Dimensional Analysis Under Pythagorean Fuzzy Set with Hesitant Linguists Term Entropy Information

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Abstract Dimensional Analysis (DA) is a method that consider an association of all the criteria involved in a problem, able to capture the interrelationship usually presents in multi-criteria problems. At the same time Pythagorean Fuzzy Set (PFS), is a recent tool used for handling fuzziness and vagueness, due is able to provide greater flexibility for decision makers to give their assessments. In addition, Multi-criteria decision making (MCDM) problems involves criteria predetermined weights and difficulty when information given is unknown or incomplete. This paper proposes the application and combination of three important tools: Dimensional Analysis, Pythagorean fuzzy sets and entropy measure for hesitant fuzzy linguistic term sets (HFLTSs) in order to solve the qualitative criteria, the interrelationship among the multiple criteria, and weights calculation when are unknown. Finally, an example case is given in order to show the functioning of the proposed hybrid method, and comparison with other weight methods.

Keywords Multi-Criteria Decision Making (MDCM) · Pythagorean Fuzzy Set (PFS) · Analysis Dimensional (DA) · Entropy

1 Introduction

Since theory of fuzzy sets was introduced by Zadeh in 1965 has reached an important success in several fields and became an important approach to handle uncertainty and inaccurate information that appears in several real life problems [1–3]. Since then, different versions of fuzzy set have been studied and proposed by some researchers [1]. Under this context, researchers are working with Pythagorean Fuzzy Set (PFS) in order to improve and developing studies concerning decision-makers are truly familiar with the criteria and alternatives evaluated [4–6].

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After introducing PFS, Yager and Abbasov studied the relationship between the Pythagorean fuzzy numbers (PFNs) and the complex number [7]. In addition other proposed works has been introduced: Zhang and Xu [8] extended the TOPSIS approach concerning to hand the Multi-criteria decision-making (MCDM) problems in terms of Pythagorean fuzzy environment. Peng and Yang [9] proposed the division and subtraction equations for PFNs. Zhang [10] developed a closeness index for Pythagorean fuzzy number (PFN) and for interval-valued Pythagorean fuzzy number (IVPFN) based on distance measures of PFNs and IVPFNs. Garg [11] developed a new approach of Pythagorean fuzzy, using information aggregation by Einstein equations and applied it to decision making.

PFS is symbolized by three values: membership, non-membership and indeterminacy [3], but the main difference consist: the addition of the degree of membership and non-membership given by experts it can be more than unit, but its square sum is the same to or less than unit [12]. Particularly, if decision makers gives their valuations or perceptions information where membership grade is 0.9 and degree of non-membership is 0.5, you can know that the Intuitionistic Fussy Sets (IFS) does not address adequately this problem because $0.9 + 0.5 > 1$ their sum exceeds 1, IFS fail to handle such situations [13]. However, $0.9^2 + 0.5^2 < 1$ therefore the PFS has capacity to represent evaluation and characterize better the uncertainty by lack of clarity than IFS [14], this advantage provides a more powerful representation of uncertainty established by the Fuzzy intuitionist and therefore Fuzzy sets are best and proved tools for modeling uncertainty [3, 15].

In other hand Dimensional Analysis (DA) is a method with capacity to consider the mutual influence between several criteria [16], then, makes it properly in multi-criteria decision making (MCDM) problems in different scales of measuring, within of a single dimensionless index [16–18]. The most remarkable advantage of DA is concerning to join the valuations or perceptions of a group of decision makers (DM) based on different information, such as alternatives, criteria and their importance [16]. It should be noted that the DA is widely mentioned and applied in different industries, but there is a vast literature on its application in the agricultural and automotive sector [19]. Nevertheless, DA presents the weakness to operate with qualitative information usually involved in MCDM problems [19].

In other hand, entropy measure for hesitant fuzzy linguistic term sets (HFLTSs), is applied when information is missing, incomplete, or lots of information are lost [20, 21], due expressing decision maker´s opinion in uncertainty (caused by subjective weights) is hard to provide accurate values, therefore real numbers would change to linguistic terms which are closer to the human cognitive processes thru a proper predefined linguistic evaluation scale, is more adequate reasonable and applicable in real life problems [20, 22, 23].

However, in the literature [24–27] has been found a great amount of methods including fuzzy versions and others, but almost the majority of them has limitations, basically our purpose try to overcome the next limitations on MCDM problems: