A commentary on "An improved score function for ranking neutrosophic sets and its application to decision-making process"

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Abstract

This work aims to study and observe all the existing score functions that help to rank the single-valued neutrosophic set (SVNS) as well as interval-valued neutrosophic set (IVNS) to make a better choice among all the available alternatives in multi-criteria decision-making (MCDM) problems. An intensive study about all these existing score functions reveals that there holds some limitations in the method of ranking order which is misleading the results in decision-making problems. These observations about the existing score functions of the SVNS and IVNS have been claimed with the help of well-defined examples, illustrating an inefficiency of all these existing score functions. Thus, to propose a valid score function for ranking SVNS and IVNS for making a better selection among all the other available alternatives in MCDM problems is still an open challenging research problem.

A commentary on "An improved score function for ranking neutrosophic sets and its application to decision-making process"

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Abstract: This work aims to study and observe all the existing score functions that help to rank the single-valued neutrosophic set (SVNS) as well as interval-valued neutrosophic set (IVNS) to make a better choice among all the available alternatives in multi-criteria decision-making (MCDM) problems. An intensive study about all these existing score functions reveals that there holds some limitations in the method of ranking order which is misleading the results in decision-making problems. These observations about the existing score functions of the SVNS and IVNS have been claimed with the help of well-defined examples, illustrating an inefficiency of all these existing score functions. Thus, to propose a valid score function for ranking SVNS and IVNS for making a better selection among all the other available alternatives in MCDM problems is still an open challenging research problem.

KEYWORDS - IVNS, MCDM, score function, SVNS

1. INTRODUCTION

In the real-life uncertainty is the only thing which is certain in life, so the information available in the real-world cannot be crisp always. This theory was incorporated by a deep thinker Zadeh who proposed a new theory of sets i.e., fuzzy sets [27] which brought a huge revolution in the area of new thinking world and mathematics. Fuzzy sets holds the idea that in practical life the information available is not always certain or crisp but beholds the hand of uncertainty together and the study of this uncertainty would help a lot in the process of decision making [28,29]. Later with the time some intriguing extensions of fuzzy sets were developed like- intuitionistic fuzzy set (IFS) [2], interval-valued intuitionistic fuzzy set (IVIFS) [3], Pythagorean fuzzy set (PFS) [24-26], interval-valued Pythagorean fuzzy set (IVPFS) [32], neutrosophic set [18-20], SVNS [23] and IVNS [22] etc. In this note, a deep study have been made to analyze the ranking order of some of the extensions of fuzzy sets like, IFS [8,9,30], PFS [32], IVPFS [4-7,11,12,16,17,31], SVNS [1,10,13-15,21] and IVNS [10,13]. After a rigorous study it has been observed that there exist some restrictions in the existing methods [10,13] for comparing SVNS and IVNS. Some well-defined counter-examples are chosen where the uncertainty in the data is expressed in the form of SVNS and IVNS to claim that the existing score function defined to rank the SVNS and IVNS results incorrectly. The aim of this note is to make researchers aware that, the shortcomings pointed out by Nancy and Garg [10] in the existing methods [13] is also occurring in the methods proposed by Nancy and Garg [10]. Therefore, to propose the valid methods for the same is still an open challenging research problem.

2. A brief review of existing score functions

Nancy and Garg [10] pointed out the shortcomings of the existing methods [13] for the ranking of SVNS as well for the ranking of IVNS. Also, to resolve these limitations, Nancy and Garg proposed new methods for the same.

2.1. Existing score function

Sahin [13] proposed the following method for the ranking of two SVNS, $A_1 = \langle a_1, b_1, c_1\rangle$and $\mathrm{A}_2 = \langle a_2, b_2, c_2\rangle$. Find $K(A_1) = \frac{1+a_1-2b_1-c_1}{2}$and $K(A_2) = \frac{1+a_2-2b_2-c_2}{2}$, and check that $K(A_1) > K(A_2)$ or$K(A_1) < K(A_2)$ or$K(A_1) = K(A_2)$.

1. If $K(A_1) > K(A_2)$ then$A_1 > A_2$.
2. If $K(A_1) < K(A_2)$ then$A_1 < A_2$.
3. If $K(A_1) = K(A_2)$ then$A_1 = A_2$.

Sahin [13] also proposed the following method for the ranking of two IVNS,$A_1 = \left\langle \left[a_1^L, a_1^U\right], \left[b_1^L, b_1^U\right], \left[c_1^L, c_1^U\right] \right\rangle$and$A_2 = \left\langle \left[a_2^L, a_2^U\right], \left[b_2^L, b_2^U\right], \left[c_2^L, c_2^U\right] \right\rangle$. Find$L(A_1) = \frac{2+a_1^L+a_1^U-2b_1^L-2b_1^U-c_1^L-c_1^U}{4}andL(A_2) = \frac{2+a_2^L+a_2^U-2b_2^L-2b_2^U-c_2^L-c_2^U}{4}$, and check that $L(A_1) > L(A_2)$ or$L(A_1) < L(A_2)$ or$L(A_1) = L(A_2)$.

1. If $L(A_1) > L(A_2)$ then$A_1 > A_2$.
2. If $L(A_1) < L(A_2)$ then$A_1 < A_2$.
3. If $L(A_1) = L(A_2)$then $\mathrm{A}_1 = A_2$.

Nancy and Garg [10, Section 2, Def. 2.6, Ex. 2.1, pp. 379] considered two different SVNS,$A_1 = \langle 0.5, 0.2, 0.6\rangle$and $\mathrm{A}_2 = \langle 0.2, 0.2, 0.3\rangle$ and showed that on considering the existing method [13], the relation $\mathrm{A}_1 = A_2$ is obtained. While, it is obvious that $A_1 \neq A_2$. On the basis of this numerical example, Nancy and Garg [10, Section 2, Def. 2.6, Ex. 2.1, pp. 379] claimed that the existing method [13] for the ranking of SVNS is not valid.

It is pertinent to mention that the SVNS,$A_1 = \langle 0.5, 0.2, 0.6\rangle$and $\mathrm{A}_2 = \langle 0.2, 0.2, 0.3\rangle$ can also be represented as IVNS,$A_1 = \langle [0.5, 0.5], [0.2, 0.2], [0.6, 0.6]\rangle$and $\mathrm{A}_2 = \langle [0.2, 0.2], [0.2, 0.2], [0.3, 0.3]\rangle$. It can be verified that on considering the existing method [13], the relation $\mathrm{A}_1 = A_2$ is obtained. While, it is obvious that $A_1 \neq A_2$. Hence, the existing method [13] for the ranking of IVNS is also not valid.

2.2. Proposed score function

To resolve the shortcoming discussed in Section 2.1 of the existing methods [13], Nancy and Garg [10, Section 3, Def. 3.1, pp. 379] proposed the following method for the ranking of two SVNS, $A_1 = \langle a_1, b_1, c_1 \rangle$ and $A_2 = \langle a_2, b_2, c_2 \rangle$. Find $N(A_1) = \frac{1+(a_1-2b_1-c_1)(2-a_1-c_1)}{2}$ and $N(A_2) = \frac{1+(a_2-2b_2-c_2)(2-a_2-c_2)}{2}$, and check that $N(A_1) > N(A_2)$ or $N(A_1) < N(A_2)$ or $N(A_1) = N(A_2)$.

1. If $N(A_1) > N(A_2)$ then $A_1 > A_2$.
2. If $N(A_1) < N(A_2)$ then $A_1 < A_2$.
3. If $N(A_1) = N(A_2)$ then $A_1 = A_2$.

Furthermore, Nancy and Garg [10, Section 3, Def. 3.2, pp. 381] proposed the following method for the ranking of two IVNS, $A_1 = \left\langle \left[a_1^L, a_1^U\right], \left[b_1^L, b_1^U\right], \left[c_1^L c_1^U\right] \right\rangle$ and $A_2 = \left\langle \left[a_2^L, a_2^U\right], \left[b_2^L, b_2^U\right], \left[c_2^L c_2^U\right] \right\rangle$. Find $M(A_1) = \frac{4+(a_1^L+a_1^U-c_1^L-c_1^U-2b_1^L-2b_1^U)(4-a_1^L-a_1^U-c_1^L-c_1^U)}{8}$ and

$M(A_2) = \frac{4+(a_2^L+a_2^U-c_2^L-c_2^U-2b_2^L-2b_2^U)(4-a_2^L-a_2^U-c_2^L-c_2^U)}{8}$, and check that $M(A_1) > M(A_2)$ or $M(A_1) < M(A_2)$ or $M(A_1) = M(A_2)$.

1. If $M(A_1) > M(A_2)$ then $A_1 > A_2$.
2. If $M(A_1) < M(A_2)$ then $A_1 < A_2$.
3. If $M(A_1) = M(A_2)$ then $\mathrm{A}_1 = A_2$.

In this note, it is shown that, there exist two different SVNS A_1 and A_2 such that $N(A_1) = N(A_2)$ as well as two different IVNS A_1 and A_2 such that $M(A_1) = M(A_2)$ i.e., the shortcomings, pointed out by Nancy and Garg [10, Section 2, Def. 2.6, Ex. 2.1, Ex. 2.2, pp. 379] in the existing methods [13], is also occurring in the methods proposed by Nancy and Garg [10, Section 2, Def. 3.1, pp. 379; Def. 3.2, pp. 381]. Hence, to propose the valid methods for the ranking of two SVNS as well as the ranking of two IVNS is still an open challenging research problem.

3. Limitations of proposed method for ranking of two SVNS

Let $\mathrm{A}_1 = \langle 0.8, 0.1, 0.6 \rangle$ and $\mathrm{A}_2 = \langle 0.8, 0.2, 0.4 \rangle$ be two SVNS, then according to the proposed method [10, Section 3, Def. 3.1, pp. 379], discussed in Section 2.2, $N(A_1) = N(A_2) = 0.5$. Therefore, according to the proposed method [10, Section 3, Def. 3.1, pp. 379], $A_1 = A_2$. While, it is obvious that $\mathrm{A}_1 \neq A_2$. Hence, the proposed method [10, Section 3, Def. 3.1, pp. 379] for the ranking of two SVNS is not valid.

Similarly, let $\mathrm{A}_1 = \langle 0.1, 0.0, 0.1 \rangle$ and $\mathrm{A}_2 = \langle 0.3, 0.0, 0.3 \rangle$ be two SVNS, then according to the proposed method [10, Section 3, Def. 3.1, pp. 379], discussed in Section 2.2, $N(A_1) = N(A_2) = 0.5$. Therefore, according to the proposed method [10, Section 3, Def. 3.1, pp. 379], $\mathrm{A}_1 = A_2$. While, it is obvious that $\mathrm{A}_1 \neq A_2$. Hence, the proposed method [10, Section 3, Def. 3.1, pp. 379] for the ranking of two SVNS is not valid.

4. Limitations of proposed method for ranking of two IVNS

Let $A_1 = \langle [0.1, 0.7], [0.05, 0.15], [0.1, 0.3] \rangle$ and $\mathrm{A}_2 = \langle [0.2, 0.8], [0.05, 0.15], [0.2, 0.4] \rangle$ be any two IVNS, then according to the proposed method [10, Section 3, Def. 3.2, pp. 381], discussed in Section 2.2, $M(A_1) = M(A_2) = 0.5$. Therefore, according to the proposed method [10, Section 3, Def. 3.2, pp. 381], $A_1 = A_2$. While, it is obvious that $\mathrm{A}_1 \neq A_2$. Hence, the proposed method [10, Section 3, Def. 3.2, pp. 381] for the ranking of two IVNS is not valid.

Similarly, let $A_1 = \langle [0.1, 0.7], [0.1, 0.1], [0.1, 0.3] \rangle$ and $\mathrm{A}_2 = \langle [0.2, 0.8], [0.1, 0.1], [0.2, 0.4] \rangle$ be any two IVNS, then according to the proposed method [10, Section 3, Def. 3.2, pp. 381], discussed in Section 2.2, $M(A_1) = M(A_2) = 0.5$. Therefore, according to the proposed method [10, Section 3, Def. 3.2, pp. 381], $A_1 = A_2$. While, it is obvious that $\mathrm{A}_1 \neq A_2$. Hence, the proposed method [10, Section 3, Def. 3.2, pp. 381] for the ranking of two IVNS is not valid.

It is observed that several such examples are occurring like this, i.e., let $A_1 = \langle [0.1, 0.7], [0.0, 0.2], [0.1, 0.3] \rangle$ and $A_2 = \langle [0.2, 0.8], [0.0, 0.2], [0.2, 0.4] \rangle$ also, let another example be,$A_1 = \langle [0.1, 0.2], [0.0, 0.0], [0.1, 0.2] \rangle$and$A_2 = \langle [0.4, 0.5], [0.0, 0.0], [0.4, 0.5] \rangle$and we observe that each example according to the proposed method [10, Section 3, Def. 3.2, pp. 381], discussed in Section 2.2, results into$M(A_1) = M(A_2) = 0.5$ declaring that $A_1 = A_2$. While, it is obvious that $A_1 \neq A_2$. Hence, the proposed method [10, Section 3, Def. 3.2, pp. 381] for the ranking of two IVNS is not valid in its present form.

5. Conclusion

Thus with an intensive analysis, it is clearly observed that Nancy and Garg's proposed method [10, Section 3, Def. 3.1, pp. 379] for the ranking of two SVNS as well as the Nancy and Garg's proposed method [10, Section 3, Def. 3.2, pp. 381] for the ranking of two IVNS fails to find the correct ranking order and hence stands invalid. To propose the valid methods for the same may be considered as a challenging future research problem.

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COMPLIANCE WITH ETHICAL STANDARDS

CONFLICT OF INTEREST.

The authors declare that they do not have any financial or associative interest indicating a conflict of interest in about submitted work.

References

1. M. Abdel-Basset, M. Gunasekaran, M. Mohamed, F. Smarandache, A novel method for solving the fully neutrosophic linear programming problems. Neural Comput. Appl. (2018). https://doi.org/10.1007/s00521-018-3404-6.
2. K.T. Atanassov, Intuitionistic fuzzy sets. Fuzzy Sets Syst. 20 (1986) pp. 87–96.
3. K.T. Atanassov, G. Gargov, Interval-valued intuitionistic fuzzy sets. Fuzzy Sets Sys. 31 (1989) pp. 343–349.
4. H. Garg, A novel accuracy function under interval-valued pythagorean fuzzy environment for solving multicriteria decision making problem. J. Intell. Fuzzy Syst. 31 (1) (2016) pp. 529–540.
5. H. Garg, A novel improved accuracy function for interval-valued Pythagorean fuzzy sets and its applications in the decision-making process. Int. J. Intell. Syst. 32 (12) (2017) pp. 1247–1260.
6. H. Garg, A new improved score function of an interval-valued Pythagorean fuzzy set based TOPSIS method. Int. J. Uncertainty Quantification. 7 (5) (2017) pp. 463-474.
7. H. Garg, A linear programming method based on an improved score function for interval-valued Pythagorean fuzzy numbers and its application to decision-making. Int. J. Uncertain. Fuzziness. Knowl.-Based Syst. 26 (1) (2018) pp. 67-80.
8. D.-F. Li, Multiattribute decision making models and methods using intuitionistic fuzzy sets. J. Comput. Syst. Sci. 70 (2005) pp. 73–85.
9. L. Lin, X.-H. Yuan, Z.-Q. Xia, Multicriteria decision-making methods based on intuitionistic fuzzy sets. J. Comput. Syst. Sci. 73 (2007) pp. 84–88.
10. Nancy, H. Garg, An improved score function for ranking neutrosophic sets and its application to decision-making process. Int. J. Uncertainty Quantification. 6 (5) (2016) pp. 377-385.
11. X. Peng, Y. Yang, Some results for Pythagorean fuzzy sets. Int. J. Intell. Syst. 30 (11) (2015) pp. 1133– 1160.
12. X. Peng, Y. Yang, Fundamental properties of interval-valued Pythagorean fuzzy aggregation operators. Int. J. Intell. Syst. 31 (5) (2015) pp. 444-487.
13. R. Sahin, Multi-criteria neutrosophic decision making method based on score and accuracy functions under neutrosophic environment, (Dec 17, 2014). http://arxiv.org/abs/1412.5202.

14. A. Singh, A. Kumar, S. S. Appadoo, Modified approach for optimization of real life transportation problem in neutrosophic environment. Math. Probl. Eng. 2017 Article ID 2139791 (2017) 9 pages.
15. A. Singh, A. Kumar, S. S. Appadoo, A novel method for solving the fully neutrosophic linear programming problems: Suggested modifications. J. Intell. Fuzzy Syst. 37 (2019) pp. 885–895.
16. A. Singh, N. Singh, A note on "A novel accuracy function under interval-valued Pythagorean fuzzy environment for solving multi-criteria decision-making problem". Int. J Resea Engi Sci Mg. 3 (5) (May 2020) pp. 1235-1237. https://www.ijresm.com/volume-3-issue-5-may-2020/
17. A. Singh, N. Singh, A note on "A novel improved accuracy function for interval-valued Pythagorean fuzzy sets and its applications in decision-making process". Int J Emerging Tech. Inno. Resea.**7** (6), pp. 900-902, ISSN:2349-5162, 2020. DOI:http://doi.one/10.1729/Journal.23774.
18. F. Smarandache, A Unifying Field in Logics. Neutrosophy: Neutrosophic Probability, Set and Logic, Rehoboth, American Research Press, 1999.
19. F. Smarandache, A Unifying Field in Logics: Neutrosophic Logic. Multi-Valued Logic, 8 (2002) pp. 385-438.
20. F. Smarandache, Neutrosophic set, a generalization of the intuitionistic fuzzy set. Int. J. Pure Appl. Math. 24 (2005) pp. 287–297.
21. A. Thamaraiselvi, R. Santhi, A new approach for optimization of real life transportation problem in neutrosophic environment. Math. Probl. Eng. 2016, Article ID 5950747 (2016) 9 pages.
22. H. Wang, F. Smarandache, Y.Q. Zhang, R. Sunderraman, Interval Neutrosophic Sets and Logic: Theory and Applications in Computing, Phoenix, AZ: Hexis, 2005.
23. H. Wang, F. Smarandache, Y.Q. Zhang, R. Sunderraman, Single valued neutrosophic sets, Multispace Multistruct. 4 (2010) pp. 410–413.
24. R.R. Yager, Pythagorean fuzzy subsets. In Proc.: Joint IFSA World Congress and NAFIPS Annual Meeting (IFSA/NAFIPS) 2013 June 24,Edmonton, Canada, pp. 57–61, IEEE 2013.
25. R.R. Yager, Pythagorean membership grades in multicriteria decision making. IEEE Transa. Fuzzy Syst. 22 (2014) pp. 958–965.
26. R.R. Yager, A.M. Abbasov, Pythagorean membership grades, complex numbers and decision making. Int. J. Intell. Sys. 28 (2013) pp. 436–452.
27. L.A. Zadeh, Fuzzy sets. Inf. Control. 8 (1965) pp. 338–353.
28. L.A. Zadeh, Fuzzy sets and systems. Int. J. Gen. Syst. 17 (1965) pp. 129-138.
29. L.A. Zadeh, Is there a need for fuzzy logic? Inf. Sci. 178 (2008) pp. 2751–2779.
30. F. Zhang, Y. Ge, H. Garg, L. Luo, Commentary on "A new generalized improved score function of interval-valued intuitionistic fuzzy sets and applications in expert systems" [Appl. Soft Comput., 2016 (38) 988-999]. Appl. Soft Comput. 52 (2017) pp. 48–52.
31. X.L. Zhang, Z.S. Xu, Extension of TOPSIS to multi-criteria decision making with Pythagorean fuzzy sets. Int. J. Intell. Syst. 29 (2014) pp. 1061–1078.
32. X. Zhang, Multi-criteria Pythagorean fuzzy decision analysis: A hierarchical QULAIFLEX approach with the closeness index based ranking. Inf. Sci. 330 (2016) pp. 104-124.