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STUDENT SELECTION FOR SCHOLARSHIPS AND ADMISSIONS USING FUZZY TOPSIS: AN EFFICIENT RANKING APPROACH

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Abstract:-
Abstract. In order to overcome the complexity of various evaluation criteria, this research proposes a Fuzzy TOPSIS approach for student selection in admissions and scholarships. By incorporating fuzzy logic, the method handles uncertainty and subjectivity in candidate assessments, ranking them based on their proximity to ideal solutions. A case study illustrated as an the approach is provided effectiveness, offering a robust, transparent, and efficient tool for fair and objective decision-making. The use of MATLAB ensures computational efficiency, making the method a practical solution for real-world applications.
Keywords: Selection, Ranking, Fuzzy TOPSIS, Assessment, Decision-making
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1. Introduction

1.1. A multi-criteria decision-making (MCDM) strategy that combines fuzzy logic and the traditional TOPSIS method is called the Fuzzy strategy for Order Preference by Similarity to Ideal Solution (Fuzzy TOPSIS).It is designed to address the uncertainty and vagueness often present in decision-making processes, particularly when subjective judgments are involved. Multi-Criteria Decision Making (MCDM) issues arise and are heavily utilized in a variety of fields, including the social sciences, medical sciences, economics, and more. Multiple-Criteria Decision Analysis (MCDA) and Multi-Attribute Decision- Making (MADM) are other names for MCDM problems.

Despite its differences, the MCDM have the trait of having several goals and criteria, which are frequently at odds with one another. Decision-makers must choose, evaluate, or order these options based on the criteria's weights. MCDM approaches have emerged as a significant area of operations research in recent decades. Decision-making issues are frequently impacted by limitations, goals, and outcomes that are not fully understood in the real world. MCDM has been applied in the product industry in a number of research investigations. Nonetheless, a small number of studies in the field of education use the MCDM technique. The services that students anticipate from an institution are determined by their needs, requirements, and interests.

2. Review of Literature

2.1. Shofwatul 'Uyun et., al [1] has studied that the national education system defines education as conscious and plans some efforts to create a good learning atmosphere and learning process. Therefore, students can actively develop their potentials so they will have strong religious faith, self-control, strong personality, intellectual, ethics and skills for themselves, society, and country. Francis [3] and Singh and Rawani [2] took into account the needs of students from the point of view of accreditation. Upalanchi et al. [4,5] took into account the needs of students from the perspective of placement / career development cell, as well as professional bodies. In educational institutions, determining student rankings for scholarships and admissions is a critical decision-making process. T.C. MİLLİ EĞİTİM BAKANLIGI [6] has mentioned in his work Open-ended items play an important role in assessing advanced thinking skills, especially in inclass assessments; given the need for objectivity in scoring, testing the Fuzzy TOPSIS method's selection and ranking mechanism in the assessment of open ended items was important. He also identified that Students' scores were not

identical in the multi-criteria decision-making methods used in the study while some students received the same score when the classical method was used. Institutions often evaluate candidates based on multiple criteria, such as academic performance, extracurricular achievements, socioeconomic background and more. These criteria are typically subjective and involve inherent uncertainty and imprecision, making the ranking process complex. Multi-criteria decision-making (MCDM) techniques have become more and more popular as a way to deal with this complexity. The most popular of these is the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), which ranks options according to how far they are from an ideal and a negative-ideal solution. However, traditional TOPSIS assumes precise input data, which may not adequately capture the uncertainty in human judgment or imprecise data. The best performance value for each alternative make up a Fuzzy Positive Ideal Solution[FPIS] while the worst values make up the Fuzzy Negative Ideal Solution[FNIS]. Using this technique we can also evaluate the performance level of decision makers. the performance of students is evaluated based on certain personal level criteria, and a model based on the Fuzzy TOPSIS approach has been designed to evaluate student performance [LEKSHMI and M. REGEES, [2022]. The Fuzzy TOPSIS method extends traditional TOPSIS by incorporating fuzzy logic to handle this uncertainty.

3. Methodology

Prioritizing the prerequisites for the admissions and scholarship selection processes is the main emphasis of the study project. Prioritization is done using the fuzzy-TOPSIS approach. The key features of fuzzy TOPSIS and fuzzy set theory are presented in this section.

3.1 Fuzzy Set Theory

Lotfi A. Zadeh developed fuzzy set theory in 1965 as a mathematical framework to deal with imprecision, ambiguity, and uncertainty in data. Fuzzy set theory permits degrees of membership ranging from 0 to 1, in contrast to classical (or crisp) set theory, which states that an element either belongs to a set (membership = 1) or does not belong to it (membership = 0). Every element in the discourse universe is mapped to a membership value ((μ)) between 0 and 1, according to the membership function.

- $\mu(x) = 0$: The element does not belong to the set
- $\mu(x) = 1$: The element fully belongs to the set
- $0 < \mu(x) < 1$:The element partially belongs to the set

In decision-making, fuzzy set theory is crucial, particularly when handling complicated issues requiring ambiguity, subjective judgments, or uncertainty. Unlike traditional decision-making methods that rely on precise and deterministic data, fuzzy sets provide a robust framework for handling imprecise or qualitative information, making them ideal for real-world problems. A pentagonal fuzzy set is defined by five points (a_1,a_2,a_3,a_4,a_5). It has its application in Education field for student ranking and course allocation.

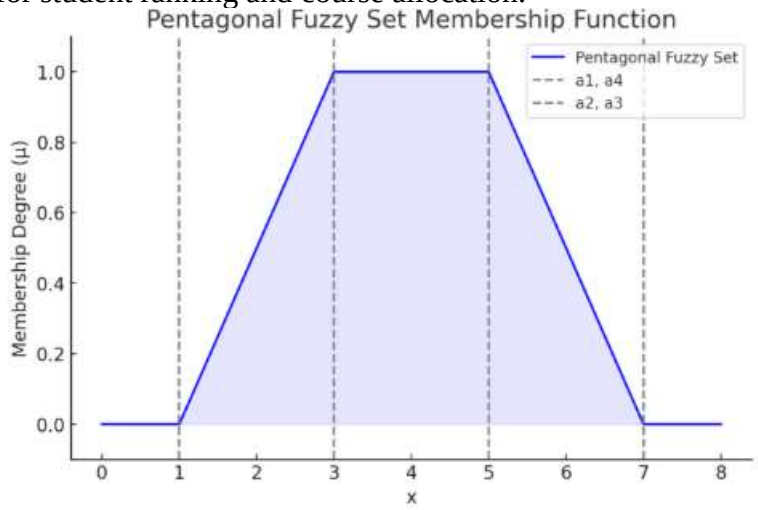

Figure 1

$$\mu A(x, w1, w2) = \begin{cases} w1, & x < 0 \\ x, & x \geq 0 \end{cases}$$

$$\mu_A(x; w_1, w_2) = \begin{cases} w_1 \frac{x-a_1}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ 1-(1-w_1)\frac{x-a_2}{a_3-a_2}, & a_2 \leq x \leq a_3 \\ 1, & x = a_3 \\ 1-(1-w_2)\frac{x-a_3}{a_4-a_3}, & a_3 \leq x \leq a_4 \\ w_2 \frac{x-a_5}{a_4-a_5}, & a_4 \leq x \leq a_5 \\ 0, & x > a_5 \end{cases}$$

3.2 Fuzzy-TOPSIS Method

The objective behind the TOPSIS technique is to choose an option that is the furthest distant from the worst-case scenario and the closest to the ideal one. In real-world situations, where decision criteria are frequently qualitative or vague, the classical TOPSIS's reliance on exact numerical data may not always be feasible. Fuzzy logic enhances TOPSIS by accommodating linguistic variables and imprecise data. Instead of relying on crisp values, Fuzzy TOPSIS represents subjective preferences and criterion weights using fuzzy numbers, such as trapezoidal or triangular fuzzy numbers. This allows for a more realistic representation of human judgments and complex decision environments.

Student Selection for Scholarships and Admissions Using Fuzzy TOPSIS: An Efficient Ranking Approach3

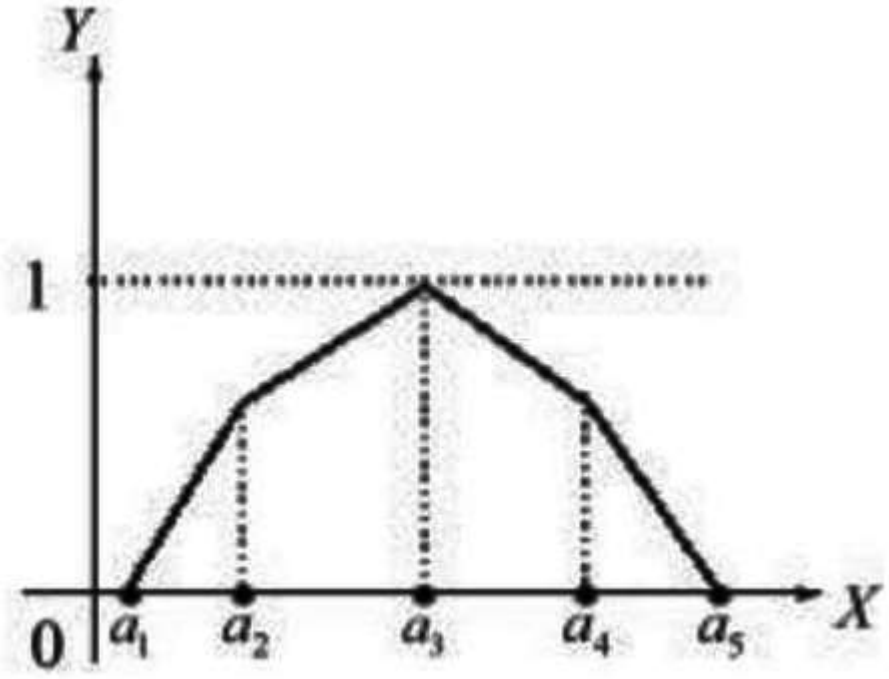

Figure 2

Key Steps in the Fuzzy TOPSIS Process

1. **Define the Problem**: Identify the alternatives to be evaluated and the criteria against which they will be assessed.
2. **Construct the Fuzzy Decision Matrix**: Gather data using fuzzy numbers to represent the performance of each alternative under each criterion.
3. **Determine Fuzzy Weights for Criteria**: Assign relative importance to each criterion using fuzzy numbers.
4. **Normalize the Fuzzy Decision Matrix**: Normalize the data to ensure comparability across criteria with different units.
5. **Determine the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS)**:
   - FPIS represents the best possible values for all criteria.
   - FNIS represents the worst possible values for all criteria.

6. **Calculate the Distance to FPIS and FNIS**: Compute the degree of closeness of each alternative to FPIS and FNIS using fuzzy distance measures.
7. **Rank the Alternatives**: Evaluate alternatives based on their closeness to the ideal solution, with higher closeness indicating better performance.

When decision makers must allocate tasks, resources, or persons to particular roles based on a number of conflicting factors, the Fuzzy TOPSIS technique is an excellent choice. This application benefits from the method's ability to handle subjective judgments and uncertainty effectively. Benefits of Using Fuzzy TOPSIS with Pentagonal Fuzzy Numbers in Student Selection Handles Uncertainty and Vagueness: Using pentagonal fuzzy numbers allows decision makers to model uncertainties in subjective evaluations (such as extracurricular activities, essays, etc.) and imprecise estimates of academic performance. Incorporates Multiple Criteria: The Fuzzy TOPSIS method allows for a multi-criteria evaluation process, which is essential in student selection where multiple factors must be considered simultaneously. Clear Ranking of Students: The output of the Fuzzy TOPSIS method provides a clear ranking of students, which helps streamline the decision-making process in scholarship and admission committee.

4. Applications

In the context of student selection for scholarships or admissions, institutions often need to evaluate students based on multiple criteria such as academic per- formance, extracurricular activities, interview results, and personal essays. The decision-making process is made less precise by the subjective and ambiguous nature of these assessments. A helpful method for managing this uncertainty is fuzzy set theory, specifically fuzzy TOPSIS, which ranks pupils according on these hazy assessments.

Steps to Apply Fuzzy TOPSIS for Student Ranking:

Create the Decision Matrix: The first step is to make a decision matrix with the students represented by rows and the selection criteria (such as extracurricular activities, academic performance, etc.) represented by columns.

Since the criteria are uncertain, each student's performance on each criterion is represented using pentagonal fuzzy numbers. For example, the academic score of a student might be uncertain and represented as a fuzzy number like p(85,88,90,92,95)

Normalize the Decision Matrix: This process transforms the values into a comparable scale and is the following step. Each value is divided by the square root of the sum of squares of all the values in the corresponding column to accomplish this.

Find the Perfect and Imperfect Solutions:

*Ideal Solution (A)**: With the highest values for every criterion, this is the best case situation. Negative Ideal Solution (A-): Tis the worst case situation, with the lowest values for every criterion. Determine the Distance to the best Solutions: Determine the distance from the ideal and negative ideal solutions for every student. These distances are calculated using the Euclidean distance formula.

$$D_i^* = \sqrt{\sum_{j=1}^{n} (x_{ij}^* - x_{ij})^2}$$

where x_{ij}^* is the value of student i for criterion j in the ideal solution, and x_{ij} is the value for the student in the actual decision matrix.

Similarly, for the negative ideal solution:

$$D_i^- = \sqrt{\sum_{j=1}^{n} (x_{ij}^- - x_{ij})^2}$$

Determine the relative proximity to the optimal solution: The next step is to determine how near each student is to the optimal solution:

$$C_i = \frac{D_i^-}{D_i^* + D_i^-}$$

Rank the Students: Each student's relative closeness is determined, and they are then arranged in descending order. The student with the lowest closeness value is ranked last, while the one with the greatest value is regarded as the best candidate.

5. Results and Discussion

A pentagonal fuzzy number is taken for applying Fuzzy-TOPSIS method.
The following decision matrix is considered for the study.

Student	Academic Performance (A)	Extracurricular Activities (B)	Leadership and Initiative (C)	Interview Score (D)
S 1	P(85, 88, 90, 92, 995)	P(4, 5, 6, 7, 8)	P(75, 78, 80, 83, 85)	P(60, 65, 70, 75, 80)
S 2	P(80, 83, 85, 88, 90)	P(5, 6, 7, 8, 9)	P(70, 73, 75, 78, 80)	P(62, 67, 72, 77, 82)
S 3	P(90, 92, 94, 96, 98)	P(3, 4, 5, 6, 7)	P(80, 82, 85, 88, 90)	P(68, 72, 76, 80, 84)
S 4	P(80, 83, 85, 87, 90)	P(6, 7, 8, 9, 10)	P(68, 70, 75, 78, 80)	P(55, 60, 65, 70, 75)

The above matrix is executed using MATLAB and the results are shown here:

```
>> ftopsis4
Defuzzified Decision Matrix:
    90.0000 85.2000 94.0000 85.0000
        6.0000 7.0000 5.0000 8.0000
    80.2000 75.2000 85.0000 74.2000
    85.0000 70.0000 76.0000 65.0000

  Normalized Decision Matrix:
          1.0000 1.0000 1.0000 1.0000
          0.0667 0.0822 0.0532 0.0941
          0.8911 0.8826 0.9043 0.8729
          0.9444 0.8216 0.8085 0.7647
  Weighted Normalized Decision Matrix:
          0.3000 0.2000 0.2000 0.3000
          0.0200 0.0164 0.0106 0.0282
          0.2673 0.1765 0.1809
          0.2833 0.1643 0.1617
  Closeness to Ideal Solution:
      1.0000
           0
      0.8756
      0.8146
  Rank of Candidates (highest rank = best):
          1
          3
          4
```

Based on the proposed method, the highest rank is considered as the best and to conclude the S3 is eligible to select for scholarship and admission.

6. Conclusion and Future Work

The fuzzy topsis method is suitable for Multi-criteria in various fields like Business, Healthcare, Public Policy, Engineering, Medical Image Processing, and so on. This may be applicable for handling uncertainty, multicriteria, flexibility, and human-like decision-making.

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