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A Novel Algorithm to Find the Best Solution for Fuzzy Pentagonal Numbers with Linear Programming Problems

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Abstract

Fuzzy numbers are used in various fields, such as fuzzy process methods, decision control theory, problems involving decision making, systematic reasoning, and fuzzy systems, including fuzzy set theory. In this paper, pentagonal fuzzy variables (PFV) are used to formulate linear programming problems (LPP). Here, we will concentrate on an approach to addressing these issues that uses the simplex technique (SM). Linear programming problems (LPP) and linear programming problems (LPP) with pentagonal fuzzy numbers (PFN) are the two basic categories into which we divide these issues. The focus of this paper is to find the optimal solution (OS) for LPP with PFN on the objective function (OF) and right-hand side. New ranking function (RF) approaches for solving fuzzy linear programming problems (FLPP) with a pentagonal fuzzy number (PFN) have been proposed, based on new ranking functions (N RF). The simplex method (SM) is very easy to understand. Finally, numerical examples (NE) are used to demonstrate the suggested approach's computing process.

Keywords: Fuzzy set (FS), pentagonal fuzzy number (PFN), linear programming problem (LPP), simplex method (SM), ranking function (RF).

1.Introduction

There are various applications for the discipline of linear programming (LP), which is a subfield of operations research (OR) [1]. A primal model's linear programming parameters and values must be precise. This assumption, however, does not reflect reality in the real world. There may be some degree of parameter uncertainty in the issues that we must deal with regularly. First, [2] and [3] used constrained and unrestricted linear fractional programming problems (LFPP) with interval coefficients in the goal function using the development Lagrange technique and developed the idea of fuzzy linear programming (FLP). Several authors have investigated fuzzy linear programming [4-8]. [9] examined the use of a linear ranking function (LRF) as a creative method of solving difficulties with fuzzy numbers (FN) in LP. The novel proposed method of S. K. Das [10], which is based on the ranking function, transforms to the crisp linear programming (CLP) problem. The currently available LP method is being used to solve the obtained CLP problem.

The structure of this article is as follows: The introduction and fundamental definitions of fuzzy sets and the Pentagonal Fuzzy Number (PFN) are provided in Section two. A new ranking function (NRF) technique and an illustration are provided in Section three. Section four is a novel algorithm to find an optimal solution of PFN with LPP, with examples followed in Section Five, and the conclusion is described in Section six.

2.Basic Concepts

This section recalls some simple definitions of fuzzy numbers (FN) and pentagonal fuzzy numbers (PFN).

Definition 2.1 (FS) [11]:

A Fuzzy set (FS) is specified by = $\{(\tilde{\mathcal{G}},(\mathcal{G})): \mathcal{G} \in X, \mu \ (\mathcal{G}) \in [0,1]\}$. In the relationship $(\tilde{\mathcal{G}},(\mathcal{G})$, the membership function is the interval [0, 1] between the second element μ $(\mathcal{G})$ and the first element $\mathcal{G}$, both of which are members of the classical set $\mathcal{N}$.

Definition 2.2 (PFN) [12]:

A Pentagonal Fuzzy Number (PFN) of a fuzzy set $Ȩ$ is defined as $\ddot{E}$= {ą, ȿ, ɛ̡, í, ϱ}, and its membership function is given by,

$$\text{Ë}(\text{ḫ}) = \begin{cases} K_1(\text{ḫ}) = \dfrac{(\text{ḫ} - \text{ą})}{(\text{ȿ} - \text{ą})} & for \quad \text{ą} \le \text{ḫ} \le \text{ȿ} \\ K_2(\text{ḫ}) = \dfrac{(\text{ḫ} - \text{ȿ})}{(\text{ɛ̡} - \text{ȿ})} & for \quad \text{ȿ} \le \text{ḫ} \le \text{ɛ̡} \\ 1 & for \quad \text{ḫ} = \text{ɛ̡} \\ H_1(\text{ḫ}) = \dfrac{(\text{ḫ} - \text{ą})}{(\text{ȿ} - \text{ą})} & for \quad \text{ɛ̡} \le \text{ḫ} \le \text{í} \\ H_2(\text{ḫ}) = \dfrac{(\text{ḫ} - \text{ą})}{(\text{ȿ} - \text{ą})} & for \quad \text{í} \le \text{ḫ} \le \text{ϱ} \\ 0 & otherwise \end{cases}$$

3.Approach New Ranking Function (NRF) Technique:

We introduce a novel ranking method in this study with a weighted pentagonal membership function.

Now, we use the following ranking function:

$$ղ(ȍ_ȶ) = \frac{\int_0^{ɣ} \varphi^{15} \left[\frac{K^{-1}(\varphi)}{2} + \frac{H^{-1}(\varphi)}{2} \right] d\varphi}{\int_0^{ɣ} \varphi^{15} \quad d\varphi}$$

$$ղ(ȍ_ȶ) = \frac{1}{2}[\frac{\frac{1}{2}\int_0^{ɣ} \varphi^{\ 15} [ą+ȿ+(ę-ą)\varphi+í+ǫ-(ǫ-ę)\varphi\ ]d\varphi}{\int_0^{ɣ} \varphi^{\ 15} \quad d\varphi}]$$

By using $the\ \alpha - cut$ where $0 \le ɣ \le 1$

$$ղ(ȍ_ȶ) = \frac{1}{2}[\frac{\frac{1}{2}\left[\frac{ą}{16}+\frac{ȿ}{16}+\frac{ę}{17}-\frac{ą}{17}+\frac{í}{16}+\frac{ǫ}{16}-\frac{ǫ}{17}-\frac{ę}{17}\right]}{\frac{1}{16}}]$$

$$ղ(ȍ_ȶ) = \frac{1}{2}[\frac{\frac{1}{2}\left[\frac{ą+17ȿ+32ę+17í+ǫ}{272}\right]}{\frac{1}{16}}$$

Then,

$$ղ(ȍ_ȶ) = \frac{1}{4}\ [\frac{[ą+17ȿ+32ę+17í+ǫ\ ]}{\frac{1}{17}}$$

$$ղ(ȍ_ȶ) = \ [\frac{ą+17ȿ+32ę+17í+ǫ}{68}]$$

4.A novel algorithm to find the best solution for pentagonal fuzzy numbers

Step 1: Create a linear programming problem from the provided problem.

Step 2: Convert the indicated data into an interval-valued pentagonal fuzzy number.

Step 3: using the given problem approach, convert the interval value into a pentagonal fuzzy number.

Step 4: The pentagonal fuzzy number can be reformulated to the CLPP using the proposed ranking function applying to the right-hand side and main objective.

Step 5: The CLPP is solved using the Simplex method to obtain the OS.

5.Illustrative Example

Take the following LPP:

$Max\ Ġ = 15\ Ƹ_1 + 6\ Ƹ_2 + 3\ Ƹ_3$

Subject to the constraints,

$13\,ƹ_1 + 5\,ƹ_2 + 3\,ƹ_3 \le 103$

$10\,ƹ_1 + 6\,ƹ_2 + 5\,ƹ_3 \le 80$

$5\,ƹ_1 + 7\,ƹ_2 + 3\,ƹ_3 \le 83$

$ƹ_1, ƹ_2, ƹ_3 \ge 0$

The optimal solution is given by the simplex method:

$ƹ_1 = 7.786, ƹ_2 = 0.357, ƹ_3 = 0, \quad Max\ \dot{G} = 118.929$

Consider the following LPP with fuzzy variables (FV),

$Max\ \dot{G} = (13,14,15,17,19)ƹ_1 + (4,5,6,8,10)ƹ_2 + (1,2,3,5,7)ƹ_3$

Subject to the constraints,

$13\,ƹ_1 + 5\,ƹ_2 + 3\,ƹ_3 \le (101,102,103,105,107)$

$10\,ƹ_1 + 6\,ƹ_2 + 5\,ƹ_3 \le (78, 79, 80,82,84)$

$5\,ƹ_1 + 7\,ƹ_2 + 3\,ƹ_3 \le (81,82, 83,85,87)$

$ƹ_1, ƹ_2, ƹ_3 \ge 0$

By using a new ranking function $\eta(\tilde{Ồ}_ŧ) = \left[\frac{ą+17ş+32ę+17í+ǫ}{68}\right]$, the FLPP is converted into CLPP becomes:

$Max\ \dot{G} = 15.279\,ƹ_1 + 6.279\,ƹ_2 + 3.279\,ƹ_3$

Subject to

$13\,ƹ_1 + 5\,ƹ_2 + 3\,ƹ_3 \le 103.279$

$10\,ƹ_1 + 6\,ƹ_2 + 5\,ƹ_3 \le 80.279$

$5\,ƹ_1 + 7\,ƹ_2 + 3\,ƹ_3 \le 83.279$

$ƹ_1, ƹ_2, ƹ_3 \ge 0$

The optimal solution of the above LPP is

$ƹ_1 = 7.796, \; ƹ_2 = 0.387, ƹ_3 = 0, \; Max\ \dot{G} = 121.540$

6.Conclusion

In this study, we present a simplex method for addressing pentagonal fuzzy number problems in fuzzy linear programming. Using the suggested approach and turning the given problem into a crisp equivalent problem, a numerical example is solved.

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