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Fuzzy linear programming technique for multiattribute group decision making in fuzzy environments

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Abstract

The aim of this paper is to develop a linear programming technique for multidimensional analysis of preferences in multiattribute group decision making under fuzzy environments. Fuzziness is inherent in decision data and group decision making processes, and linguistic variables are well suited to assessing an alternative on qualitative attributes using fuzzy ratings. A crisp decision matrix can be converted into a fuzzy decision matrix once the decision makers' fuzzy ratings have been extracted. In this paper, we first define group consistency and inconsistency indices based on preferences to alternatives given by decision makers and construct a linear programming decision model based on the distance of each alternative to a fuzzy positive ideal solution which is unknown. Then the fuzzy positive ideal solution and the weights of attributes are estimated using the new decision model based on the group consistency and inconsistency indices. Finally, the distance of each alternative to the fuzzy positive ideal solution is calculated to determine the ranking order of all alternatives. A numerical example is examined to demonstrate the implementation process of the technique.

Keywords: Fuzzy multiattribute group decision making; Linear programming technique for multidimensional analysis of preference; Linguistic variable; Fuzzy number; Linear programming

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1. Introduction

Multiple attribute decision making (MADM) problems are widespread in real life decision situations [3,4,8–11]. A MADM problem is to find a best compromise solution from all feasible alternatives assessed on multiple attributes, both quantitative and qualitative. Suppose the decision makers have to choose one of or rank n alternatives: $A_1, A_2, \dots, A_n$ based on m attributes: $C_1, C_2, \dots, C_m$. Denote an alternative set by $A = \{A_1, A_2, \dots, A_n\}$ and an attribute set by $C = \{C_1, C_2, \dots, C_m\}$. Let x_{ij} be the score of alternative A_i $(i = 1, 2, \dots, n)$ on attribute C_j $(j = 1, 2, \dots, m)$, and suppose ω_j is the relative weight of attribute C_j, where $\omega_j \geqslant 0$ $(j = 1, 2, \dots, m)$ and $\sum_{j=1}^{m} \omega_j = 1$. Denote a weight vector by $\boldsymbol{\omega} = (\omega_1, \omega_2, \dots, \omega_m)^{\mathrm{T}}$. A MADM problem can then be expressed as the following decision matrix:

$$D = (x_{ij})_{n\times m} = \begin{matrix} \\ A_1 \\ A_2 \\ \vdots \\ A_n \end{matrix} \begin{matrix} \begin{matrix} C_1 & C_2 & \cdots & C_m \end{matrix} \\ \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{pmatrix} \end{matrix}$$

The above MADM problem can be dealt with using several existing methods such as the technique for order preference by similarity to ideal solution (TOPSIS) developed by Hwang and Yoon [8], the linear programming technique for multidimensional analysis of preference (LINMAP) developed by Srinivasan and Shocker [13] and the nonmetric multidimensional scaling (MDS). The TOPSIS and LINMAP methods are two well-known MADM methods, though they require different types of information. In the TOPSIS method, the decision matrix $\boldsymbol{D}$ and the weight vector $\boldsymbol{\omega}$ are given as crisp values a priori; a positive ideal solution (PIS) and a negative ideal solution (NIS) are generated from $\boldsymbol{D}$ directly; the best compromise alternative is then defined as the one that has the shortest distance to PIS and the farthest from NIS. However, in the LINMAP method, the weight vector $\boldsymbol{\omega}$ and the positive ideal solution are unknown a priori. The LINMAP method is based on pairwise comparisons of alternatives given by decision makers and generates the best compromise alternative as the solution that has the shortest distance to the positive ideal solution.

Under many conditions, however, crisp data are inadequate or insufficient to model real-life decision problems [1,2,5,6,12]. Indeed, human judgments are vague or fuzzy in nature and as such it may not be appropriate to represent them by accurate numerical values. A more realistic approach could be to use linguistic variables to model human judgments [3–5,9,12]. In this paper, we further extend the LINMAP method to develop a new methodology for solving multiattribute group decision making problems in a fuzzy environment [6,7]. In