal Neutrosophic number

Table [1]

Linguistic Variables	**SVLBHenNN**
Very Low (VL)	{0.0,0.01,0.02,0.03,0.04,0.05,0.06,0.07,0.08,0.09,0.10; 0.20,0.21,0.22,0.23,0.24,0.25,0.26,0.27,0.28,0.29,0.30; 0.52,0.53,0.54,0.55,0.56,0.57,0.58,0.59,0.60,0.61,0.62}
	{−0.55, −0.56, −0.57, −0.58, −0.59, −0.60, −0.61, −0.62, −0.63, −0.64, −0.65; −0.34, −0.35, −0.36, −0.37, −0.38, −0.39, −0.40, −0.41, −0.42, −0.43, −0.44; −0.15, −0.16, −0.17, −0.18, −0.19, −0.20, −0.21, −0.22, −0.23, −0.24, −0.25}
Low (L)	{0.35,0.36,0.37,0.38,0.39,0.40,0.41,0.42,0.43,0.44,0.45; 0.41,0.42,0.43,0.44,0.45,0.46,0.47,0.48,0.49,0.50,0.51; 0.50,0.51,0.52,0.53,0.54,0.55,0.56,0.57,0.58,0.59,0.60}
	{−0.60, −0.61, −0.62, −0.63, −0.64, −0.65, −0.66 − 0.67 − 0.68 − 0.69, −0.70; −0.50, −0.51, −0.52, −0.53, −0.54, −0.55,0.56, −0.57, −0.58, −0.59, −0.60; −0.45, −0.46, −0.47, −0.48, −0.49, −0.50, −0.51, −0.52, −0.53, −0.54, −0.55,}
Moderate (M)	{0.50,0.51,0.52,0.53,0.54,0.55,0.56,0.57,0.58,0.59,0.60, ; 0.55,0.56,0.57,0.58,0.59,0.60,0.61,0.62,0.63,0.64,0.65; 0.58,0.59,0.60,0.61,0.62,0.63,0.64,0.65,0.66,0.67,0.68}
	{−0.50, −0.51, −0.52, −0.53, −0.54, −0.55, −0.56, −0.57, −0.58, −0.59, −0.60, ; −0.55, −0.56, −0.57, −0.58, −0.59, −0.60, −0.61, −0.62, −0.63, −0.64, −0.65; −0.58, −0.59, −0.60, −0.61, −0.62, −0.63, −0.64, −0.65, −0.66, −0.67, −0.68}
High (H)	{0.60,0.61,0.62,0.63,0.64,0.65,0.66,0.67,0.68,0.69,0.70; 0.55,0.56,0.57,0.58,0.59,0.60,0.61,0.62,0.63,0.64,0.65; 0.43,0.44,0.45,0.46,0.47,0.48,0.49,0.50,0.51,0.52,0.53}
	{−0.75, −0.76, −0.77, −0.78, −0.79, −0.80, −0.81, −0.82, −0.83, −0.84, −0.85; −0.64, −0.65, −0.66, −0.67, −0.68, −0.69, −0.70, −0.71, −0.72, −0.73, −0.74; −0.45, −0.46, −0.47, −0.48, −0.49, −0.50, −0.51, −0.52, −0.53, −0.54, −0.55}
Very High (VH)	{0.85,0.86,0.87,0.88,0.89,0.90,0.91,0.92,0.93,0.94,0.95; 0.63,0.64,0.65,0.66,0.67,0.68,0.69,0.70,0.71,0.72,0.73; 0.50,0.51,0.52,0.53,0.54,0.55,0.56,0.57,0.58,0.59,0.60}
	{−0.80, −0.81, −0.82, −0.83, −0.84, −0.85, −0.86, −0.87, −0.88, −0.89, −0.90; −0.62, −0.63, −0.64, −0.65, −0.66, −0.67, −0.68, −0.69, −0.70, −0.71, −0.72; −0.54, −0.55, −0.56, −0.57, −0.58, −0.59, −0.60, −0.61, −0.62, −0.63, −0.64}
Excellent (E)	{0.90,0.91,0.92,0.93,0.94,0.95,0.96,0.97,0.98,0.99,1.0; 0.73,0.74,0.75,0.76,0.77,0.78,0.79,0.80,0.81,0.82,0.83; 0.55,0.56,0.57,0.58,0.59,0.60,0.61,0.62,0.63,0.64,0.65}
	{−0.85, −0.86, −0.87, −0.88, −0.89, −0.90, −0.91, −0.92, −0.93, −0.94, −0.95; −0.70, −0.71, −0.72, −0.73, −0.74, −0.75, −0.76, −0.77, −0.78, −0.79, −0.80; −0.65, −0.66, −0.67, −0.68, −0.69, −0.70, −0.71, −0.72, −0.73, −0.74, −0.75}

Table 2: De-bipolarization, the values of linguistic variables are provided as follows:

Linguistic variable	**Crisp Value of SVLBHenNN**
Very Low	0.7280
Low	0.7730
Moderate	0.7700
High	0.8326
Very High	0.8753
Excellent	0.88066

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6. Procedure for the TOPSIS method for Bipolar Environment

Step 1: Normalization of the Decision Matrix

Normalized decision matrix is considered as below

$C_{ij}^{N} = \frac{(C_{ij}-C_{ij}^{-})}{(C_{j}^{+}-C_{j}^{-})}$ where $C_j^+ = max_i(C_{ij})$ and $C_j^- = min_i(C_{ij})$

Step 2: compute the weighted normalized decision matrix

$V_{ij} = w_j \times C_{ij}^N$ for $i = 1,2,3, \dots m$ and $j = 1,2,3, \dots n$

Where w_j is criteria's weight, $w_j \geq 0$ for $j = 1,2,3, \dots n$, $\sum_{j=1}^{n} w_j = 1$

Step 3: Determine the positive and negative ideal solutions

PIS=$P^+ = \{\mu_1^+, \mu_2^+, \dots \mu_n^+\}$

$$= \{(max_j \mu_{ij} | j \in J_1), (min_j \mu_{ij} | j \in J_2) | j = 1,2, \dots n\}$$

NIS=$P^- = \{\mu_1^-, \mu_2^-, \dots \mu_n^-\}$

$$= \{(min_j \mu_{ij} | j \in J_1), (max_j \mu_{ij} | j \in J_2) | j = 1,2, \dots n\}$$

Step 4: Estimate the alternatives from PIS and NIS

$$E_i^+ = \sqrt{\sum_{j=1}^{n} (\mu_{ij} - \mu_j^+)^2} \quad i = 1,2,3, \dots m$$

$$E_i^- = \sqrt{\sum_{j=1}^{n} (\mu_{ij} - \mu_j^-)^2} \quad i = 1,2,3, \dots m$$

Step 5: Calculate the relative closeness index of the positive ideal solution

The closeness index of the PIS $P^+$is

$$K_i = \frac{E_i^-}{E_i^+ - E_i^-}$$

for $i = 1,2,3, \dots m$

Step 6: Prioritise the alternatives.

Rank the options in order of greater value using the PIS's proximity index.

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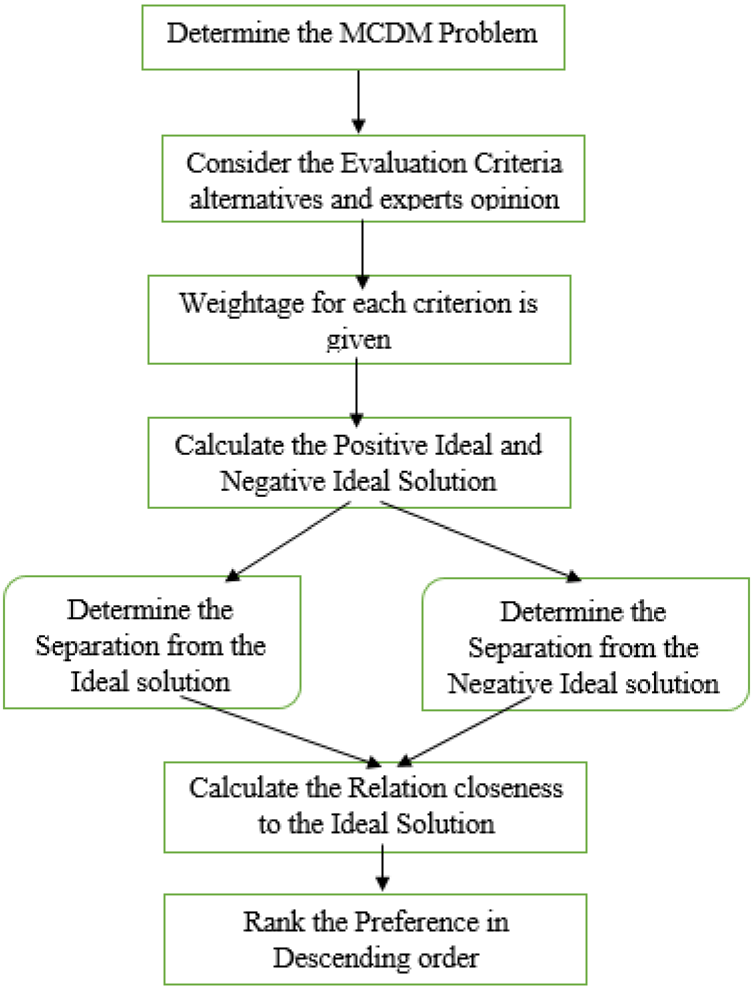

Flow chart of the proposed TOPSIS method

7. Matlab Code for Solving the MCDM problem using TOPSIS method

```
%input data for solving selection of agricultural aircraft using Topsis
%Method
clear
clc
filename = 'TOPSIS_CAL.xlsx';
sheetread = 'INPUTS';

Decision_Making_Matrix = 'c6:k9';
SignofCriteria_SC= 'c10:k10';
WeightofLambda_WL='c11:k11';

MCDMM = xlsread(filename,sheetread, Decision_Making_Matrix);
SignofCriteria = xlsread(filename, sheetread, SignofCriteria_SC);
WeightofLambda = xlsread(filename, sheetread,WeightofLambda_WL);
```


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Solving selection of agricultural aircraft using TOPSIS method Matlab code for the TOPSIS method

```
function [ cc ] = Topsis_Aircraft (MCDMM,SignofCriteria,WeightofLambda )
SumDmm=sum(MCDMM());
SumDmmMatrix=repmat(SumDmm,size(MCDMM,1),1);
pij=MCDMM./SumDmmMatrix; %Normalizing Decision Making Matrix
lnm= -1 / log(size(MCDMM,1));
lnNormDmm = log(pij);
%Step 3: Calculate weight of criteria by entropy technique
E=lnm .* sum(pij .* lnNormDmm);
dj=ones(1,size(E,2))-E ;%Calculating the information Entropy of Criterion
j
weight_Entropy=dj ./sum(dj) ;% computing Entropy weight
wt=SignofCriteria .*weight_Entropy ./sum(SignofCriteria .*weight_Entropy);
sqrtxij=sqrt(sum(MCDMM().^2)) ;
%Step 4-Construct a normalized decision matrix:
N =MCDMM./repmat(sqrtxij,[size(MCDMM,1) 1]);
Wj=eye(size(wt,2)) .* repmat(wt.*WeightofLambda,size(wt,2),1);
%Step 5: Construct the weighted normalized decision matrix by building the
diagonal matrix
V=N*Wj;
%Step 6: Compute the positive ideal solution (PIS) A+ and the negative
ideal solution (NIS) A? of the alternatives:
A_positive=max(V);
A_negetive= min(V);
A_positivMtrix=repmat(A_positive,size(V,1),1);
A_negetiveMtrix=repmat(A_negetive,size(V,1),1);
s1=(V-A_positivMtrix).^2;
s2=(V-A_negetiveMtrix).^2;
for (j=1:1:size(s1,1))
sumAPositive(j)=sum(s1(j,:));
end
for (j=1:1:size(s2,1))
sumANegetive(j)=sum(s2(j,:));
end
%Step 7: Compute the distance of each alternative from PIS(dPositive) and
%NIS (dNegative)
dPositive=sqrt(sumAPositive);
dNegetive=sqrt(sumANegetive);
sumD=dNegetive+dPositive;
%Step 8: Compute the closeness coefficient of each alternative:
cc=dNegetive./sumD;
%xlswrite( 'TOPSIS_CAL.xlsx',cc,'OUTPUT_CC' ,'C6:K6')
%xlswrite( 'TOPSIS_CAL.xlsx',N,'OUTPUT_N' ,'C5:K8')
%xlswrite( 'TOPSIS_CAL.xlsx',V,'OUTPUT_V' ,'C5:K8')
%xlswrite( 'TOPSIS_CAL.xlsx',N,'TOPSIS OUTPUT' ,'C5:K8')
%xlswrite( 'TOPSIS_CAL.xlsx',V,'TOPSIS OUTPUT' ,'C11:K14')
%xlswrite( 'TOPSIS_CAL.xlsx',Apositive,'TOPSIS OUTPUT' ,'C17:K17')
%xlswrite( 'TOPSIS_CAL.xlsx',Anegetive,'TOPSIS OUTPUT' ,'C18:K18')
%xlswrite( 'TOPSIS_CAL.xlsx',dPositive,'TOPSIS OUTPUT' ,'E26:G26')
%xlswrite( 'TOPSIS_CAL.xlsx',dNegetive,'TOPSIS OUTPUT' ,'E27:G27')
%xlswrite( 'TOPSIS_CAL.xlsx',cc,'TOPSIS OUTPUT' ,'E28:G28')
%xlswrite( 'TOPSIS_CAL.xlsx',sumDmmMatrix,'OUTPUT_ENTROPY' ,'C6:K9')
%xlswrite( 'TOPSIS_CAL.xlsx',pij,'OUTPUT_ENTROPY' ,'C14:K17')
%xlswrite( 'TOPSIS_CAL.xlsx',wt,'OUTPUT_ENTROPY' ,'C21:K24')
end
```


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8. Numerical Example:

A selection of agricultural aircraft with four alternatives and nine attributes is given below.

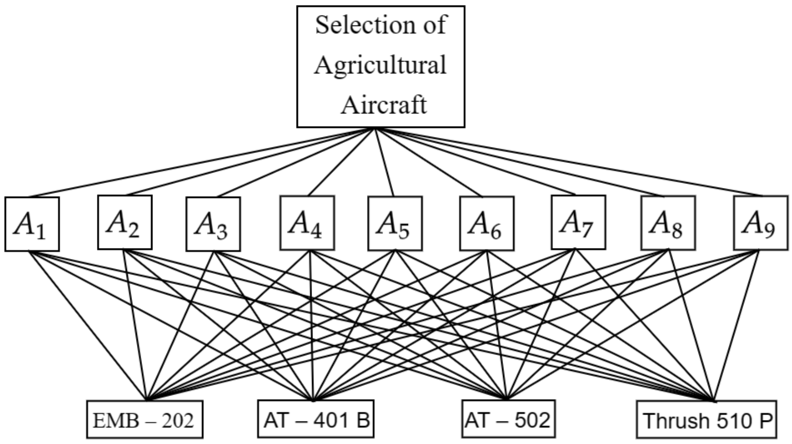

Figure 10: Hierarchical structure of the Selection of Agricultural Aircraft

Table 3: The four alternatives for the agricultural aircraft are given below.

S. No	Agricultural aircraft	Manufacture
1	EMB – 202 IPANEMA	Embraer
2	AT – 401 B	Air Tractor
3	AT – 502	Air Tractor
4	Thrush 510 P	Thrush

Table 4: The following are the nine criteria for choosing the agricultural aircraft:

Criteria	
A_1	Hopper Capacity
A_2	Takeoff Distance
A_3	Fuel Tank Capacity
A_4	Engine Power
A_5	Aspect Ratio
A_6	Climb Ratio
A_7	Dihedral Spam
A_8	Wing Spam
A_9	Fuel Consumption

Table 5: The decision-makers' assessment of the aircraft is as follows:

Criteria	EMP – 202	AT – 401B	AT – 502	Thrush
A_1	Low	High	Excellent	Excellent
A_2	Low	High	Very Low	Very High
A_3	Low	Medium	Very High	Excellent
A_4	Low	High	Very High	Very High
A_5	Moderate	Very High	Very High	Low
A_6	High	Very High	Moderate	Very Low
A_7	Excellent	Moderate	Moderate	Moderate
A_8	Low	Very High	Very High	High
A_9	Very Low	High	High	Very High

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Table 6: A pairwise comparison of the criteria and their weight determination is as follows:

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9
A_1	1.00	0.50	0.33	0.50	0.50	3.00	0.50	0.50	3.00
A_2	2.00	1.00	0.33	1.00	0.50	2.00	0.50	0.33	2.00
A_3	3.00	3.00	1.00	2.00	1.00	3.00	1.00	1.00	4.00
A_4	2.00	1.00	0.50	1.00	0.50	2.00	1.00	1.00	3.00
A_5	2.00	2.00	1.00	2.00	1.00	3.00	2.00	1.00	4.00
A_6	0.33	0.50	0.33	0.50	0.33	1.00	0.50	0.33	1.00
A_7	2.00	3.00	1.00	1.00	0.50	2.00	1.00	0.50	3.00
A_8	2.00	3.00	1.00	1.00	1.00	3.00	2.00	1.00	2.00
A_9	0.33	0.50	0.25	0.33	0.25	1.00	0.33	0.50	1.00

Table 7: A weighted normalised decision matrix is given below.

Criteria	EMP – 202	AT – 401B	AT – 502	Thrush
A_1	0.7730	0.8326	0.88066	0.88066
A_2	0.7730	0.8326	0.7280	0.8753
A_3	0.7730	0.7700	0.8753	0.88066
A_4	0.7730	0.8326	0.8753	0.8753
A_5	0.7700	0.8753	0.8753	0.7730
A_6	0.8326	0.8753	0.7700	0.7280
A_7	0.88066	0.7700	0.7700	0.7700
A_8	0.7730	0.8753	0.8753	0.8326
A_9	0.7280	0.8326	0.8326	0.8753

Table 8: Ideal solutions for the bipolar environment are as follows:

	BPIS	BNIS
A_1	(1.0,1.0,1.0)	(0.0,0.0,0.0)
A_2	(0.0,0.0,0.0)	(1.0,1.0,1.0)
A_3	(1.0,1.0,1.0)	(0.0,0.0,0.0)
A_4	(1.0,1.0,1.0)	(0.0,0.0,0.0)
A_5	(1.0,1.0,1.0)	(0.0,0.0,0.0)
A_6	(1.0,1.0,1.0)	(0.0,0.0,0.0)
A_7	(1.0,1.0,1.0)	(0.0,0.0,0.0)
A_8	(1.0,1.0,1.0)	(0.0,0.0,0.0)
A_9	(0.0,0.0,0.0)	(1.0,1.0,1.0)

Table [9] Closeness Index of the Alternatives is given below.

Closeness Index	EMP – 202	AT – 401B	AT – 502	Thrush
	0.378403451	0.625510034	0.475245047	0.552377843

9. Comparative study

The robustness analysis is done by means of Single valued Neutrosophic number comparatively the proposed number gives better approximation result than Single valued Neutrosophic number. The graphical representation shows the result.

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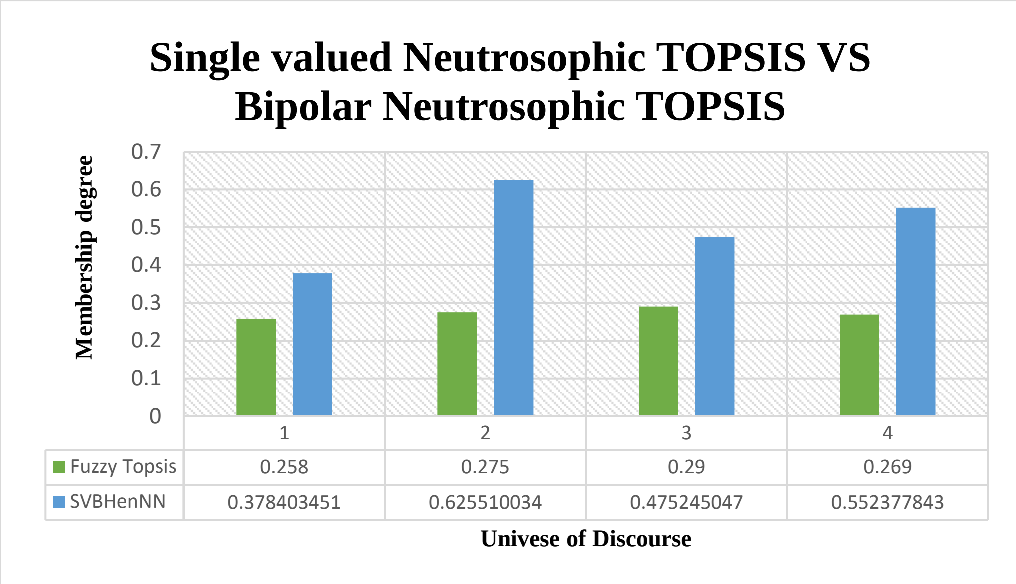

Figure 11: Comparative analysis of Single valued Neutrosophic TOPSIS and Bipolar Neutrosophic TOPSIS

10. Conclusion

The Bipolar concept has been incorporated in Neutrosophic environment with eleven parameters which helps to reduce the ambiguity of the problem and analyses the ambidexterity performances of the proposed Neutrosophic number is used in the multi criteria decision making problem to solve the selection of agricultural aircraft using given criteria and the linguistic variables helps in experts' opinion in the field of aircraft. Table 9's results show that alternative 2, or AT-401B, has the highest Closeness Index score of 0.625510034. As a result, choosing alternative 2 as the best aircraft. The proposed number has a high proximity index when compared to the single valued Neutrosophic number used in the comparison research for the TOPSIS approach.

11. Advantages

In domains including scheme optimisation in the context of SNIEs, service estimation, and quality assessment, the expanded TOPSIS method-based MADM model has a wide range of applications.

12. Future Directions

Future research will be conducted to identify the primary factors influencing the choice of an agricultural aircraft, such as maintenance requirements, operating expenses, and additional pertinent factors that were not considered. Additionally, it is vital to look up pilots and machinists' assessments and viewpoints on the choosing of agricultural aircraft the enhanced TOPSIS method – based MADM.

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