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A NOVEL APPROACH FOR SOLVING FUZZY LINEAR PROGRAMMING PROBLEMS USING ICOSAGONAL FUZZY NUMBERS

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ABSTRACT

This study introduces a new approach for solving fuzzy linear programming problems using Icosagonal Fuzzy Numbers (IFNs**)**. The IFN is defined by twenty parameters, providing greater flexibility for representing uncertainty compared to conventional fuzzy numbers. Arithmetic operations and a ranking-based defuzzification method are developed for IFNs. The proposed approach converts the fuzzy optimization problem into an equivalent crisp linear programming model. The resulting model is solved using the Simplex Method. A numerical example is presented to demonstrate the effectiveness of the proposed technique.The results show that IFNs provide improved modelling capability and more realistic representation of uncertainty compared with traditional fuzzy numbers.

KEYWORDS: Fuzzy linear programming, Icosagonal fuzzy number, ranking method, optimization under uncertainty.

1.INTRODUCTION

Real-world optimization problems often involve uncertainty and imprecision in parameters. Classical linear programming models assume deterministic data, which restricts their applicability in complex decision environments. To address this issue, fuzzy optimization techniques have been widely used. Traditional fuzzy linear programming approaches generally rely on triangular or trapezoidal fuzzy numbers. However, these representations may not adequately capture complex uncertainty structures.Optimization plays a fundamental role in decision-making problems across engineering, economics, and management science. Linear programming is one of the most widely applied optimization techniques for resource allocation, transportation planning, and production scheduling.

However, classical linear programming assumes that all parameters are precisely known. In practical situations, decision parameters such as cost, demand, and resource availability often involve uncertainty. Such uncertainty may arise from incomplete data, measurement errors, or subjective judgment.To deal with imprecision in mathematical modelling, Lotfi A. Zadeh introduced the concept of Fuzzy Set Theory in 1965. Since then, fuzzy logic has been widely used to extend classical optimization models to uncertain environments.

The concept of **Fuzzy Linear Programming Problems (FLPP)** was introduced to incorporate fuzzy parameters into linear programming models. Several researchers have proposed various approaches for solving FLPPs using different types of fuzzy numbers such as triangular, trapezoidal, pentagonal, and hexagonal fuzzy numbers.Although these fuzzy representations are widely used, they may not accurately describe complex uncertainty patterns because they involve only a small number of parameters.To overcome these limitations, this paper introduces **Icosagonal Fuzzy Numbers (IFNs)** for modelling uncertain parameters in fuzzy linear programming problems. The IFN uses twenty parameters to represent uncertainty more flexibly and realistically.

Fuzzy optimization has been extensively studied over the past several decades. The concept of fuzzy decision making was initially developed by Lotfi A. Zadeh and later extended to optimization problems by Bellman and Zadeh.Several researchers have proposed methods for solving fuzzy linear programming problems. Early approaches primarily used triangular fuzzy numbers due to their simplicity and computational efficiency.Zimmermann developed a flexible programming approach for solving fuzzy optimization problems by converting fuzzy constraints into equivalent crisp constraints using membership functions.Subsequent studies introduced trapezoidal fuzzy numbers to provide a more realistic representation of uncertainty. Later research explored more complex fuzzy representations such as pentagonal and hexagonal fuzzy numbers.

However, these models still provide limited flexibility in representing uncertainty because they rely on relatively few parameters. Increasing the number of parameters allows more accurate modelling of real-world uncertainty. Recently, researchers have explored advanced fuzzy numbers such as decagonal and dodecagonal fuzzy numbers. Nevertheless, research on

Icosagonal Fuzzy Numbers in optimization remains limited. Therefore, this study aims to fill this research gap by developing a fuzzy linear programming model based on IFNs.

2. PRELIMINARIES

In this section, we give the preliminaries that are required for this study.

Definition 2.1. *A fuzzy set* A *is defined by* $A = \{(x, \mu_A(x)) : x \in A, \mu_A(x) \in [0,1]\}$. *Here* x *is crisp set* A *and* $\mu_A(x)$ *is membership function in the interval* $[0,1]$.

Definition 2.2. *The fuzzy number* A *is a fuzzy set whose membership function must satisfy the following conditions.*

(i) A fuzzy set A of the universe of discourse X is convex

(ii) A fuzzy set A of the universe of discourse X is a normal fuzzy set if $x_i \in X$ exists

(iii) $\mu_A(x)$ is piecewise continuous

3. ARITHMETIC OPERATIONS OF IFNS

For two Icosagonal fuzzy numbers:

$E_1 = (a_1, a_2, ...a_{20})$

$E_2 = (b_1, b_2, ...b_{20})$

3.1 Addition: $E_1 + E_2 = (a_1 + b_1, a_2 + b_2, ...a_{20} + b_{20})$

3.2 Subtraction : $E_1 - E_2 = (a_1 - b_1, a_2 - b_2, ...a_{20} - b_{20})$

3.3 Scalar multiplication : $(ka_1, ka_2, ...ka_{20})$

4. FUZZY LINEAR PROGRAMMING MODEL

The classical linear programming model is given by

Maximize $z = c_1x_1 + c_2x_2 \ldots\ldots + c_{n1}x_n$

Subject to $\sum a_{ij}x_j \le b_i$

$x_i \ge 0$

5. PROPOSED METHODOLOGY

Step 1: Maximize $z = \sum_{j=1}^{n} c_j x_j$

Subject to $\sum_{j=1}^{n} a_{ij} x_j \le b_i$

$x_i \geq 0$ where all co efficients are represented by IFNs

Step 2: Apply ranking function $R(A) = \frac{1}{20}\sum_{i=1}^{20} a_i$

Step 3: Transform fuzzy model into Maximize $z = \sum_{j=1}^{n} R(C_j)x_j$

Subject to $\sum_{j=1}^{n} R(a_{ij})x_j \leq R(b_i)$

Step 4: Solve using simplex method

Step 5: Obtain the optimal solution

6. Numerical Example

Consider the fuzzy optimization problem

Maximize $z = (5,5.1,5.2,5.3\ldots\ldots6.9)x_1 + (4,4.1,4.2,\ldots\ldots5.9)x_2$

Subject to the constraints $(3,3.1,3.2,3.3\ldots\ldots4.9)x_1 + (2,2.1,2.2,\ldots\ldots3.9)x_2 \leq (20,20.2,\ldots23.8)$

$x_1, x_2 \geq 0$

Applying the ranking function, Maximize $z = 6x_1 + 5x_2$

Subject to $4x_1 + 3x_2 \leq 22$

$x_1, x_2 \geq 0$

Using Simplex method, optimal solution is $x_1 = 0, x_2 = \frac{22}{3} = 7.33$, $Z_{\max} = \frac{110}{3} = 36.67$

Maximum value of the objective function is 36.67

The numerical example demonstrates the effectiveness of the proposed IFN-based fuzzy optimization model. Compared with triangular fuzzy numbers, the IFN provides the higher modelling flexibility, better uncertainty representation, improved decision accuracy. The proposed approach is particularly useful for decision problems involving complex uncertainty patterns.

CONCLUSION

This paper introduced a new method for solving fuzzy linear programming problems using **Icosagonal Fuzzy Numbers**. Arithmetic operations and a ranking method were developed for IFNs. The fuzzy optimization model was transformed into a crisp linear programming problem and solved using classical techniques. The proposed approach improves uncertainty modeling compared with traditional fuzzy numbers.

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