List of Publications

1. Bhaumik, A., Roy, S. K., Li, D. F., Analysis of triangular intuitionistic fuzzy matrix games using robust ranking, *Journal of Intelligent and Fuzzy Systems*, **33**(1) (2017) 327-336. **IOS Press, SCIE, IF: 1.637**
2. Roy, S. K., Bhaumik, A., Intelligent water management: a triangular type-2 intuitionistic fuzzy matrix games approach, *Water Resources Management*, **32**(3) (2018) 949-968. **Springer, SCIE, IF: 2.987**
3. Bhaumik, A., Roy, S. K., Weber, G. H., Hesitant interval-valued intuitionistic fuzzy-linguistic term set approach in Prisoners' dilemma game theory using TOPSIS: a case study on Human-trafficking, *Central European Journal of Operations Research*, **28** (2020) 797-816. **Springer, SCIE, IF: 1.260**

The list of Communicated Papers in Journals

4. Two-person zero-sum game through artificial neural network structures [communicated].
5. Two-person zero-sum game in linguistic neutrosophic environment [communicated].
6. Two-person non-zero-sum game in neutrosophic environment through cut-set approach [communicated].

List of presented papers in conferences/seminars

1. Presented a paper entitled "Triangular intuitionistic fuzzy matrix games and a new ranking approach" in National Seminar on Application of Mathematics in Technology and Management (NSAMTM 2016), Department of Basic Science & Humanities (Mathematics), Narula Institute of Technology (An Autonomous Institute under MAKAUT), Agarpara, Kolkata, September 8-9, 2016.

2. Presented a paper entitled "Fuzzy matrix games under triangular intuitionistic fuzzy environment" in UGC Sponsored 2 day National Seminar on Advanced Level of Mathematical Science, PG Department of Mathematics, Raja N. L. Khan Womens' College, Midnapore, West Bengal, February 9-10, 2017.

3. Presented a paper entitled "Triangular type-2 intuitionistic fuzzy matrix games approach to water resource management" in International Conference on Exploring Advances in Mathematical Sciences (ICEAMS 2017), Department of Mathematics, University of Gour Banga, Malda, West Bengal, March 23-24, 2017.

4. Presented a paper entitled "Hesitant interval-valued intuitionistic fuzzy linguistic term set approach in prisoners' dilemma game theory using TOPSIS" in 3rd International Conference on Mathematical Techniques in Engineering Applications (ICMTEA 2018), Department of Mathematics, Graphic Era Deemed to be University & Graphic Era Hill University, Dehradun, Uttarakhand, December 7-8, 2018.

Journal of Intelligent & Fuzzy Systems 33 (2017) 327–336
DOI:10.3233/JIFS-161631
IOS Press

Analysis of triangular intuitionistic fuzzy matrix games using robust ranking

Ankan Bhaumik[a], Sankar Kumar Roy[a] and Deng-Feng Li[b,*]
[a]*Department of Applied Mathematics with Oceanology and Computer Programming, Vidyasagar University, Midnapore, West Bengal, India*
[b]*School of Economics and Management, Fuzhou University, Fuzhou, Fujian 350108, P.R. China*

Abstract. In the last three to four decades, Fuzzy decision and Game theory are received great attention from the scientists, engineers, economists and businessmen, and achieved tremendous success as well. To realize the day-to-day problems, researchers use fuzzy and vague sets in their discussions of the game problems. In this article, we consider a matrix game whose payoffs are triangular intuitionistic fuzzy numbers and also apply robust ranking technique as ranking of fuzzy numbers to solve the matrix game. Different types of score function approaches, and accuracy function approaches are used in matrix games, but robust ranking technique to solve matrix games is rare in use. We utilize the robust ranking technique to solve matrix game and analyze numerical examples to validate the proposed technique. We describe a conclusion about the proposed study with an outlook of future study.

Keywords: Matrix game, triangular intuitionistic fuzzy number, robust ranking technique, score and accuracy functions

1. Introduction

Nothing ever exists entirely alone in this universe. Everything is in relation to everything else, though the relations are not so simple. In real-life situations, very often we are to encounter with problems which are conflicting, cooperative and coparallel game like in nature. Some problems can be solved with the applications of classical game theory. But the uncertainties due to the existence of diversified factors and asymmetric information between game players have made the situations more and more complex. 'Crisp' data fails to solve most of the critical problems and it has become feasible for a 'fuzzy set' to represent an uncertainty of payoffs of games. Fuzzy game theory provides an efficient framework which solves real life conflict, cooperative problems with fuzzy information. It is an interesting research field not only for mathematicians but also for biologists, medical diagonists, economists, behavioral scientists, pattern recognizers, environmentalists, and even for political reviewers.

Neumann and Morgenstern [15] invented the mathematical theory of games. A game involves a number of players, a set of strategies or plan of actions for each player, and a payoff which shows quantitatively the outcome of each play of the game in terms of the amounts that each player wins or losses. A player, who chooses a pure strategy, randomly selects a row or column according to some probability processes. These probability orient strategies are called mixed strategies for players. Now, if the players use mixed strategies, then the payoff can be calculated only in the expected sense such that the payoff will represent what each player can expect to receive and the player will actually receive on average only if the game is played several times. Matrix game and duality theory in Linear Programming Problem (LPP) are like twin sisters in problems where members are crisp in nature. But reality does not promote 'crisp'.

*Corresponding author. Deng-Feng Li, School of Economics and Management, Fuzhou University, Fuzhou, Fujian 350108, P.R. China. Tel./Fax: +86 0591 83768427; E-mail: lidengfeng@fzu.edu.cn.

Water Resour Manage (2018) 32:949–968
https://doi.org/10.1007/s11269-017-1848-6

Intelligent Water Management: a Triangular Type-2 Intuitionistic Fuzzy Matrix Games Approach

Sankar Kumar Roy[1] · **Ankan Bhaumik**[1]

Received: 14 December 2016 / Accepted: 25 October 2017 /
Published online: 4 November 2017

Abstract Matrix games with fuzzy payoffs have spread itself nowadays in diverse fields. Fuzzy game theory with triangular type-1 fuzzy numbers are visited more by researchers. In this paper, we consider matrix games with payoffs as triangular type-2 intuitionistic fuzzy numbers, i.e., Triangular Type-2 Intuitionistic Fuzzy Matrix Game (TT2IFMG) as a new and rare concept. A new ranking function is used to get relevant solutions of TT2IFMG. We are living in times of unprecedented scientific-technical advancement, yet facing several critical global problems that threaten human welfare and our ecosystem. Water management, a burning problem of the Earth now-a-days, is treated here under the scanner of TT2IFMG environment where we discuss some policy-management toward the free and fair accession of water against its limited resources.

Keywords Matrix games · Triangular type-1 intuitionistic fuzzy number · Triangular type-2 intuitionistic fuzzy number · Ranking function · Water management

1 Introduction and Review on Research

Water is the greatest and inordinate gift of nature. But, unfortunately, a gift that humans are squandering away. Water pollution, human waste, ground-water decrease, infrastructural affects etc. and the stolid-stultify management of water by us have made the situation worse.

Everyday, 2 million tons of sewage, industrial and agricultural waste are discharged into the world's water and 60% of the world's 227 biggest rivers' stream flows have been

✉ Sankar Kumar Roy
sankroy2006@gmail.com

Ankan Bhaumik
la.ankan@gmail.com

[1] Department of Applied Mathematics with Oceanology and Computer Programming, Vidyasagar University, Midnapore 721102, West Bengal, India

Central European Journal of Operations Research
https://doi.org/10.1007/s10100-019-00638-9

Hesitant interval-valued intuitionistic fuzzy-linguistic term set approach in Prisoners' dilemma game theory using TOPSIS: a case study on Human-trafficking

Ankan Bhaumik[1] · **Sankar Kumar Roy**[1] · **Gerhard Wilhelm Weber**[2,3]

Abstract

A game is a situation which conceives and concludes through reality involving a set of players, may be two or more. Conclusions of such situations are not always very easy, e.g., if one wins other loses. Sometimes, when considering the totality, the outcome of game is not linguistically zero, and we utter the term *non-zero-sum game*. Prisoners' dilemma game is one of most cited examples in non-zero-sum game literature. In this paper, human trafficking, one of the most rising problems of today's society is viewed through Prisoners' dilemma game using hesitant interval-valued intuitionistic fuzzy-linguistic term set, where linguistic terms in interval are expressed by linguistic semantics first, and then corresponding indices are used. Finally, Nash equilibrium is derived from the given definition, and the achieved result establishes a close contact with reality using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Dominance property of matrix game theory.

Keywords Prisoners' dilemma · Linguistic term set · Hesitant interval-valued intuitionistic fuzzy set · TOPSIS · Nash equilibrium · Human trafficking

Sankar Kumar Roy
sankroy2006@gmail.com

Ankan Bhaumik
la.ankan@gmail.com

Gerhard Wilhelm Weber
gerhard.weber@put.poznan.pl

[1] Department of Applied Mathematics with Oceanology and Computer Programming, Vidyasagar University, Midnapore, West Bengal 721102, India

[2] Faculty of Engineering Management, Chair of Marketing and Economic Engineering, Poznan University of Technology, ul. Strzelecka 11, 60-965 Poznan, Poland

[3] Institute of Applied Mathematics, Middle East Technical University, 06800 Ankara, Turkey

Published online: 25 July 2019