Chapter 15
An Intuitionistic Fuzzy Entropy Measure and Its Application in Multi-Attribute Decision Making With Incomplete Weights Information

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ABSTRACT

Fuzzy sets, as well as their extension intuitionistic fuzzy sets (IFS), are more effective and appealing tools for expressing quantitative complexity throughout the decision-making process, and they have gotten greater attention from researchers in recent years for new study directions. Keeping the advantages of IFS, this chapter proposes a novel information measure to measure the fuzziness of IFS known as entropy measure (EM). The various notable features of the proposed EM are also presented. EM is a very useful tool to determine the attribute's weight during the multi-attribute decision-making (MADM) process. Therefore, in this chapter, the authors propose a new MADM approach by using the proposed EM where the attribute's weights are absolutely unknown. Finally, the proposed MADM methodology is applied to solve the real-life MADM examples. Comparative studies are also given to show the advantages of the proposed MADM methodology. The proposed MADM methodology can overcome the weaknesses of the existing MADM approaches.

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INTRODUCTION

In the real world, every day, humans like as engineers, doctors, lawyers, scientists, or HR managers etc. face the various types of problems to complete their task successfully. In these problems to complete the task, the main important problem is to take the appropriate decision about the task. Appropriate decisions are taken to make the task easy and to find the optimal results, and it is an integral part of daily life. Decision-making is the most difficult problem for humans. Indeed, in ordinary life, "to do or not to do" is one of the foremost riddles that a person faces before jumping to action. In the real-world, for solving decision-making problems, the first main difficulty for decision maker(s) is to choose the environment to the give the assessments for performance towards the attributes of the alternatives. This aspect makes the problem more complex and uncertain for decision-makers, and can not provide their assessments in the form of crisp numbers. To remove such types of difficulties of the decision-makers Zadeh (Zadeh, 1965) introduced the concept of the fuzzy set (FS), and after that extensions of it like as intuitionistic FS (IFS) (Atanassov, 1986) have been proposed. Under the IFSs environment, the various authors (Garg & Kumar, 2019; C.-Y. Wang & Chen, 2017; Xu, 2007; Zeng et al., 2019) solve the decision-making (DM) issues.

In DM problems, multi-attribute decision-making (MADM) problems are usually use in daily-life. During the MADM process, attribute's weights directly affect the ranking orders (ROs) of alternatives. Due to the complexity of decision time, DMks cannot assign the weights for attributes. To manage this, entropy measure (EM) is an effective tool which measure the uncertainty of any data set. In last decade, EMs for the IFSs are introduced by the many researchers (Garg et al., 2017; Garg & Kaur, 2018; Liu & Ren, 2014; Szmidt & Kacprzyk, 2001; Verma & Sharma, 2013; J.-Q. Wang & Wang, 2012; Wei et al., 2012; Xu, 2005). Garg & Kaur (2018) EM is based on the two parameters R and S where either $R>1$, $0<S<1$ or $S>1$, $0<R<1$. During the MADM process, these parameters directly affect the ROs of the alternatives. In some cases, we get the different-different ROs of the alternatives as mentioned in ***Example 1*** and ***Example 2***. Therefore, there is a need of a new entropy measure that gives a unique ROs of the alternatives.

Keeping the disadvantages of the Garg & Kaur (2018) EM, in this chapter, a new EM to depict the uncertainty of the IFS has been proposed. The legality and validity of the proposed EM has been described by proofing some certain features of EM. The primary goal of defining the EM is to measure the uncertainty of IFS and to find out the weights of attribute's during the MADM process when they are absolutely unknown. Afterwards, based on the proposed EM, we establish a new MADM framework in the IFSs environment. Real-life illustrative examples are used to evaluate the developed MADM framework, and ROs are compared to current strategies to show the proposed strategy's benefits. The proposed MADM methodology can tackle the shortcomings of the MADM methods discussed in (Garg, 2019), (Garg & Kaur, 2018) and (G. Wang et al., 2018) which include the inability to classify the ROs of alternatives in certain scenarios.

This chapter is sorted out as: - A literature review about the IFS is given in Section "**LITERATURE REVIEW**". Section "**PRELIMINARIES**" reviews basic concepts of IVIFSs theory. In section "**PROPOSED ENTROPY MEASURE FOR IFS"**, an EM has been introduced for the IFSs, and defined some properties and axiom definitions. Section "**PROPOSED MADM APPROACH"** describes the proposed MADM method. In Section "**ILLUSTRATIVE EXAMPLE"**, an example has been created to demonstrate the proposed MADM technique. Section "**ADVANTAGES OF THE PROPOSED MADM APPROACH"** lists the benefits of the proposed MADM process. Section "**VALIDITY TEST**