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A new method to rank fuzzy numbers using Dempster–Shafer theory with fuzzy targets

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ABSTRACT

In this paper, an extended ranking method for fuzzy numbers, which is a synthesis of fuzzy targets and the Dempster–Shafer Theory (DST) of evidence, is devised. The use of fuzzy targets to reflect human viewpoints in fuzzy ranking is not new. However, different fuzzy targets can lead to contradictory fuzzy ranking results; making it difficult to reach a final decision. In this paper, the results from different viewpoints are treated as different sources of evidence, and Murphy's combination rule is used to aggregate the fuzzy ranking results. DST allows fuzzy numbers to be compared and ranked while preserving their uncertain and imprecise characteristics. In addition, a hybrid method consisting of fuzzy targets and DST with the Transferable Belief Model is formulated, which fulfils a number of important ordering properties. A series of empirical experiments with benchmark examples has been conducted and the experimental results clearly indicate the usefulness of the proposed method.

1. Introduction

Fuzzy ranking is a procedure used to compare and order a sequence of fuzzy numbers. It has been employed in a variety of application domains, such as decision making [4,6,7,12,15,39,40], risk assessment [29,30], and artificial intelligence [17]. While many fuzzy ranking methods are available in the literature [1–9,12–16,21,23,37,39], a generic method that can provide a satisfactory solution across a variety of situations has yet been developed [12]. Indeed, fuzzy ranking is challenging as fuzzy numbers are represented by possibility distributions which can overlap with one another [15]. It is important to consider the overall possibility distribution of a fuzzy number, instead of converting a fuzzy number into a single real number (e.g., centroid-based method [9], minimizing and maximizing set-based method [5], distance-based method [1], area-based method [4,8]), as reducing the entire analysis into one number can result in the loss of information which can affect the accuracy of certain calculations [11].

A number of fuzzy ranking methods pertaining to the principle of a possibility distribution [3,6,12,14,15,23,39] have been proposed in the literature. These methods can be categorised as possibility distribution-based methods with: (i) no reference set [23]; (ii) a single reference set [14]; (iii) multiple reference sets [3,6,12,15,39]. The focus of this paper is on a synthesis of possibility distributions and multiple reference sets (also known as fuzzy targets [3,6,12,15,39]), which allows more than two fuzzy numbers to be ranked simultaneously. Fuzzy targets (i.e., optimistic, neutral, and pessimistic) are adopted to reflect human viewpoints on fuzzy ranking [3,6,12,15,39]. As an example, a ranking method based on a satisfaction function

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