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Development of Fuzzy-Based Methodologies for Decision-Making Problem

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Abstract

Decision-making is a crucial task of our life. In the real world, the decision parameters of most decision-making problems are imprecise and ambiguous in nature, which makes the problems uncertain. To solve uncertain problems, fuzzy sets (FSs) along with its various extensions perform a crucial part in decision-making paradigm. In this thesis, we have presented approaches to tackle with decision-making problems using FS extensions such as the interval type-2 fuzzy set (IT2FS), probabilistic interval-valued intuitionistic hesitant fuzzy set (P-IVIHFS) and interval-valued

intuitionistic linear Diophantine fuzzy set (IVILDFS). We have developed an interactive decision-making approach on fuzzy production inventory using granular differentiability. The centroid index, rank index, and correlation coefficient are used in the proposed IT2FS ranking technique. Extended TOPSIS and VIKOR methods are studied to solve multi-attribute group decision-making (MAGDM) problems in the framework of P-IVIHFS. We have introduced IVILDFS as an extension of the linear Diophantine fuzzy set (LDFS). Score functions, accuracy functions and aggregation operators are proposed in the framework of IVILDFS and implemented to tackle decision-making problems. Preservation technology is used in the fuzzy production model to control the deterioration rate of the product, and granular differentiability approach is used for defuzzification. The proposed techniques are illustrated using numerical examples and comparative studies.

Keywords

Multi-criteria decision-making **IT2FS**

Centroid point value **Correlation coefficient**

Mellin transform **P-IVIHFS** **TOPSIS method**

VIKOR method **IVILDFS**

Fuzzy optimal control (FOC)

Granular differentiability

References

1. Koontz H, O'Donnell C (1964) Principles of management; an analyses of managerial functions. McGraw-Hill, New York

2. Zadeh LA (1965) Fuzzy sets. Inf Control 8:338–353. https://doi.org/10.1016/S0019-9958(65)90241-X

3. De A, Das S, Kar S (2021) Ranking of interval type 2 fuzzy numbers using correlation coefficient and Mellin transform. OPSEARCH. 1–31. https://doi.org/10.1007/s12597-020-00504-2

4. Zadeh LA (1975) The concept of a linguistic variable and its application to approximate reasoning-I. Inf Sci (Ny) 8:199–249. https://doi.org/10.1016/0020-0255(75)90036-5

5. Mendel JM, John RI, Liu F (2006) Interval type-2 fuzzy logic systems made simple. IEEE Trans Fuzzy Syst 14:808–821. https://doi.org/10.1109/TFUZZ.2006.879986

6. Zhang Z (2013) Interval-valued intuitionistic hesitant fuzzy aggregation operators and their application in group decision-making. J Appl Math. https://doi.org/10.1155/2013/670285

7. De A, Das S, Kar S (2019) Multiple attribute decision making based on probabilistic interval-valued intuitionistic hesitant fuzzy set and extended TOPSIS method. J Intell Fuzzy Syst 37:5229–5248. https://doi.org/10.3233/JIFS-190205

8. Riaz M, Hashmi MR (2019) Linear Diophantine fuzzy set and its applications towards multi-attribute decision-making problems. J Intell Fuzzy Syst 37:5417–5439. https://doi.org/10.3233/JIFS-190550

9. Bellman RE, Zadeh LA (1970) Decision-making in a

fuzzy environment. Manage Sci 17:B-141-B-164. https://doi.org/10.1287/mnsc.17.4.b141

10. Kacprzyk J, Stanieski P (1982) Long-term inventory policy-making through fuzzy decision-making models. Fuzzy Sets Syst 8:117–132. https://doi.org/10.1016/0165-0114(82)90002-1

11. Yager RR (1978) Fuzzy decision making including unequal objectives. Fuzzy Sets Syst 1:87–95. https://doi.org/10.1016/0165-0114(78)90010-6

12. Awasthi A, Omrani H, Gerber P (2018) Investigating ideal-solution based multicriteria decision making techniques for sustainability evaluation of urban mobility projects. Transp Res Part A Policy Pract 116:247–259. https://doi.org/10.1016/j.tra.2018.06.007

13. Baas SM, Kwakernaak H (1977) Rating and ranking of multiple-aspect alternatives using fuzzy sets. Automatica 13:47–58. https://doi.org/10.1016/0005-1098(77)90008-5

14. Mendel JM (2007) Type-2 fuzzy sets and systems: an overview

15. Karnik N, Mendel MJ (2001) Operations on type-

2 fuzzy sets. Fuzzy Sets Syst 122:327–348. https://doi.org/10.1016/S0165-0114(00)00079-8

16. Mendel JM, John RIB (2002) Type-2 fuzzy sets made simple. IEEE Trans Fuzzy Syst 10:117–127. https://doi.org/10.1109/91.995115

17. Chen SM, Wang CY (2013) Fuzzy decision making systems based on interval type-2 fuzzy sets. Inf Sci (Ny) 242:1–21. https://doi.org/10.1016/j.ins.2013.04.005

18. Runkler T, Coupland S, John R (2017) Interval type-2 fuzzy decision making. Int J Approx Reason 80:217–224. https://doi.org/10.1016/j.ijar.2016.09.007

19. Qin J, Liu X, Pedrycz W (2017) An extended TODIM multi-criteria group decision making method for green supplier selection in interval type-2 fuzzy environment. Eur J Oper Res 258:626–638. https://doi.org/10.1016/j.ejor.2016.09.059

20. Chen SM, Lee LW (2010) Fuzzy multiple attributes group decision-making based on the interval type-2 TOPSIS method. Exp Syst Appl

37:2790–2798. https://doi.org/10.1016/j.eswa.2009.09.012

21. Celik E, Bilisik ON, Erdogan M, Gumus AT, Baracli H (2013) An integrated novel interval type-2 fuzzy MCDM method to improve customer satisfaction in public transportation for Istanbul. Transp Res Part E Logist Transp Rev 58:28–51. https://doi.org/10.1016/j.tre.2013.06.006

22. Qin J, Liu X, Pedrycz W (2015) An extended VIKOR method based on prospect theory for multiple attribute decision making under interval type-2 fuzzy environment. Knowledge-Based Syst 86:116–130. https://doi.org/10.1016/j.knosys.2015.05.025

23. Mitchell HB (2006) Ranking type-2 fuzzy numbers. IEEE Trans Fuzzy Syst 14:287–294. https://doi.org/10.1109/TFUZZ.2005.864078

24. Sang X, Liu X (2016) Possibility mean and variation coefficient based ranking methods for type-1 fuzzy numbers and interval type-2 fuzzy numbers. J Intell Fuzzy Syst 30:2157–2168. https://doi.org/10.3233/IFS-151928

25. Atanassov KT (1986) Intuitionistic fuzzy sets.

Fuzzy Sets Syst 20:87–96. https://doi.org/10.1016/S0165-0114(86)80034-3

26. Atanassov K, Gargov G (1989) Interval valued intuitionistic fuzzy sets. Fuzzy Sets Syst 31:343–349. https://doi.org/10.1016/0165-0114(89)90205-4

27. Lakshmana Gomathi Nayagam V, Sivaraman G (2011) Ranking of interval-valued intuitionistic fuzzy sets. Appl Soft Comput J 11:3368–3372. https://doi.org/10.1016/j.asoc.2011.01.008

28. Chen SM, Chiou CH (2015) Multiattribute decision making based on interval-valued intuitionistic fuzzy sets, PSO techniques, and evidential reasoning methodology. IEEE Trans Fuzzy Syst 23:1905–1916. https://doi.org/10.1109/TFUZZ.2014.2370675

29. Gupta P, Mehlawat MK, Grover N, Pedrycz W (2018) Multi-attribute group decision making based on extended TOPSIS method under interval-valued intuitionistic fuzzy environment. Appl Soft Comput J 69:554–567. https://doi.org/10.1016/j.asoc.2018.04.032

30. Kumar K, Chen SM (2021) Multiattribute decision

making based on interval-valued intuitionistic fuzzy values, score function of connection numbers, and the set pair analysis theory. Inf Sci (Ny) 551:100–112. https://doi.org/10.1016/j.ins.2020.11.032

31. Weibo L (2009) A novel method for ranking interval-valued intuitionistic fuzzy numbers and its application to decision making. In: 2009 international conference on intelligent human-machine systems and cybernetics, IHMSC. pp 282–285

32. Lakshmana Gomathi Nayagam V, Muralikrishnan S, Sivaraman G (2011) Multi-criteria decision-making method based on interval-valued intuitionistic fuzzy sets. Exp Syst Appl 38:1464–1467. https://doi.org/10.1016/j.eswa.2010.07.055

33. Chen SM, Yang MW, Yang SW, Sheu TW, Liau CJ (2012) Multicriteria fuzzy decision making based on interval-valued intuitionistic fuzzy sets. Expert Syst Appl 39:12085–12091. https://doi.org/10.1016/j.eswa.2012.04.021

34. Lee HM, Yao JS (1998) Economic production quantity for fuzzy demand quantity and fuzzy production quantity. Eur J Oper Res 109:203–

211. https://doi.org/10.1016/S0377-2217(97)00200-2

35. Lin DC, Yao JS (2000) Fuzzy economic production for production inventory. Fuzzy Sets Syst 111:465–495. https://doi.org/10.1016/S0165-0114(98)00037-2

36. Dutta P, Chakraborty D, Roy AR (2007) An inventory model for single-period products with reordering opportunities under fuzzy demand. Comput Math Appl 53:1502–1517. https://doi.org/10.1016/j.camwa.2006.04.029

37. Najariyan M, Farahi MH (2013) Optimal control of fuzzy linear controlled system with fuzzy initial conditions. Iran J Fuzzy Syst 10:21–35. https://doi.org/10.22111/ijfs.2013.807

38. Khatua D, Maity K, Kar S (2019) A fuzzy optimal control inventory model of product-process innovation and fuzzy learning effect in finite time horizon. Int J Fuzzy Syst 21:1560–1570. https://doi.org/10.1007/s40815-019-00659-1

39. De A, Khatua D, Kar S (2020) Control the preservation cost of a fuzzy production inventory model of assortment items by using the granular differentiability approach. Comput

Appl Math 39:1–22. https://doi.org/10.1007/s40314-020-01333-1

40. Sałabun W, Piegat A (2017) Comparative analysis of MCDM methods for the assessment of mortality in patients with acute coronary syndrome. Artif Intell Rev 48:557–571. https://doi.org/10.1007/s10462-016-9511-9

41. Anisseh M, Piri F, Shahraki MR, Agamohamadi F (2012) Fuzzy extension of TOPSIS model for group decision making under multiple criteria. Artif Intell Rev 38:325–338. https://doi.org/10.1007/s10462-011-9258-2

42. Sun B, Ma W (2014) Soft fuzzy rough sets and its application in decision making. Artif Intell Rev 41:67–80. https://doi.org/10.1007/s10462-011-9298-7

43. De A, Kundu P, Das S, Kar S (2020) A ranking method based on interval type-2 fuzzy sets for multiple attribute group decision making. Soft Comput 24:131–154. https://doi.org/10.1007/s00500-019-04285-9

44. Chen CT (2000) Extensions of the TOPSIS for group decision-making under fuzzy

environment. Fuzzy Sets Syst 114:1–9. https://doi.org/10.1016/S0165-0114(97)00377-1

45. Cheng CH (1998) A new approach for ranking fuzzy numbers by distance method. Fuzzy Sets Syst 95:307–317. https://doi.org/10.1016/S0165-0114(96)00272-2

46. Chu TC, Tsao CT (2002) Ranking fuzzy numbers with an area between the centroid point and original point. Comput Math Appl 43:111–117. https://doi.org/10.1016/S0898-1221(01)00277-2

47. Murakami S, Maeda H, Imamura S (1983) Fuzzy decision analysis on the development of centralized regional energy control system. IFAC Proc 16:363–368. https://doi.org/10.1016/S1474-6670(17)62060-3

48. Yager R (1978) Ranking fuzzy subsets over the unit interval. In: 1978 IEEE conference on decision and control including the 17th symposium on adaptive processes, pp 1435–1437

49. Chen SJ, Chen SM (2007) Fuzzy risk analysis based on the ranking of generalized trapezoidal

fuzzy numbers. Appl Intell 26:1–11. https://doi.org/10.1007/s10489-006-0003-5

50. Chen SM, Chen JH (2009) Fuzzy risk analysis based on ranking generalized fuzzy numbers with different heights and different spreads. Expert Syst Appl 36:6833–6842. https://doi.org/10.1016/j.eswa.2008.08.015

51. Chen SM, Yang MW, Lee LW, Yang SW (2012) Fuzzy multiple attributes group decision-making based on ranking interval type-2 fuzzy sets. Expert Syst Appl 39:5295–5308. https://doi.org/10.1016/j.eswa.2011.11.008

52. Xu Z (2007) Methods for aggregating interval-valued intuitionistic fuzzy information and their application to decision making. Control Decis 22:215–219. https://doi.org/10.12011/1000-6788(2016)06-1526-10

53. Faizi S, Sałabun W, Rashid T, Wątróbski J, Zafar S (2017) Group decision-making for hesitant fuzzy sets based on characteristic objects method. Symmetry (Basel) 9:136. https://doi.org/10.3390/sym9080136

54. Zhang S, Xu Z, He Y (2017) Operations and integrations of probabilistic hesitant fuzzy

information in decision making. Inf Fusion 38:1–11. https://doi.org/10.1016/j.inffus.2017.02.001

55. Yager RR (2014) Pythagorean membership grades in multicriteria decision making. IEEE Trans Fuzzy Syst 22:958–965. https://doi.org/10.1109/TFUZZ.2013.2278989

56. Yager RR (2016) Properties and applications of pythagorean fuzzy sets. Stud Fuzziness Soft Comput 332:119–136. https://doi.org/10.1007/978-3-319-26302-1_9

57. Liu P, Wang P (2018) Some q-Rung orthopair fuzzy aggregation operators and their applications to multiple-attribute decision making. Int J Intell Syst 33:259–280. https://doi.org/10.1002/int.21927

58. Zhai Y, Xu Z, Liao H (2018) Measures of probabilistic interval-valued intuitionistic hesitant fuzzy sets and the application in reducing excessive medical examinations. IEEE Trans Fuzzy Syst 26:1651–1670. https://doi.org/10.1109/TFUZZ.2017.2740201

59. Chen TY, Wang HP, Lu YY (2011) A multicriteria group decision-making approach based on

interval-valued intuitionistic fuzzy sets: a comparative perspective. Expert Syst Appl 38:7647–7658. https://doi.org/10.1016/j.eswa.2010.12.096

60. Yue Z, Jia Y (2013) A method to aggregate crisp values into interval-valued intuitionistic fuzzy information for group decision making. Appl Soft Comput J 13:2304–2317. https://doi.org/10.1016/j.asoc.2012.12.032

61. Xu J, Shen F (2014) A new outranking choice method for group decision making under Atanassov's interval-valued intuitionistic fuzzy environment. Knowledge-Based Syst 70:177–188. https://doi.org/10.1016/j.knosys.2014.06.023

62. Zhang X, Xu Z (2015) Soft computing based on maximizing consensus and fuzzy TOPSIS approach to interval-valued intuitionistic fuzzy group decision making. Appl Soft Comput J 26:42–56. https://doi.org/10.1016/j.asoc.2014.08.073

63. Yue C (2016) A geometric approach for ranking interval-valued intuitionistic fuzzy numbers with an application to group decision-making.

Comput Ind Eng 102:233–245. https://doi.org/10.1016/j.cie.2016.10.027

64. Abdullah L, Najib L (2016) A new preference scale mcdm method based on interval-valued intuitionistic fuzzy sets and the analytic hierarchy process. Soft Comput 20:511–523. https://doi.org/10.1007/s00500-014-1519-y

65. Wang LE, Liu HC, Quan MY (2016) Evaluating the risk of failure modes with a hybrid MCDM model under interval-valued intuitionistic fuzzy environments. Comput Ind Eng 102:175–185. https://doi.org/10.1016/j.cie.2016.11.003

66. Hajek P, Prochazka O (2018) Interval-valued intuitionistic fuzzy cognitive maps for supplier selection. In: Smart innovation, systems and technologies. Springer Science and Business Media Deutschland GmbH, pp 207–217

67. Hajek P, Froelich W (2019) Integrating TOPSIS with interval-valued intuitionistic fuzzy cognitive maps for effective group decision making. Inf Sci (Ny) 485:394–412. https://doi.org/10.1016/j.ins.2019.02.035

68. Biswas MHA, Huda MA, Ara M, Rahman MA

(2011) Optimal control theory and it's applications in aerospace engineering. Int J Acad Res 3:349–357

69. Derakhshan M (2015) Control theory and economic policy optimization: the origin, achievements and the fading optimism from a historical standpoint. Int J Bus Dev Stud 7:5–29. https://doi.org/10.22111/IJBDS.2015.2197

70. Thomas PJ, Olufsen M, Sepulchre R, Iglesias PA, Ijspeert A, Srinivasan M (2019) Control theory in biology and medicine: introduction to the special issue. Biol Cybern 113:1–6. https://doi.org/10.1007/s00422-018-00791-5

71. Biswas MHA, Ali A (2016) Production and process management: an optimal control approach. Yugosl J Oper Res 26:331–342. https://doi.org/10.2298/YJOR141015008K

List of Publications

72. De A, Das S, Kar S (2019) Multiple attribute decision making based on probabilistic interval-valued intuitionistic hesitant fuzzy set and extended TOPSIS method. J Intell Fuzzy Syst 37(4):5229–5248

73. De A, Kundu P, Das S, Kar S (2020) A ranking

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74. De A, Khatua D, Kar S (2020) Control the preservation cost of a fuzzy production inventory model of assortment items by using the granular differentiability approach. Comput Appl Math 39(4):1–22

75. De A, Das S, Kar (2021) Ranking of interval type 2 fuzzy numbers using correlation coefficient and Mellin transform. OPSEARCH 1–31

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