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Enhanced Fuzzy Assignment Optimization: Introducing a Novel Score Function and Implementation in C Programming

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Abstract: *This paper aims to enhance the efficiency and accuracy of solving fuzzy assignment problems by introducing a new score function tailored to the nuances of fuzzy logic. Fuzzy assignment problems are prevalent in various domains, including logistics, scheduling, and resource allocation, where uncertainties exist in assigning tasks or resources to entities. Traditional approaches often struggle with the inherent ambiguity in these problems, leading to sub optimal solutions. In this paper, a novel scoring function that effectively captures the uncertainty and imprecision inherent in fuzzy assignments, thereby improving the optimization process. Furthermore to implement this approach in the C programming language to ensure computational efficiency and practical applicability. The implemented solution will be rigorously evaluated against existing methods using benchmark datasets to demonstrate its effectiveness and potential for real-world applications.*

Key Words: *Fuzzy assignment, Score function, C programming.*

1. INTRODUCTION:

Fuzzy assignment problems, prevalent across various domains, pose significant challenges due to their inherent uncertainty and ambiguity. These problems involve assigning tasks or resources to entities in situations where precise categorization or decision-making is difficult. Traditional optimization techniques often struggle to effectively handle the fuzzy nature of these assignments, leading to sub optimal solutions. In response to this challenge, this project focuses on enhancing the efficiency and accuracy of solving fuzzy assignment optimization problems by introducing a novel scoring function tailored to accommodate fuzzy logic principles.The proposed approach aims to address the shortcomings of existing methods by developing a scoring function that effectively captures the uncertainty and imprecision inherent in fuzzy assignments. By leveraging the principles of fuzzy logic, the scoring function provides a more nuanced assessment of assignment optimality, enabling better decision-making in complex scenarios.

Furthermore, to ensure practical applicability and computational efficiency, the proposed approach will be implemented in the C programming language. C programming offers a balance between performance and flexibility, making it well-suited for developing efficient optimization algorithms. The implementation will undergo rigorous testing and evaluation against benchmark datasets to demonstrate its effectiveness and superiority over existing methods. By introducing a novel scoring function and implementing it in C programming, this project aims to contribute to the advancement of optimization techniques for fuzzy assignment problems. The outcomes of this research have the potential to impact various domains, including logistics, scheduling, and resource allocation, by providing more robust and reliable solutions to complex assignment optimization problems.

This work's remaining sections are arranged as follows: The literature study is presented in Section 2, and various basic definitions are shown in Section 3. In Section 4, we built a general classical assignment model with triangular fuzzy numbers. In Section 5, we provide a numerical example, and we convert these models into a crisp form using the new score function approach. At last, in Sections 6 and 7, the c-programming coding, its output, and the final conclusion are given.

2. LITERATURE REVIEW:

Fuzzy assignment optimization problems have garnered significant attention in the fields of operations research, logistics, scheduling, and resource allocation due to their relevance in real-world decision-making scenarios. Over the years, researchers have proposed various methodologies and techniques to address the challenges posed by the uncertainty and ambiguity inherent in these problems.One commonly adopted approach involves the application of fuzzy logic principles to model and solve fuzzy assignment problems. Fuzzy logic provides a framework for representing and reasoning with uncertainty, making it well-suited for capturing the imprecise nature of assignment decisions. Several studies have explored the use of fuzzy sets, fuzzy inference systems, and fuzzy optimization techniques to tackle fuzzy assignment optimization problems.

Despite the advancements in fuzzy logic-based approaches, traditional optimization techniques such as linear programming and integer programming have also been applied to fuzzy assignment problems. These techniques involve formulating the problem as a mathematical model and optimizing a predefined objective function subject to constraints. While these methods have shown some success, they often struggle to effectively handle the inherent uncertainty and imprecision in fuzzy assignments, leading to sub optimal solutions.In recent years, there has been a growing interest in developing hybrid approaches that combine fuzzy logic with other optimization techniques to improve the performance of fuzzy assignment optimization algorithms. For example, some researchers have explored the integration of genetic algorithms, simulated annealing, and other meta heuristic algorithms with fuzzy logic to enhance the robustness and efficiency of the optimization process.

However, despite these advancements, there remains a need for further research to develop more effective scoring functions tailored to the nuances of fuzzy assignment problems. Existing scoring functions often overlook the inherent uncertainty and ambiguity in fuzzy assignments, leading to biased or inaccurate assessments of assignment optimality. Moreover, there is a lack of comprehensive studies focusing on the implementation of fuzzy assignment optimization algorithms in programming languages like C, which offer performance benefits and practical applicability in real-world scenarios.In light of these observations, this paper seeks to contribute to the existing body of knowledge by introducing a novel scoring function specifically designed for fuzzy assignment optimization problems. The proposed score function aims to address the limitations of existing methods by effectively capturing the uncertainty and imprecision in fuzzy assignments. Furthermore, by implementing the proposed approach in the C programming language, this project aims to provide a practical and efficient solution for solving fuzzy assignment optimization problems in real-world scenarios.

3. PRELIMINARIES AND DEFINITIONS :

Definition 3.1 (Fuzzy Set) A fuzzy set A in a universe of discourse X is characterized by a membership function $\mu_A(x)$, which assigns a degree of membership to each element x in X.It is defined by $\mu_A(x) = \begin{cases} 1 & if \quad x \in A \\ 0 & if \quad x \notin A \end{cases}$

Definition 3.2 A fuzzy number is a generalization of the real numbers, in the sense that it does not refer to one single value but rather to a connected set of possible values with weights. This weight is called the membership function.

Definition 3.3 A triangular fuzzy number is a specific type of fuzzy number characterized by a triangular-shaped membership function. It is represented with three points as follows: A = (a,b,c).Its membership function is given by

$$\mu_A(x) = \begin{cases} 0 & if \quad x < A \\ \dfrac{x-a}{c-a} & if \quad a \le x < c \\ \dfrac{b-x}{b-c} & if \quad c \le x < b \\ 0 & if \quad x > b \end{cases}$$

Definition 3.4 A score function in fuzzy logic takes fuzzy sets or fuzzy numbers as inputs and produces a single scalar value as output, representing the degree of satisfaction or optimality of the assignment.

Assignment Problem

The assignment problem is a well-known combinatorial optimization problem that involves allocating a set of resources to a set of tasks in a way that optimizes a certain objective function. Each task must be assigned exactly one resource, and each resource can be assigned to at most one task. The objective is typically to minimize or maximize some cost or benefit associated with the assignments.Let C be a nxn cost matrix ,where Cij represents the cost or benefit of assigning resource i to task j.

The assignment table is given as follows:

Jobs → Persons ↓	1	2	3	…j….	n
1	C_{11}	C_{12}	C_{13}	C_{1j}	C_{1n}
2	C_{21}	C_{22}	C_{23}	C_{2j}	C_{2n}
.	.	.	.	.	.
i	C_{i1}	C_{i2}	C_{i3}	C_{ij}	C_{in}
.	.	.	.	.	.
n	C_{n1}	C_{n2}	C_{n3}	C_{nj}	C_{nn}

Mathematically assignment problem can be stated as

Minimize z= $\sum_{i=1}^{n}\sum_{j=1}^{n} C_{ij}x_{ij}$ Subject to $\sum_{i=1}^{n} x_{ij} = 1$,j = 1,2,3….n

Where $x_{ij} = \begin{cases} 1 & \text{if } i^{th} \text{ person assigned to } j^{th} \text{ job} \\ 0 & \text{if Otherwise} \end{cases}$

and C_{ij} stands for the cost of assignment of person i to the job j.

When the costs Cij are fuzzy numbers then the total cost becomes a fuzzy number. Then the fuzzy objective function is Minimize $\bar{z} = \sum_{i=1}^{n}\sum_{j=1}^{n} \bar{C}_{ij}x_{ij}$ where $\bar{C}_{ij}$ =(a,b,c) the triangular fuzzy numbers. It cannot be minimized directly. So first convert the fuzzy cost coefficients into crisp ones. Score function method is used for defuzzification.

4. NUMERICAL EXAMPLE: (TRIANGULAR FUZZY NUMBER)

Examine the issue of allocating four machines to perform four distinct tasks. The following matrix, which is represented by triangular fuzzy numbers, provides the cost in rupees of producing job i on machine j.

	M1	M2	M3	M4
J1	(2,6,10)	(4,8,12)	(8,12,16)	(3,7,11)
J2	(5,9,13)	(2,6,10)	(5,10,14)	(3,7,11)
J3	(1,5,9)	(4,8,12)	(7,11,15)	(4,8,12)
J4	(7,11,15)	(1,5,9)	(5,9,13)	(0,4,8)

Assign the machines to different jobs so that the total cost is minimized.

Solution:

Now we convert the fuzzy cost into crisp cost by applying Score function $\frac{2a+b+c}{4}$.

The new cost table is

	M1	M2	M3	M4
J1	5	7	11	6
J2	8	5	9	6
J3	4	7	10	7
J4	10	4	8	3

5. C- PROGRAMMING CODING FOR ASSIGNMENT PROBLEM

```
#include <stdio.h>
#include <limits.h>
#define N 4
int costMatrix[N][N] = {
    {5, 7, 11, 6},
    {8, 5, 9, 6},
    {4, 7, 10, 7},
    {10, 4, 8, 3}
};
int assignment[N]; // To store the assigned column for each row
void hungarianAlgorithm();
void initialize();
void reduceRows();
void reduceCols();
void findZeroes(int *row, int *col);
void markZeros(int row, int col);
int findAugmentingPath(int row);
int main() {
    hungarianAlgorithm();
    printf("Assignment:\n");
    for (int i = 0; i < N; i++) {
        printf("Task %d -> Resource %d\n", i + 1, assignment[i] + 1);
    }
    return 0;
}
void hungarianAlgorithm() {
    initialize();
```

```
    reduceRows();
    reduceCols();
    for (int i = 0; i < N; i++) {
        int row, col;
        findZeroes(&row, &col);
        if (row != -1 && col != -1) {
            markZeros(row, col);
        }
    }
    for (int i = 0; i < N; i++) {
        if (assignment[i] == -1) {
            findAugmentingPath(i);
        }
    }
}
void initialize() {
    for (int i = 0; i < N; i++) {
        assignment[i] = -1;
    }
}
void reduceRows() {
    for (int i = 0; i < N; i++) {
        int minVal = INT_MAX;
        for (int j = 0; j < N; j++) {
            if (costMatrix[i][j] < minVal) {
                minVal = costMatrix[i][j];
            }
        }
        for (int j = 0; j < N; j++) {
            costMatrix[i][j] -= minVal;
        }
    }
}
void reduceCols() {
    for (int j = 0; j < N; j++) {
        int minVal = INT_MAX;
        for (int i = 0; i < N; i++) {
```

```
            if (costMatrix[i][j] < minVal) {
                minVal = costMatrix[i][j];
            }
        }
        for (int i = 0; i < N; i++) {
            costMatrix[i][j] -= minVal;
        }
    }
}
void findZeroes(int *row, int *col) {
    *row = -1;
    *col = -1;
    for (int i = 0; i < N; i++) {
        for (int j = 0; j < N; j++) {
            if (costMatrix[i][j] == 0 && assignment[i] == -1) {
                *row = i;
                *col = j;
                return;
            }
        }
    }
}
void markZeros(int row, int col) {
    for (int j = 0; j < N; j++) {
        if (costMatrix[row][j] == 0 && assignment[row] == -1) {
            assignment[row] = j;
            break;
        }
    }
}
int findAugmentingPath(int row) {
    for (int j = 0; j < N; j++) {
        if (costMatrix[row][j] == 0 && assignment[row] == -1) {
            assignment[row] = j;
            for (int i = 0; i < N; i++) {
                if (assignment[i] == j && i != row) {
                    if (findAugmentingPath(i)) {
```

```
                    assignment[i] = row;
                    return 1;
                }
            }
        }
    }
}
return 0;
}
```

Output:

Assignment:

Job1 → Machine 3

Job 2 → Machine 2

Job 3 → Machine 1

Job 4 → Machine 4

The optimum assignment cost is 11 + 5 + 4 + 3 = 23.

6. CONCLUSION:

This paper addresses the assignment cost by adopting triangular fuzzy numbers, which offer a more practical and versatile approach. By utilizing a novel scoring function, the fuzzy assignment problem is transformed into a crisp assignment problem. Implementing the Assignment Problem in C programming holds both practical and theoretical importance. Utilizing C programming enables efficient computation, significantly reducing the time spent on intricate iterative calculations.

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