REVIEW OF LITERATURE ON GROUP DECISION-MAKING USING PYTHAGOREAN FUZZY ENTROPY

[1]Mahantesh T S and [2]Dr. Chandra Bhan Singh
[1]Research Scholar, Department of Mathematics, SunRise University, Alwar, Rajasthan (India)
[2]Professor, Department of Mathematics, SunRise University, Alwar, Rajasthan (India)
Corresponding author Email: Mahanteshts49@gmail.com

Abstract: As a new conception of IFS (Intuitionistic Fuzzy Sets), Pythagorean Fuzzy Sets can manage conflicted details more fexibly in decision-making. This extension has been used repeatedly for decision making. This is an important trend in decision making that is worth further study in combination with the study of entropy properties. This paper proposes a new entropy for the Pythagorean Fuzzy Sets and an application measure using the TOPSIS method. The new entropy approach was used to estimate the objective weights in the decision-making procedure. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) technique is presumed that the optimum alternative has the least distance from the positive and farthest from the negative ideal solution. This approach has been widely adopted to solve MCDM issues in multiple fields. We present a simple study case where we use TOPSIS and new entropy to solve the group decision-making problem.

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Introduction: The Pythagorean fuzzy sets conveniently capture unreliable, ambiguous, and uncertain information, especially in problems involving multiple and opposing criteria. Pythagorean fuzzy sets are one of the popular generalizations of the intuitionistic fuzzy sets. They are instrumental in expressing and managing hesitant under uncertain environments, so they have been involved extensively in a diversity of scientific fields. This paper proposes a new Pythagorean entropy for Multi-Criteria Decision-Analysis (MCDA) problems. The entropy measures the fuzziness of two fuzzy sets and has an influential position in fuzzy functions. The more comprehensive the entropy, the more inadequate the ambiguity, so the decision-making established on entropy is beneficial. The COmplex PRoportional ASsessment (COPRAS) method is used to tackle uncertainty issues in MCDA and considers the singularity of one alternative over the rest of them. This can be enforced to maximize and minimize relevant criteria in an assessment where multiple opposing criteria are considered. Using the Pythagorean sets, we represent a decisional problem solution by using the COPRAS approach and the new Entropy measure.

Information fusion is a very complex process due to the existence of uncertainty. Hence, the decision-making (DM) processes are uncertain because the fusion of information is crucial in these processes. To deal with the uncertainty while collecting data from real-life scenarios, Zadeh [1] introduced the idea of the fuzzy set (FS) by using the membership degree (MrD) to express the belongingness of an object to a certain environment. According to the concept of the FS introduced by Zadeh, the value of the MrD should be assigned from [0,1]. FS is a tool to overcome the problem of uncertainty while describing real-life scenarios and it helps to model several measures that could not be dealt with crisp set theory such as height, age, beauty, etc. However, the FS contains only MrD to express the phenomenon and an object may be described with the help of two degrees. To describe the real-life phenomenon, Atanssov [2] gave the idea of intuitionistic FS (IFS) by introducing an additional degree called non-MrD (NMrD). The idea of the IFS became very popular and several researchers have applied it in many fields. The IFS is widely used in many different fields, including, business [3], economics [4], medicine [5], engineering [6], and so on. According to the idea of the IFS of Atanssov, the sum of MrD and NMrD cannot exceed [0,1]. This restriction limited the decision-makers to choose the values of the MrD and NMrD because sometimes the sum of the MrD and NMrD exceeds 1. Hence, to overcome the gap, the concept of the Pythagorean FS (PyFS) was introduced by Yager [7]. He extended the range of the MrD and NMrD by changing the condition that the sum of the squares of MrD and NMrD should be from [0,1]. By relaxing this condition, the decision-maker can choose the values of MrD and NMrD more independently than the IFS. Consequently, the PyFS has been applied by several researchers. Akram et al. [8] used the PyFS to develop the aggregation operators (AOs) based on Dombi t-norm (TNM) and Dombi t-conorm (TCNM). Jana et al. [9] used the PyFS to introduce the technique for the solution of the multi-attribute DM (MADM) by introducing the AOs. Biswas and Deb [10] used the PyFS to introduce the technique to solve the MADM problem by introducing the AOs. Biswas and Deb [10] used the PyFS to introduce the technique to solve the MADM problem.

Review of Literature:

Materials selection is very important in design and manufacturing because it maximizes the performance and minimizes the cost (Thakker, Jarvis, Buggy, & Sahed, 2008). Materials selection decisions should be taken within the initial design stage of the product life cycle once the component is first designed or redesigned (Edwards, 2005; Deng & Edwards, 2007). Any false decision making in this initial stage could lead to early failure of the component and unwanted cost. New materials have been discovered and manufactured throughout the last few decades to provide many innovative opportunities to companies in different industries through using those materials to maximize performance and minimize cost. However, due to the rapid development and manufacturing of materials, many new alternatives in materials can be used for the same product or component. Thus, engineers and designers encounter some challenges in decision making on selecting the best material from a large set of options and alternatives, taking in consideration different criteria that affect the material performance (Jajimoggala & Karri, 2013). Also, it is essential to prioritize between these criteria in order to decide which property is more critical than the others (Zhao, Su, Chen, & Yu, 2016).

Jajimoggala & Karri (2013) developed a multiple criteria decision making methodology based on two phases to select the best suitable material for an impellor. The first phase weighted and prioritized the criteria by implementing fuzzy AHP and the second phase ranked the material alternatives using fuzzy TOPSIS. In addition, the use of ranking scores in the TOPSIS methodology allowed decision makers to identify alternatives from best to worst. Moreover, employing fuzzy methods improved uncertainty and imprecise evaluation of material alternatives and criteria.

Fuzzy methods application focused on implementing triangular numbers into traditional AHP method. Therefore, this allows DMs to get a clear improvement in the overall criteria weighting and material alternatives ranking results. It was found that the proposed method is very reasonable to rank material alternatives considering several differing criteria and attributes. As well, it is capable of reinforcing the existing MCDM material selection techniques mainly when there are many alternatives (Jajimoggala & Karri, 2013).

Arul, Arumugam, & Parthiban (2014) also have applied multiple criteria decision making fuzzy TOPSIS to evaluate lean manufacturing in small and medium sized Indian industries. The TOPSIS method usually provides criteria and performance weights as crisp values. Crisp values are not always perfect in demonstrating real world situations because some of these cannot be projected with numerical values. Consequently, fuzzy set theory has been suggested to solve the vagueness and uncertainty of this issue; as a result, the model of fuzzy TOPSIS is founded.

Yang, Nasr, Ong, & Nee (2017) also concentrate on developing a multi-criteria decisionmaking framework by using the fuzzy TOPSIS method to facilitate materials selection from remanufacturing perspective and to determine the performance of alternative automotive materials. Also, this developed methodology can aid designers to improve their options about 10 materials and increase the opportunity for product remanufacturing. This method is illustrated by using two case studies in the automotive materials, an engine block and an intake manifold.

Mohagheghi, Mousavi, & Vahdanib (2017) introduce a new decision making methodology based on Pythagorean fuzzy sets (PFSs). PFSs have been extended from intuitionistic fuzzy sets and are characterized by increasing the influence of decision makers (DMs) to express their ideas and opinions. Also, PFSs gives the DMs more smoothness and flexibility in expressing uncertainty unlike many other methods, making it more credible in solving real-life decision making issues.

Zavadskas et al. (2014) reviewed various MCDM methods and pointed out that COPRAS is a rapid developed method to deal appropriately with real problems. Chatterjee and Chakraborty (2012) studied implementing COPRAS and additive ratio assessment (ARAS)-based techniques in the application of gear material selection by performing a comparative analysis. The outcome of this study showed that both methods can be effectively applied to any type of industrial material selection decision making processes, including problems with a large number of criteria and alternatives. Aghdaie, Zolfani, & Zavadskas (2013) evaluated and selected the most suitable machine tool using a hybrid model that integrates stepwise assessment ratio analysis (SWARA) and COPRAS-G. By studying the results of implementing the hybrid model in a machine tool selection problem, the implementation of COPRAS-G proves its validity by assisting the model in ranking the alternatives precisely from 23 best to worst. Petković, Madić, Radenković (2015) implemented COPRAS with weighted aggregated sum product assessment (WASPAS) in a novel MCDM approach to the machining of materials specifically in a non-conventional machining process for ceramics machining. Despite the challenge of requiring a large number of criteria and alternatives in most NCMP selection problems, this method has shown its efficiency in selecting the best NCMP for ceramics machining; therefore, it can be successfully employed for solving any type of decision-making problems in the manufacturing area. Yazdani (2015) tests the effect of implementing various normalization methods in COPRAS on decision making about selecting the most proper materials and designs. He mentioned that selecting COPRAS to be tested as MCDM method in this study is due to its recognition as a promising approach in the material selection field. It is constructed based on the attributes of alternatives to handle the complex real-world problems where the properties of attributes are conflicting.

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