Fuzzy Inf. Eng. (2017) 9: 181–203

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ORIGINAL ARTICLE

Parametric (R, S)-norm Entropy on Intuitionistic Fuzzy Sets with a New Approach in Multiple Attribute Decision Making

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Received: 2 May, 2016 / Revised: 7 November, 2016 /
Accepted: 20 May, 2017 /

Abstract The theory of intuitionistic fuzzy sets (IFSs) is well suitable to deal with vagueness and hesitancy. In the present communication, a new parametric (R, S)-norm intuitionistic fuzzy entropy is proposed with the proof of validity and some of its properties also discussed. The intuitionistic fuzzy entropy is useful to represent the decision information in decision making process since it is characterized by the degree of satisfiability, degree of non-satisfiability and hesitancy degree. Based on this proposed IF entropy, a new multiple attribute decision making (MADM) method is introduced and compared with an existing method. In case of attributes weight, two cases (one with completely unknown attributes weight and other with partially known attributes weight) are discussed with the help of examples. In the end, a case study of insurance companies on the basis of service qualitities is given.

Keywords Intuitionistic fuzzy entropy · (R, S)-norm intuitionistic fuzzy entropy · Multiple attribute decision making · TOPSIS · Weighted hamming distance

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Peer review under responsibility of Fuzzy Information and Engineering Branch of the Operations Research Society of China.

http://dx.doi.org/10.1016/j.fiae.2017.06.004

1. Introduction

For a multiple attribute decision making problem, where there are so many factors which need to be considered simultaneously, it becomes very difficult to arrive at a conclusion. Sometimes the situation is so complex that the crisp data are inadequate or insufficient to handle it. For such type of problems which are uncertain or vague in nature, fuzzy sets play an important role to model the human judgement. The concept of fuzzy sets was first introduced by Zadeh [37] in 1965, which assigns each element a membership number. Later in 1968, Zadeh [38] introduced the concept of fuzzy entropy. De Luca and Termini [11] axiomatized the fuzzy entropy. In addition to this, Kauffman [17] introduced the fuzzy entropy measure by a metric distance of a set from its crisp set. Yager [34] defined the entropy measure of a fuzzy set in terms of the distance of a fuzzy set from its complement.

The concept of fuzzy sets was first generalized by Atanassov [2] to 'Intuitionistic Fuzzy Sets (IFSs)'. The distinguishing fact of the IFS is that it assigns to each element a membership degree, a non-membership degree and a hesitancy degree. Firstly, Burillo and Bustince [5] defined the entropy on IFS. Szmidt and Kacprzyk [21] defined the entropy measure on IFSs with a different approach based on geometrical interpretation of IFS. Hung and Yang [13] used the concept of probability to define the entropy. Vlachos and Sergiadis [26] proposed a new entropy measure connecting the notion of entropy of a fuzzy set and intuitionistic fuzzy set. Zhang and Jiang [39] gave another intuitionistic fuzzy entropy by means of intersection and union of membership and non-membership degree of IFSs. The concept of IFSs was further extended to interval valued intuitionistic fuzzy sets by Atanassov and Gargov Atanassov [3] and Zhao and Xu [40]. Thus, more and more authors have been giving the applications of IFS theory to MADM problems in which there are mainly two hot topics:

1. Determination of attribute weights;

2. Aggregation of information for alternatives.

1. Since each factor affecting MADM has a different meaning, it can not be assumed that all have equal weights and as a result, finding the appropriate weight for each criterian is one of the main points in MADM. Various methods have been developed for finding the weights by many researchers and most of them can be categorized into two groups: subjective and objective weights. Subjective weights are determined only according to the preference decision makers. The AHP method [22], weighted least squares method [9] and Delphi method [14] belong to this category. The objective methods determine weights by solving the mathematical models without considering the decision maker's preferences. Entropy method, multi objective programming [10, 12], principle element analysis [12] etc. belong to this category. Since in many practical problems, decision maker's expertise and experience matters but when it is difficult to obtain such reliable subjective weights, the use of objective weights is useful. Many such methods were suggested by various researchers. In particular, Xia and Xu [28] proposed two methods to determine the optimal weights