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A new parametric method for ranking fuzzy numbers

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Abstract

Ranking fuzzy numbers is important in decision-making, data analysis, artificial intelligence, economic systems and operations research. In this paper, to overcome the limitations of the existing studies and simplify the computational procedures an approach to ranking fuzzy numbers based on α-cuts is proposed. The approach is illustrated by numerical examples, showing that it overcomes several shortcomings such as the indiscriminative and counterintuitive behavior of existing fuzzy ranking approaches.

Keywords: Fuzzy number; Ranking fuzzy numbers; α-cuts

1. Introduction

Fuzzy numbers are an important issue in research in fuzzy set theory [16]. Because of the suitability for representing uncertain values, fuzzy numbers have been widely used in many applications and various methods manipulating them have also been developed [2,4,8,26,28]. The results of studies on ranking fuzzy numbers have been used in application areas such as decision-making, data analysis, artificial intelligence and socioeconomic systems. In order to rank fuzzy numbers, one fuzzy number needs to be evaluated and compared to the others, but this may not be easy. Since fuzzy numbers are represented by possibility distributions, they can overlap with each other and, thus, it is difficult to determine clearly whether one fuzzy number is larger or smaller than another.

In the literature about fuzzy sets, ranking fuzzy numbers is well investigated because of its widespread usage in the area of decision making. It is a necessity to rank the obtained fuzzy

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numbers in a decision-making problem. The ranking methods can be classified in three categories. The first category directly transforms each fuzzy number into a crisp real number and the second category compares a fuzzy number to all the other $n-1$ fuzzy numbers to obtain its mapping into a positive real number. The third category differs substantially from the first two. In this category, a method for pairwise ranking or preference for all pairs of fuzzy numbers is determined and then based on these pairwise orderings, a final order of the n fuzzy numbers is attempted. Two factors play significant roles in fuzzy decision systems:

(1) Contribution of the decision-maker in the decision making process,
(2) Simplicity of calculation.

The proposed method in the present paper has both of the factors. The first factor, because the choice of α depends on the decision maker and it plays an important role in this paper.

The significance of ranking fuzzy numbers for solving real world decision problems in a fuzzy environment [27] has led to tremendous efforts being spent on the development of various ranking approaches [1,3,2,4–10,12,11,13–30]. These approaches can be categorized into mathematical approaches and linguistic approaches. Linguistic approaches focus on the development and the use of linguistic terms for describing the ranking outcome which is not sequential. This study presents a mathematical approach to ranking the fuzzy numbers.

More than 30 fuzzy ranking indices have been proposed since 1976. Jain [14,15], Dubois and Prade [11] introduced the relevant concepts of fuzzy numbers. Bortolan and Degani [1] reviewed some methods to rank fuzzy numbers, Chen and Hwang [3] proposed fuzzy multiple attribute decision making, Choobineh and Li [6] proposed an index for ordering fuzzy numbers, Dias [10] ranked alternatives by ordering fuzzy numbers, Lee and Lee-Kwang [19] ranked fuzzy numbers with a satisfaction function, Requena et al. [24] utilized artificial neural networks for the automatic ranking of fuzzy numbers, Fortemps and Roubens [13] presented ranking and defuzzification methods based on area compensation, and Raj and Kumar [23] investigated maximizing and minimizing sets to rank fuzzy alternatives with fuzzy weights. Chu and Tsao [7] proposed a method of ranking fuzzy numbers with an area between the centroid and original points. Chu and Tsao's method originated in the concepts of Lee, Li [20] and Cheng [5]. Lee and Li proposed the comparison of fuzzy numbers, for which they considered mean and standard deviation values for fuzzy numbers based on the uniform and proportional probability distributions. Wang and Lee [26] presented a new method of ranking fuzzy numbers using radius of gyration. In this paper, we shall propose a new method for ranking fuzzy numbers to overcome the shortcomings of some previous methods.

It should be noted that many existing fuzzy number ranking methods tried to make a comparison of the fuzzy numbers in an objective way. However, an important aspect of the fuzzy number applications is that it can represent the subjective knowledge of the decision maker. Since the results of comparison in real problems affect implicated individuals, the decision maker's subjective attitude should be reflected in the process of ranking. However, the objective ranking methods use a neutral attitude to evaluating them. In previous research, some preference methods were suggested. However, most of them were rather simple. They often only considered two extremes (optimistic and pessimistic) and just linearly combined the results with both the extremes. On the other hand, the method proposed in this paper, can represent the decision maker's preference information explicitly.

Our discussion is presented in 5 sections. In Section 2, we give some definitions and preliminaries. In Section 3, we describe the proposed method. In Section 4, we first give some examples to state the shortcomings of previous methods and then present a new method to overcome these