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Taylor series approach to fuzzy multiobjective linear fractional programming

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Abstract

This paper presents the use of a Taylor series for fuzzy multiobjective linear fractional programming problems (FMOLFP). The Taylor series is a series expansion that a representation of a function. In the proposed approach, membership functions associated with each objective of fuzzy multiobjective linear fractional programming problem transformed by using a Taylor series are unified. Thus, the problem is reduced to a single objective. Practical applications and numerical examples are used in order to show the efficiency and superiority of the proposed approach.

Keywords: Multiobjective linear fractional programming; Fuzzy multiobjective linear fractional programming; Taylor series; Fuzzy programming

1. Introduction

The fractional programming (FP) problem, which has been used as an important planning tool for the past four decades, is applied to different disciplines such as engineering, business, finance, economics, etc. FP is generally used for modeling real life problems with one or more objective(s) such as profit/cost, inventory/sales, actual cost/standard cost, output/employee etc.

The multiobjective linear fractional programming problem (MOLFP) is considered in the literature, cf. [9,10,14,16,18]. MOLFP problems pose some computational difficulties, so they are converted into single objective FPs and then solved using the method of Bitran and Novaes [4] or Charnes and Cooper [6]. Uncertainty is an attribute of information [21], and fuzzy set theory has been used for all forms of uncertainty. The model of MOLFP is reconstructed with fuzzy data. Bellman and Zadeh [3] introduce fuzzy decision-making models in mathematical programming. Luhandjula [15] proposed a linguistic approach to MOLFP by introducing linguistic variables. A fuzzy approach for solving MOLFP was presented by Sakawa and Kato [19]. Dutta et al. [7,8] and Hitosi and Takahashi [12] also studied solutions to FMOLFP problems. A goal programming procedure for fuzzy multiobjective linear fractional programming problem was studied by

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Pal et al. [17]. However, many methods of solving fuzzy multiobjective linear programming (FMOLP) problems are available in the literature [5,11,20]. They are effective and robust approaches. Furthermore, there are a few studies [1,2,13] on multiobjective nonlinear fractional problems in recent years. Ahmad [1] proposed a symmetric duality for fuzzy multiobjective nonlinear fractional problems. Antczak [2] presented a modified objective function method for solving nonlinear multiobjective fractional programming problems.

In this paper, membership functions, which are associated with each objective of FMOLFP, are transformed by using first-order Taylor polynomial series. Here, the Taylor series obtains polynomial membership functions which are equivalent to fractional membership functions associated with each objective. Then, FMOLFP can be reduced into a single objective. In other words, suitable transformations can be applied to formulate an equivalent fuzzy multiobjective linear fractional programming problem. The performance of the proposed method was experimentally validated by two practical applications and examples which are considered by Pal et al. [17]. Results demonstrate that the proposed approach runs more effectively.

2. Formulation of the problem

In this section, first, LFP, MOLFP and FMOLFP will be described mathematically and then application of the Taylor series for FMOLFP problems will be explained in detail.

2.1. Linear fractional programming

Charnes and Cooper [6] stated the general format of LFP, which can be written as

$$
\begin{aligned}
&\text{Optimize} \quad \frac{c^k x+\alpha}{d^k x+\beta},\\
&\text{s.t.} \quad Ax\begin{pmatrix}\leqslant\\=\\\geqslant\end{pmatrix}b,\\
&\quad x\geqslant 0,\quad x\in R^n,\ c^k,d^k\in R^n,\\
&\quad A\in R^{m\times n},\ \alpha,\beta,b\in R^n.
\end{aligned}
\tag{2.1}
$$

For some values of x, $d^kx+\beta$ may be equal to zero. To avoid such cases, $d^kX+\beta$ is generally set to greater than zero.

2.2. Multiobjective linear fractional programming

Pal et al. [17] stated the general format of MOLFP as follows: If $Z_i(x)=\dfrac{c_ix+\alpha_i}{d_ix+\beta_i}$ $x\in R^n, c_i, d_i\in R^n, \alpha_i, \beta_i\in R^n$.

then,

$$
\begin{aligned}
&\text{Max} \quad Z(x)=(Z_1(x),Z_2(x),\ldots,Z_K(x)),\\
&\text{s.t.} \quad Ax\begin{pmatrix}\leqslant\\=\\\geqslant\end{pmatrix}b,\\
&\quad x\geqslant 0,\\
&\quad A\in R^{m\times n},\ b\in R^n.
\end{aligned}
\tag{2.2}
$$

2.3. Fuzzy multiobjective linear fractional programming

If an imprecise aspiration level is introduced to each of the objectives of MOFP, then these fuzzy objectives are called fuzzy goals [17].