Single Valued Neutrosophic Numbers and Applications in Selection Criteria

Sapna Gahlot and R. N. Saraswat
Department of Mathematics and Statistics,
Manipal University Jaipur Jaipur (Rajasthan) - 303007, INDIA

sapna1994gahlot@gmail.com, saraswatramn@gmail.com

Abstract. A SVNN is just a common number whose exact worth is to some degree dubious from a philosophical perspective. Present single valued neutrosophic numbers (SVNN) which is a speculation of fuzzy numbers and intuitionistic fuzzy numbers. Here, we will discuss about special types of SVNN. Additionally, presented a few procedures on single valued trapezoidal. At last, developed single valued trapezoidal neutrosophic measure and its applications in multi-criteria decision making.

1. Introduction

In 1965, fuzzy set hypothesis has for some time been presented to contract through unclearness, vague information via Zadeh (1965). After Zadeh, fuzzy sets, particularly FN (Fuzzy Numbers) have been broadly examined and useful to different fields, for example, dynamic, design acknowledgment, game hypothesis, etc. In FS (“Fuzzy Sets”), the degree of memberships of the components in a universe is a single value at the same time, those single values can’t give any extra data in light of the fact that, and data with respect to components comparing to a fuzzy idea might be inadequate. The fuzzy set hypothesis isn’t equipped for managing the absence of information with deference to degrees of membership, Atanassov (1999) proposed the hypothesis of IFS (Intuitionistic Fuzzy Sets) the augmentation of Zadeh FS by utilizing a non-membership degree adapt to the nearness of ambiguity and hesitancy originating from imprecise information or data. Intuitionistic fuzzy sets were stretched out via Smarandache (2005), in 1995, to neutrosophic sets which can just deal with fragmented data not the vague data and conflicting data according to philosophical perspective. This hypothesis is significant in numerous applications Indeterminacy is evaluated expressly and truth, indeterminacy and falsity membership respectively are free and furthermore the hypothesis sums up the idea of the classical sets FS, IFS, etc. As of late, some fuzzy models with FS have been looked into the numerous neutrosophic models with NS (Neutrosophic Sets) and investigated by numerous creators.

Yue (2014) built MAGDM model dependent on crisp values into IFN. Ye (2012) demonstrated an all-inclusive system for order preference by similarity to ideal solution (TOP-SIS) technique for MAGDM with interval valued intuitionistic fuzzy numbers to take care of the accomplice choice issue under inadequate and unsure data condition. Chen et al. (2011) built up a way to deal with handle numerous criteria collective choice making issues in the setting of interval valued intuitionistic fuzzy sets. Boycott (2008) explored a few parameters for intuitionistic fuzzy numbers, for example, value, vagueness, width and weighted anticipated that worth should use in build an approximation operator. Xu (2007) proposed a technique for the examination between two intuitionistic fuzzy qualities dependent on score capacity and exactness work and built up some aggregation operators. Li (2016), Nehi (2010), Wei (2010) and Jianqiang and Zhong (2009) presented the trapezoidal...
intuitionistic fuzzy numbers and gave a few activities for them. At that point, they proposed some averaging operators. Palanivelrajan Kaliraju (2012) explored the arithmetical properties of intuitionistic fuzzy numbers built up another idea called trapezoidal intuitionistic fuzzy number gathering. Yu (2013) inquired about the accumulation techniques the ITF (Intuitionistic Trapezoidal Fuzzy) data. He presented a Generalized ITF Weighted Averaging operator and demonstrated the assessment of the teaching quality dependent on the proposed operator under intuitionistic trapezoidal fuzzy condition. Gani et al. (2011) proposed the cooperative choice making issues where every one of the components are portrayed by ITFN. Li (2010) characterized the idea of triangular intuitionistic fuzzy numbers and build up another procedure for positioning triangular intuitionistic fuzzy numbers. Esmailzadeh (2013) developed another technique to calculate the separation between intuitionistic fuzzy sets, in particular triangular intuitionistic fuzzy number, based on α-cuts. Wan (2013) and Wan et al. concentrated on multi-property collective choice making issue building up another choice strategy dependent on power average operator of TIFN. As of late, some intuitionistic models with IFS have been investigated by numerous creators.

SVNN (“Single Valued Neutrosophic Numbers”) are an exceptional instance of SVNS and are of significance for neutrosophic multi-attribute dynamic issues. The paper is composed as follows. In area 2, the ideas of FS, IFS, SVNN and proposed SVTN numbers. In area 3, a strategy for multi-criteria group decision making dependent on the developed is introduced. Likewise, we used it to the assessment of teaching quality. At last, the paper is concluded in area 4.

2. Preliminaries

Here, we present some basic ideas of FS, IFS, IFN and NS.

Definition 2.1.
Assume that (1965) E be a universe. Then a FS Y on S is a function defined as follows:
\[ Y = \{ \mu_{x}(y) / y \in S \} \text{, where } \mu_{x} : S \rightarrow [0, 1] \]

Here, \( \mu_{x} \) is membership function of \( Y \), and \( \mu_{x}(y) \) is membership-grade of \( y \in S \). The value of degree \( y \) belongs to FS \( X \).

Definition 2.2 (2010)
Assume that \( S \) is a universe and IFS K over S may be defined as follows:
\[ k = \{ \{ y, \mu_{k}(y), \nu_{k}(y), \pi_{k}(y) / y \in S \} \} \]

Where
\[ \mu_{K} : S \rightarrow [0, 1] \]
and
\[ \nu_{K} : S \rightarrow [0, 1] \text{ such that } 0 \leq \mu_{K}(y) + \nu_{K}(y) \leq 1 \text{ for any } y \in S. \]

Here, \( \mu_{K}(y) \) and \( \nu_{K}(y) \) is membership and non- membership degree to the element \( y \) respectively.

Definition 2.3
Assume that \( S \) is an arbitrary universe of discourse and generic element represented by \( y \). An INS K in S is defined by
\[ k = \{ \{ y, \mu_{i}(y), \nu_{i}(y), \pi_{i}(y) / y \in S \} \} \quad k = \{ \{ y, \mu_{i}(y), \nu_{i}(y), \pi_{i}(y) / y \in S \} \}
\[ \mu_{i}(y), \nu_{i}(y), \pi_{i}(y) \in [0, 1] \text{ and } 0 \leq \mu_{i}(y) + \nu_{i}(y) + \pi_{i}(y) \leq 3. \]

Here,
\( \mu_{i}(y) \) is the membership function of truth, \( \nu_{i}(y) \) is the membership function of indeterminacy and \( \pi_{i}(y) \) is the membership function of falsity.

Definition 2.4.
A SVTN \( \bar{a} = (a_1, b_1, c_1, d_1); \sigma_a, \partial_a, \gamma_a \) is a NS over real number R, whose membership of truth, indeterminacy, and a falsity respectively are as following:

\[
\mu_a(x) = \begin{cases} 
\frac{(x - a_1)\sigma_a}{b_1 - a_1}, & \text{if } a_1 \leq x < b_1; \\
\sigma_a, & \text{if } x = b_1; \\
\frac{(c_1 - x)\sigma_a}{c_1 - b_1}, & \text{if } b_1 \leq x < c_1; \\
0, & \text{otherwise.}
\end{cases}
\]

\[
\nu_a(x) = \begin{cases} 
\frac{(b_1 - x + \partial_a(x - a_1))}{b_1 - a_1}, & \text{if } a_1 \leq x < b_1; \\
\partial_a, & \text{if } x = b_1; \\
\frac{(c_1 - x)\gamma_a}{c_1 - b_1}, & \text{if } b_1 \leq x < c_1; \\
1, & \text{otherwise.}
\end{cases}
\]

\[
\pi_a(x) = \begin{cases} 
\frac{(b_1 - x + \gamma_a(x - a_1))}{b_1 - a_1}, & \text{if } a_1 \leq x < b_1; \\
\gamma_a, & \text{if } x = b_1; \\
\frac{(c_1 - x)\pi_a}{c_1 - b_1}, & \text{if } b_1 \leq x < c_1; \\
1, & \text{otherwise.}
\end{cases}
\]

Where, \( 0 \leq \mu_a \leq 1, 0 \leq \nu_a \leq 1, 0 \leq \pi_a \leq 1 \) and \( 0 \leq \mu_a + \nu_a + \pi_a \leq 1; a_1, b_1, c_1, d_1 \in \text{R}. \)

The SVTN numbers are a generalization of the ITF numbers [16]

**Definition 2.5.**

Assuming that \( \bar{a} = (a_1, b_1, c_1, d_1); \sigma_a, \partial_a, \gamma_a \) and \( \bar{b} = (a_2, b_2, c_2, d_2); \sigma_b, \partial_b, \gamma_b \) be two SVTN numbers and \( \lambda \neq 0 \) then

(i) \( \bar{a} + \bar{b} = \left\{ (a_1 + a_2, b_1 + b_2, c_1 + c_2, d_1 + d_2); \sigma_a \wedge \sigma_b, \partial_a \vee \partial_b, \gamma_a \vee \gamma_b \right\} \)

(ii) \( \bar{a} - \bar{b} = \left\{ (a_1 - a_2, b_1 - b_2, c_1 - c_2, d_1 - d_2); \sigma_a \vee \sigma_b, \partial_a \wedge \partial_b, \gamma_a \wedge \gamma_b \right\} \)

(iii) \( \bar{a} \bar{b} = \left\{ (a_1 a_2, b_1 b_2, c_1 c_2, d_1 d_2); \sigma_a \wedge \sigma_b, \partial_a \vee \partial_b, \gamma_a \vee \gamma_b (d_1 > 0, d_2 > 0); \sigma_a \wedge \sigma_b, \partial_a \vee \partial_b, \gamma_a \wedge \gamma_b (d_1 < 0, d_2 < 0); \sigma_a \wedge \sigma_b, \partial_a \vee \partial_b, \gamma_a \wedge \gamma_b (d_1 > 0, d_2 < 0); \right\} \)

(iv) \( \bar{a} \lambda \bar{a} = \left\{ (\lambda a_1, \lambda b_1, \lambda c_1, \lambda d_1); \sigma_a, \partial_a, \gamma_a (\lambda > 0); \right\} \)

\( \left\{ (\lambda d_1, \lambda c_1, \lambda b_1, \lambda a_1); \sigma_a, \partial_a, \gamma_a (\lambda < 0); \right\} \)
New Euclidean distance

Here we define the new Euclidean measures on based SVTN.

Let \( \mathbf{a} = (a_1, a_2, a_3, a_4) \) and \( \mathbf{b} = (b_1, b_2, b_3, b_4) \) be two SVTN then the normalized Euclidean distance between \( \mathbf{a} \) and \( \mathbf{b} \) are given below:

\[
\frac{d(\mathbf{a}, \mathbf{b})}{8} = \frac{1}{8} \left[ \left( 1 + \frac{a_1 - b_1}{a_2 - b_2} \right)^2 + \left( 1 + \frac{a_2 - b_2}{a_3 - b_3} \right)^2 + \left( 1 + \frac{a_3 - b_3}{a_4 - b_4} \right)^2 \right]
\]

(2.3)

3. Applications:

Right now, will use the developed measure to multi-criteria decision making issue and show the adequacy of the measure by the case of assessment of the teaching quality. Some of it is cited from application in (2013). Expect that there is a multi-criteria decision issue under neutrosophic trapezoidal condition.

Let \( K = \{k_1, k_2, ..., k_n\} \) be the arrangement of choices and \( U = \{u_1, u_2, ..., u_n\} \) the set of criteria. The leaders evaluate the objects (the criteria \( u_j \) for the alternative \( x_i \)) and communicated by single valued trapezoidal neutrosophic numbers \( a_{ij} \). Based on proposed measure, we develop a decision technique by the accompanying calculation:

- Step 1: The experts evaluate the objects (the criterion \( u_j \) for the alternative \( k_i \) and express by SVTN numbers \( a_{ij} \) as a Table.

- Step 2: Find SVTN numbers by the measure.

- Step 3: Rank of the alternatives and choose the good decision. According to the rank of the alternatives, select the good decision as per to the descending order of \( k_i \) (i = 1, 2, ..., m).

Table 1: single valued trapezoidal neutrosophic decision table

| \( k_i \) | \( \mu_1 \) | \( \mu_2 \) | \( \mu_3 \) |
|----------|--------|--------|--------|
| \( k_1 \) | (0.3, 0.4, 0.5, 0.7) | (0.2, 0.3, 0.5, 0.6) | (0.1, 0.2, 0.7, 0.8) |
| \( k_2 \) | (0.2, 0.5, 0.6, 0.9) | (0.2, 0.4, 0.6, 0.8) | (0.2, 0.3, 0.6, 0.7) |
| \( k_3 \) | (0.3, 0.4, 0.7, 0.8) | (0.3, 0.5, 0.8, 0.9) | (0.3, 0.4, 0.5, 0.6) |
| \( k_4 \) | (0.3, 0.5, 0.8, 0.9) | (0.2, 0.3, 0.7, 0.8) | (0.4, 0.6, 0.7, 0.8) |
| \( k_5 \) | (0.4, 0.6, 0.7, 0.8) | (0.1, 0.3, 0.5, 0.7) | (0.4, 0.5, 0.6, 0.7) |

Case Study

Expect that an administration needs to fill a position. There are five applicants (ki (i = 1, 2, 3, 4, 5) and they will be assessed by specialist’s board of the Management Science and Engineering Institute from the accompanying three viewpoints, their teaching attitude (u_1), capacity (u_2) and content (u_3). These 5 teachers who have great teaching attitude could in general produce a multiplier impact while teaching capacity will be assessed by their expert information and social practice. The last factor is the educators instructing content, to check whether the substance is intently around teaching Guidance. The weight vector of the three criteria is assumed as (.4, .3, .3)T . Then,
Step 1: The specialists assess the teachers and indicated their assessment brings about Table 1.

Step 2: \(k_1 = .3516, k_2 = .3986, k_3 = .3185, k_4 = .3948, k_5 = .2172\)

Step 3: Rank the alternatives and choose the good decision based on the rank. Select the good decision as per the descending order of \(k_i\) \((i = 1, 2, ..., m)\) \(k_5 > k_3 > k_1 > k_4 > k_2\)

4. Conclusion

Right now, have characterized SVN numbers which is a speculation of FN and IFN and we have introduced uncommon types of single esteemed neutrosophic numbers, for example, SV trapezoidal neutrosophic numbers with activities. At long last, we have utilized to MCDM (“multi-criteria decision issue”). In future work, we will apply this idea to game hypothesis, mathematical structure, streamlining, etc.

References

[1]. Atanassov.K.T., 1999, Intuitionistic Fuzzy Sets, Pysica-Verlag A Springer- Verlag Company. New York.

[2]. Ban, A. “Trapezoidal approximations of intuitionistic fuzzy numbers expressed by value, 2008, ambiguity, width and weighted expected value.” Twelfth Int. Conf. on IFSs, Sofia, NIFS Vol. 14 (1), 38–47.

[3]. Chen.T.Y., H.P. Wang, Y.Y. Lu. “A multicriteria group decision- making approach based on interval-valued intuitionistic fuzzy sets: a com- parative perspective.”, 2011, Exp. Syst. Appl. 38 (6), 7647-7658.

[4]. Chen, T. “Multiple criteria group decision-making with generalized interval-valued fuzzy numbers based on signed distances and incomplete weights.”, 2012, Appl. Math. Model. 36 (7), 3029-3052.

[5]. Esmailzadeh, M. and M. Esmailzadeh. “New distance between triangular intuitionistic fuzzy numbers.”, 2013, Advances in Computational Mathematics and its Applications 2(3), 310–314.

[6]. Gani,A. N., N. Sritharan and C. Arun Kumar. “Weighted Average Rating (WAR) Method for Solving Group Decision Making Problem Using an Intuitionistic Trapezoidal Fuzzy Hybrid Aggregation (ITFHA) Opera tor.”, 2011, International Journal of Pure and Applied Sciences and Technology Int. J. Pure Appl. Sci. Technol., 6(1), 54–61.

[7]. Jain K.C. and R. N. Saraswat Some well-known inequalities and its applications in information theory”, 2013, Jordan Journal of Mathematics and Statistics., 157-167.

[8]. Jain K. C. and R. N. Saraswat, Some Bounds of Information Divergence Measures in Terms of Relative-Arithmetic Divergence Measure”, 2013, International Journal of Applied Mathematics and Statistics, 32 (2), 48-58.

[9]. Jain K.C. and A. Srivastava, On Symmetric Information Divergence Measures of Csiszar’s f-Divergence Class, 2007, Journal of Applied Mathematics, Statistics and Informatics (JAMSI), 3(1), 85-102.

[10]. Jain K.C. & R. N. Saraswat., (2012), A New Information Inequality and its Application in Establishing Relation among various f-Divergence Measures, Journal of Applied Mathematics, Statistics and Informatics, 8 (1), 17-32.

[11]. Khatod N. and R. N. Saraswat., (2019): Symmetric Fuzzy Divergence Measure, Decision Making and Medical Diagnosis Problems” Journal of Intelligent and Fuzzy Systems, 36(6), 5721-5729.

[12]. Li, D. F. “Decision and Game Theory in Management With Intuitionistic Fuzzy Sets.”, 2014, Studies in Fuzziness and Soft Computing Volume springer 308.

[13]. Li, D. F. “A ratio ranking method of triangular intuitionistic fuzzy numbers and its application to MADM problems.”, 2010, Computers and Mathematics with Applications 60, 1557–1570.

[14]. Nehi, H. M. “A New Ranking Method for Intuitionistic Fuzzy Numbers.”, 2010, International Journal of Fuzzy Systems, 12(1), 80–86.

[15]. Palanivelrajan M. and K. Kaliraju. "A Study on Intuitionistic Fuzzy Number Group.", 2012, International Journal of Fuzzy Mathematics and Systems 2(3), 269–277.

[16]. Saraswat R. N. and Adeeba Umar, “New Fuzzy Divergence Measure and its Applications in Multi Criteria Decision Makin Using New Tool”, 2020, Springer Proceedings in Mathematics & Statistics Vol 307, 191-206.
[17]. Saraswat R. N. and N. Khatod, “New Fuzzy Divergence Measures, Series, Its Bounds and Applications in Strategic Decision-Making”, 2020, *Lecture notes in Electrical Engineering (springer)* vol 607, 641-653.

[18]. Smarandache, F. “A Unifying Field in Logics. Neutrosophy: Neutrosophic Probability, Set and Logic”, 1998, *Rehoboth: American Research Press*, 1998.

[19]. Smarandache, F. “Neutrosophic set, a generalisation of the intuitionistic fuzzy sets.”, 2005, *Int. J. Pure Appl. Math.*, 24, 287-297.

[20]. Umar A. and R.N. Saraswat, “New generalized intuitionistic fuzzy divergence measure with applications to multi-attribute decision making and pattern recognition”, 2020, *Recent Patents on Computer Science* 13 (1).

[21]. Umar A. and R.N. Saraswat, “Novel divergence measure under neutrosophic environment and its utility in various problems of decision making”, 2020, *International Journal of Fuzzy System Applications*, 9(4).

[22]. Wang, J., R. Nie, H. Zhang and X. Chen. “New operators on triangular intuitionistic fuzzy numbers and their applications in system fault analysis.”, 2013, *Information Sciences* 251, 79-95.

[23]. Wan, S. P. “Power average operators of trapezoidal intuitionistic fuzzy numbers and application to multi-attribute group decision making.”, 2013, *Applied Mathematical Modelling* 37, 4112-4126.

[24]. Wei, G. “Some Arithmetic Aggregation Operators with Intuitionistic Trapezoidal Fuzzy Numbers and Their Application to Group Decision Making.”, 2010, *Journal of Computers*, 5(3), 345–351.

[25]. Wu, J. and Q. Cao. “Same families of geometric aggregation opera- tors with intuitionistic trapezoidal fuzzy numbers.”, 2013, *Applied Mathematical Modelling*, 37, 318-327.

[26]. Xu, Z.S. “Intuitionistic fuzzy aggregation operators.”, 2007, *IEEE Trans. Fuzzy Syst*. 15 (6), 1179-87.

[27]. Ye, J. “Expected value method for intuitionistic trapezoidal fuzzy multicriteria decision-making problems.”, 2011, *Expert Systems with Applications* 38, 1173-11734.

[28]. Ye, J. “A multicriteria decision-making method using aggregation operators for simplified neutrosophic sets.”, 2014, *Journal of Intelligent and Fuzzy Systems*, 26, 2459–66.

[29]. Ye, J. “The Dice similarity measure between generalized trapezoidal fuzzy numbers based on the expected interval and its multi-icriteria group decision-making method.”, 2012, *Journal of the Chinese Institute of Industrial Engineers*, 29(6), 375-382.

[30]. Yu, D. “Intuitionistic Trapezoidal Fuzzy Information Aggregation- Methods and Their Applications to Teaching Quality Evaluation.”, 2013, *Journal of Information Computational Science* 10(6), 1861–69.

[31]. Yue, Z. “Aggregating crisp values into intuitionistic fuzzy number for group decision making.”, 2014, *Applied Mathematical Modelling*, 38, 2969-82.

[32]. Zadeh, L.A. *Fuzzy Sets*, 1965, *Information and Control*, 8, 338-353.

[33]. Zhang, X. and P. Liu. “Method For Aggregating Triangular Fuzzy Intuitionistic Fuzzy Information and Its Application to Decision Making.”, 2010, *Technological and economic development of economy Baltic Journal on Sustainability*, 16(2), 280-290.