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UNRAVELING TYPE-3 FUZZY SHORTEST CYCLE ROUTE PROBLEM BY RMM

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ABSTRACT: For minimizing the trail in a network shortest cycle route problem is applied. The quest of locating a shortest possible route that visits each city precisely once for the prearranged catalog of cities and their pair wise distance is called the SCRP. In this paper we have applied reduced matrix method for unraveling a shortest cyclic route problem with crisp, fuzzy and Intuitionistic fuzzy numbers as cost coefficients. A numerical example is solved by applying this algorithm. This method is easy to understand and offer an effective tool for handling all types of FSCRP.

KEYWORDS: Type-3 Fuzzy Shortest Cyclic Route Problem, Triangular intuitionistic fuzzy numbers, and mixed constraints
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I. INTRODUCTION

In the inference of certainty the anxiety which is grant about after Transportation and Assignment problem is the Travelling sales man problem. W.R Hamilton in 19th century was the foremost to originate SCRP. The SCRP confer with perceiving the shortest route in n-city situations where each city is tripped precisely once. The SCRP has mixed appliances even in its purest formulation, such as planning, logistics, and the manufacture of microchips. The SCRP has numerous engineering implementation as scheming hardware devices and radio electronic devices, communications in the architecture of computational networks etc. Variations in measurement, deviation in accuracy, errors in computation leads to uncertainty and in exactness. Hadi Basirzadeh [7] has launched the Ones Assignment Method for untangling traveling salesman Problem. Dantzig and Fulkerson [6] have found the solution of a large-scale SCRP. Sudhakar and Navaneetha Kumar [18] presented a new method known as zero suffix method to solve SCRP s. In order to dispense with this uncertainty, we use fuzzy assignment problems rather than classical assignment problems. The Intuitionistic fuzzy set can be used if it is not viable to simplify an imprecise notion by manipulating the conventional fuzzy set. The membership of an element to a fuzzy set is a single value with the degree of acceptance between zero and one. Optimization in intuitionistic fuzzy environment was predicted by Angelov [3] .The scheme of intuitionistic fuzzy set (IFS) developed by Atanassov [4,5] is the extension of Zadeh's [19] fuzzy set.
Stephen Dingar and Thiripura Sundari[17] have found a neighboring optimal solution for Fuzzy Travelling Salesman Problem. A new algorithm for decipher a Fuzzy SCRP was proposed by Srinivasan and Geetharamani [16]. Three different methods of finding the elucidation for Intuitionistic fuzzy Assignment Problem were discussed by Krishna Prabha and Vimala [8].
Amit Kumar and Anila Gupta [1] solved assignment and travelling salesman problems with coefficients as *LR* Fuzzy parameters. Travelling Salesman Problem (SCRP) exerting Fuzzy Quantifier is evolved by Nirmala and Anju [10]. Senthil Kumar and Jahir Hussain[13] presented a new algorithm for solving Type-3 fuzzy assignment problem. Solid travelling salesman problems were examined by Mukherjee [9]. Genetic Algorithm was used by Shweta Rana [15] to solve travelling salesman problem. Pavithraa [11] applied a simple method for solving multi objective travelling salesman problem. Haar Hungarian algorithm approach was applied by Amit Kumar Rana [2] to solve a fuzzy travelling salesman Problem.

This paper has been explained in the following manner. In Section 2, some elementary interpretation on IFS, TrIFN'S, have been narrated .In Section 3, the algorithm for solving Type-3 fuzzy shortest cyclic route problem has been elucidated. In section 4 the above algorithm is interpreted with a numerical example. Section 5 concludes the paper.

II. PRELIMINARIES

In this module, some rudimentary connotation and arithmetic operations are reviewed

2.1 Intuitionistic fuzzy number:

Assorted precisions for Intuitionistic fuzzy sets were delineated by Atanassov [4, 5], Sagaya Roseline , Henry Amirtharaj [12] and Senthil kumar[13,14].

Definition 2.1.1: An IF Set Γ in X is given by Γ = $\{ x, ɱ_\Gamma(x), ɲ_\Gamma(x)/x\epsilon\, X\}$ where the functions, $ɱ_\Gamma, ɲ_\Gamma : X \rightarrow$ [0, 1] are functions such that $0 \leq ɱ_\Gamma(x), ɲ_\Gamma(x) \leq 1, \forall\, x \,\epsilon\, X$. For each, the numbers $ɱ_\Gamma(x)$ and $ɲ_\Gamma(x)$ portray the degree of membership and degree of non-membership of the element $x \in X$.

Definition 2.1.2:

A TrIFN $\tilde{\Gamma}^I$ is an intuitionistic fuzzy set in R with the subsequent membership function $ɱ_\Gamma$ (x) and non membership function $ɲ_\Gamma$(x)

$$ɱ_\Gamma(x) = \begin{cases} 0 & if\ x \leq \alpha \\ \frac{x-\alpha_1}{\alpha_2-\alpha_1} & \alpha_1 \leq x \leq \alpha_2 \\ 1 & x = \alpha_2 \\ \frac{\alpha_3-x}{\alpha_3-\alpha_2} & \alpha_2 \leq x \leq \alpha_3 \\ 0 & x > \alpha_3 \end{cases} \quad \text{and} \quad ɲ_\Gamma(x) = \begin{cases} 1 & x < \alpha' \\ \frac{\alpha_2-x}{\alpha_2-\alpha_1'} & \alpha_1' \leq x \leq \alpha_2 \\ 0 & x = \alpha_2 \\ \frac{x-\alpha_2}{\alpha_3'-\alpha_2} & \alpha_2 \leq x \leq \alpha_3' \\ 1 & x \geq \alpha_3' \end{cases}$$

Where $a_1' \leq \alpha_1 \leq \alpha_2 \leq \alpha_3 \leq \alpha_3'$ and $ɱ_\Gamma$ (x), $ɲ_\Gamma$ (x) ≤ 0.5 for $ɱ_\Gamma$ (x) = $ɲ_\Gamma$(x), $\forall\ x \in R$.

This TrIFN is represented by $\tilde{\Gamma}^I = (\alpha_1, \alpha_2, \alpha_3)\ (\alpha_1', \alpha_2, \alpha_3')$

Definition 2.1.3: The SCRP is supposed to be Type-3 F SCRP or mixed FSCRP if all the parameters of the TSP are crisp numbers, traiangular fuzzy numbers or intuitionistic triangular fuzzy numbers.

2.2 Ranking Techniques:

Defuzzification: Defuzzification is the procedure of detecting singleton value (crisp value) which delineates the average value of the TrIFNs.

2.2.1. Yager's Ranking Technique

Yager's ranking technique which gratifies recompense, linearity, additivity properties and presumes verdicts which consists of human intuition. For a convex fuzzy number ã, the Robust's Ranking Index is interpreted by,

R (ã) $= \int_0^1 (0.5)(a^L{}_\propto, a^U{}_\propto) d \propto$ -- (1)

Where $(a^L{}_\propto, a^U{}_\propto) = \{(b-a) \propto +a, c-(c-b) \propto\}$ which is the α – level cut of the fuzzy number ã

2.2.2 Ranking of triangular intuitionistic fuzzy numbers

The Ranking of a TrIFN $\tilde{\Gamma}^I = (\alpha_1, \alpha_2, \alpha_3)\ (\alpha_1', \alpha_2, \alpha_3')$ is expounded by

$$R(\tilde{\Gamma}^I) = \frac{1}{3}\left[\frac{(\alpha_3'-\alpha_1')(\alpha_3-2\alpha_1'-2\alpha_3')+(\alpha_3-\alpha_1)(\alpha_1+\alpha_2+\alpha_3)+3(\alpha_3'-\alpha_1')}{\alpha_3'-\alpha_1'+\alpha_3-\alpha_1}\right] \text{ ---------- (2)}$$

The ranking technique [4] is: If $\mathcal{R}(\tilde{\Gamma}^I) \leq \mathcal{R}(\tilde{\Upsilon}^I)$, then $\tilde{\Gamma}^I \leq \tilde{\Upsilon}^I$ i.e, min $\{\tilde{\Gamma}^I, \tilde{\Upsilon}^I\} = \tilde{\Gamma}^I$

2.3 Mathematical Formulation of SCRP:

Mathematically a SCRP can be framed as given bellow:

Optimize

$$\sum_{i=1}^{n}\sum_{j=1}^{n} d_{ij}x_{ij} \qquad \text{(i)}$$

subject to

$\sum_{j=1}^{n} x_{ij}$ = 1, i =1, 2, 3….n.

$\sum_{i=1}^{n} x_{ij}$= 1, j = 1, 2, 3….n.

$x_{ij} = 0\ or\ 1$, i=1, 2, 3….n. j = 1, 2, 3….n. (ii)

Where d_{ij} is the distance from the city 'i' to city 'j', and x_{ij} is to be some positive integer or zero, and the only possible integer is one, so the condition of $x_{ij} = 0\ or\ 1$, is automatically satisfied .

III. INTUITIONISTIC FUZZY REDUCED MATRIX METHOD (IFRMM)

Step 1: Defuzzify the Type-3 fuzzy cost matrix (T-3 FCM) for the given SCRP by utilizing the delineated ranking techniques (1) and (2) and transform the cost to crisp numbers.

Step 2: Perceive the row minimum in each row and then deduct it from each row entry of that row.

Step 3: Perceive the column minimum from each column in the upshot SCRP after employing step2 and then deduct the column minimum from each column entry of that column. Now the resulting matrix will have at least one element with rank zero in every column and row.

Step 4: In the revamped SCRP table acquired in **step3**, probe for optimal assignment as bellow

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a) Sift the rows sequentially as far as a row with a single element with rank zero is identified. Allocate this element with rank zero and cross off all other elements with rank zero in its column. Per sue this for all the rows.
b) Reiterate the procedure for each column of the truncated TS table.
c) If a row (and / or) column has two or more element with rank zero then allocate arbitrary any one of that and cross off all other elements with rank zero of that row/column.
d) Reiterate a) through c) above consecutively till the chain of assigning or cross terminates.

Step 5: The SCRP optimal solution is attained if the number of assignments is equal to n (i.e. the order of the SCRP cost matrix).If the number of assignments is less than n (i.e. the order of the SCRP cost matrix) then proceed to the **step 6**.

Step 6: Plot the minimum number of horizontal (and / or) vertical lines to cover
all the zeros of the truncated matrix. This can be done by using the following:
i) Spot the rows that do not have any allocated zero.
ii) Spot the columns that have zeros in the spotted rows.
iii) Spot rows that do have allocated zeros in the spotted columns.
iv) Ingeminate ii) and iii) above till the chain of spotting is completed.
v) Sketch lines through all the unspotted rows and spotted columns.
This renders the expected minimum number of lines.

Step 7: Erupt the new redrafted truncated SCRP cost matrix as given bellow
i) Root out the smallest entry of the truncated SCRP cost matrix not enclosed by any of the lines.
ii) Deduct this entry from all the exposed entries and add the same to all the entries existing at the convergence of any two lines.

Step 8: Reiterate step 5 to step 7 until the optimal solution to the given Type-3 fuzzy SCRP problem is achieved.

IV. ARITHMETICAL EXEMPLAR:

Consider the given example,

$$\begin{matrix} P \\ Q \\ R \\ S \\ T \end{matrix}\begin{pmatrix} - & (17,37,57) & (45,65,85)(25,65,105) & 25 & (17,37,57) \\ 37 & - & (35,55,75) & 25 & 37 \\ (45,65,85) & (37,57,77)(17,57,97) & - & (45,65,85)(25,65,105) & 45 \\ 25 & 25 & (45,65,85) & - & (45,65,85)(25,65,105) \\ (15,35,55) & 35 & (27,47,67)(17,47,77) & (45,65,85) & - \end{pmatrix} P \quad Q \quad R \quad S \quad T$$

The fuzzy numbers are renovated to crisp numbers by applying (1) and (2),

$$\begin{pmatrix} \infty & 37 & 65 & 25 & 37 \\ 37 & \infty & 55 & 25 & 37 \\ 65 & 57 & \infty & 65 & 45 \\ 25 & 25 & 65 & \infty & 65 \\ 35 & 35 & 47 & 65 & \infty \end{pmatrix}$$

Identify the least element in each row and deduct it from the remaining elements in that resultant row. Identify the least element in each column and deduct it from the remaining elements in that resultant column
.

$$\begin{pmatrix} \infty & 12 & 28 & 0 & 12 \\ 12 & \infty & 18 & 0 & 12 \\ 20 & 12 & \infty & 20 & 0 \\ 0 & 0 & 28 & \infty & 40 \\ 0 & 0 & 0 & 30 & \infty \end{pmatrix}$$

Consign the rows and columns that comprise single zeros.

$$\begin{pmatrix} \infty & 12 & 28 & (0) & 12 \\ 12 & \infty & 18 & \otimes & 12 \\ 20 & 12 & \infty & 20 & (0) \\ \otimes & (0) & 28 & \infty & 40 \\ \otimes & \otimes & (0) & 30 & \infty \end{pmatrix}$$

The recent solution is not best possible because several rows and columns are lacking allotment. By sketching bare minimum of straight lines plot all the zeros.

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$$\left(\begin{array}{ccc|cc} \infty & 12 & 28 & (0) & 12 \\ 12 & \infty & 18 & \otimes & 12 \\ 20 & 12 & \infty & 20 & (0) \\ \otimes & (0) & 28 & \infty & 40 \\ \otimes & \otimes & (0) & 30 & \infty \end{array}\right)$$

Subtract the smallest entry 12, not sketched by any line and add 12 with the elements that are in the overlap of the lines.Donot alter the elements which lie on the straight lines.

$$\begin{pmatrix} \infty & 0 & 16 & (0) & 0 \\ (0) & \infty & 3 & 0 & 0 \\ 20 & 12 & \infty & 32 & (0) \\ 0 & (0) & 28 & \infty & 40 \\ 0 & 0 & (0) & 42 & \infty \end{pmatrix}$$

Allot the rows /columns which have single zero. The present allotment is best as each row/column have accurately one enclosed zero.

The optimum schedule is given by P→S, Q→P, R→T, S→Q, and T→R ie, P→S→Q→P,R→T→R,and the corresponding distance = (25+37+45+25+47) =179 Km.

The present solution does not satisfy the route condition. Hence the above solution is not accepted. Further to identify the solution which satisfies the route condition, select 10 which is the next minimum cost entry in the given matrix. As the value occurs in two places we can deal the problem in separate two cases.

Instead of assigning at (2, 1) shift the assignment to (2, 3).we get,

$$\begin{pmatrix} \infty & \otimes & 16 & (0) & \otimes \\ \otimes & \infty & (3) & \otimes & \otimes \\ 20 & 12 & \infty & 32 & (0) \\ \otimes & (0) & 28 & \infty & 40 \\ (0) & \otimes & \otimes & 42 & \infty \end{pmatrix}$$

The best possible allotment is précised by

P→S, Q→R, R→T, S→Q, T→P, ie, P→S→Q→R→T→P.

Instead of assigning at (3, 5) shift the assignment to (3, 2).we get,

$$\begin{pmatrix} \infty & \otimes & 16 & \otimes & (0) \\ \otimes & \infty & 3 & (0) & \otimes \\ 20 & (12) & \infty & 32 & \otimes \\ (0) & \otimes & 28 & \infty & 40 \\ \otimes & \otimes & (0) & 42 & \infty \end{pmatrix}$$

P→T, Q→S, R→Q, S→P, T→R, ie, P→T→R→Q→S→P

Hence the particular sum has two best possible schedules

P→S→Q→R→T→P and P→T→R→Q→S→T.

V. CONCLUSION:

This technique can be tried for solving problems like balanced and unbalanced assignment problems, project scheduling problems, network flow problems etc, television relays, assembly lines, job scheduling. This research work can be extended for bipolar-valued fuzzy set, fuzzy multiset, fuzzy rough set, fuzzy soft set, hesistant fuzzy set, interval-valued fuzzy set, interval type-2 fuzzy sets, interval-valued Atanassov intuitionistic fuzzy set, multipolar- valued fuzzy set, neutrosophic set, and set-valued fuzzy set. Mat Lab Coding can be generated and implemented in real life time problems.

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