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ORIGINAL ARTICLE

A Note on Ranking Fuzzy Numbers with an Area Method using Circumcenter of Centroids

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Abstract In this study, we show that ranking fuzzy numbers with the area method using circumcenter of centroids presented by Rao and Shankar failed to rank effectively the generalized fuzzy numbers. By proving a theorem and using some numerical examples, we demonstrate that their proposed method cannot rank consistently some fuzzy numbers or is not consistent with human intuition.

Keywords Fuzzy numbers · Ranking function · Centroid points · Circumcenter.

1. Introduction

Ranking fuzzy numbers has always been an attractive topic for researchers due to widely usage of this method in decision making and optimization [1-15]. Over the

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last few decades, numerous methods have been proposed in the literature to rank fuzzy numbers [15-24]. Some ranking approaches are based on centroid point of fuzzy numbers [27-38]. In a recent study, Rao and Shankar [37] using the concepts of circumcenter of centroids and index of modality proposed a fuzzy ranking method which allows the participation of decision makers in ranking fuzzy numbers. After that, they generalized their proposed rankling method to order fuzzy quantities [38]. They used an index of optimism to reflect the decision maker's optimistic attitude and also an index of modality to reflect the importance of using mode and spreads of fuzzy numbers. In this paper, we show that their proposed approach fails to rank effectively the generalized fuzzy numbers. By proving a theorem and using numerical examples, it is demonstrated that their proposed method cannot rank consistently the fuzzy numbers with small heights. Then, an improved method is proposed to overcome the shortcoming of Rao and Shankar's ranking approach. The rest of the paper is organized as follows: In Section 2, some basic concepts and definitions of fuzzy numbers are given. In Section 3, Rao and Shankar's ranking approach is reviewed briefly. In Section 4, shortcoming of Rao and Shankar's ranking approach is explored by proving a theorem and using numerical examples. Finally, Section 5 draws the conclusions.

2. Preliminaries

In this section, some basic definitions and notations required for ranking fuzzy numbers are reviewed which are taken from [37-38].

Definition 2.1 *Let U be a universe of discourse. A fuzzy set $\tilde{A}$ of U is defined by a membership function $f_{\tilde{A}} : U \to [0,1]$, where $f_{\tilde{A}}(x)$ is the degree of x in $\tilde{A}$ and is represented as $\tilde{A} = \{(x, f_{\tilde{A}}(x))/x \in U\}$.*

Definition 2.2 *The membership function of the real fuzzy number $\tilde{A}$ is given by*

$$f_{\tilde{A}}(x) = \begin{cases} f_{\tilde{A}}^{L}(x), & a \leq x \leq b, \\ w_{\tilde{A}}, & b \leq x \leq c, \\ f_{\tilde{A}}^{R}(x), & c \leq x \leq d, \\ 0, & otherwise, \end{cases}$$

where $0 \leqslant w_{\tilde{A}} \leqslant 1$ is a constant, a, b, c, d are real numbers and $f_{\tilde{A}}^{L}(x) : [a,b] \to [0, w_{\tilde{A}}]$, $f_{\tilde{A}}^{L}(x) : [c,d] \to [0, w_{\tilde{A}}]$ are two strictly monotonic and continuous functions from $\mathbb{R}$ to the closed interval $[0, w_{\tilde{A}}]$. Such fuzzy number is denoted by $\tilde{A} = (a,b,c,d; w_{\tilde{A}})$. If $w_{\tilde{A}} = 1$, then $\tilde{A} = (a,b,c,d;1)$ is a normalized fuzzy number, otherwise $\tilde{A}$ is said to be a generalized or non-normal fuzzy number. If the membership function is $f_{\tilde{A}}(x)$ piecewise linear, then $\tilde{A}$ is said to be a trapezoidal fuzzy number.

Definition 2.3 *The membership function of a trapezoidal fuzzy number is given by*

$$f_{\tilde{A}}(x) = \begin{cases} \frac{w_{\tilde{A}}(x-a)}{b-a}, & a \leq x \leq b, \\ w_{\tilde{A}}, & b \leq x \leq c, \\ \frac{w_{\tilde{A}}(x-d)}{c-d}, & c \leq x \leq d, \\ 0, & otherwise. \end{cases}$$