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Special Issue of Second International Conference on Science and Technology (ICOST 2021) **Enhanced Zero Suffix approach for the Optimal Solution of a Travelling Salesman and Assignment Problem: A summary**

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Abstract

The Enhanced Zero Suffix Method is implementing in this paper to find an optimal solution to the problem of assignment & traveling salesman. To achieve optimality, the proposed approach requires a smaller number of iterations for finding the optimal ASP solution. In order to verify the validity of the proposed procedure, numerical examples are provided here. The approach proposed is very basic, easy to understand and implement.

Keywords: Assignment Problem, Unbalanced Transportation Problem, Initial Basic Feasible Solution, Optimal Solution & Traveling Salesman Problem

1. Introduction

One of the earliest applications is the problem of assignment, and it is a special case of linear programming issues that occur in a number of fields, such as healthcare, transport, education, and sports. In fact, intensive research into problems of combinatorial optimization or branches of operational research has been conducted. There is also mention of the sales force accessible to various regions: vehicles to highways. Suppose that 'n' tasks are to be done and 'n' people are available to do these jobs. Assume that each person can do any job at a time with varying degrees of efficiency. The purpose of looking at the issue of employment is to find an assignment such that the overall cost of doing all jobs is zero. Typically, the rows represent the objects or people to be assigned, whereas the columns represent the items or tasks to be assigned. A large number of methods, such as linear programming techniques or transport methods have been applied so far; the assignment method developed by Hungary is more convenient than the previous methods. The Hungarian method of assignment problem [5-7] is known to be much faster and more effective. In

this method, we can reduce the given matrix by at least one zero per row and column. The assignment of heterogeneous employees to heterogeneous jobs was referenced [8-10] and the assignment of workers to jobs was investigated in an economy with teamwork frictions. Several strategies for transportation problems have been suggested and different papers on the topic have been published. Many of the transportation problems were done in different methods by authors [1-4] have done the transportation problems in different methods. We implemented a new approach in this paper, namely the Enhanced Zero Suffix method, to solve the problem of distinct from the previous methods to be applied to assignment and travelling salesman, which is different from previous methods.

2. Enhanced Zero Suffix Method

The procedure of solving an assignment problem to find the optimal solution is as follows:

Step 1: Formulate the assignment problem.

Step 2: Deduct the minimum element in the matrix from each element in the corresponding row.

Step 3: Remove the minimum of each column in

the matrix from each element in the corresponding column.

Step 4: Now there is a reduced matrix in every row and column for a minimum and an S is shown for each zero of the reduced matrix with the following simplicity.

Step 5: Now assign a person a task by choosing a maximum S value, and if the maximum value of the task is one and then we can also assign the

task to their respective persons (if the zeros are not located in the same column or row), and if the value of the task is over a maximum S value.

In addition, if the zeros lie in the same column or row, the individual can be allocated the minimum cost. Now we obtain a new assignment table by removing the allocated row and column.

Step6: Repeat step 2 to step 3 until all tasks are allocated to the individual.

$$s = \frac{\text{(Sum of non – zero costs in the } i - \text{ th row and } j - \text{ th column)}}{\text{(No of zeros in the } i - \text{ throw and } j - \text{ th column)}}$$

Examples:

Consider the following problem of assignment minimization of costs

	J ₁	J ₂	J ₃	J ₄	J ₅	J ₆
A	9	22	58	11	19	27
B	43	78	72	50	63	48
C	41	28	91	37	45	33
D	74	42	27	49	39	32
E	36	11	57	22	25	18
F	3	56	53	31	17	28

Solution: We get minimum row operation as in the following table

	J ₁	J ₂	J ₃	J ₄	J ₅	J ₆
A	0	13	49	2	10	18
B	0	35	29	7	20	5
C	13	0	63	9	17	5
D	47	15	0	22	12	5
E	25	0	46	11	14	7
F	0	53	50	28	14	25

Again, we get minimum column operation

	J ₁	J ₂	J ₃	J ₄	J ₅	J ₆
A	0	13	49	0	0	13
B	0	35	29	5	10	0
C	13	0	63	7	7	0
D	47	15	0	20	2	0
E	25	0	46	9	4	2
F	0	53	50	26	4	20

Now find each element's suffix value with the value zero and write the suffix value into the [] bracket. The suffix meaning is defined using the formula:

$$s = \frac{(\text{Sum of non - zero costs in the } i - \text{th row and } j - \text{th column})}{(\text{No of zeros in the } i - \text{th row and } j - \text{th column})}$$

	J ₁	J ₂	J ₃	J ₄	J ₅	J ₆
A	0[32]	13	49	0[47.33]	0[34]	13
B	0[41]	35	29	5	10	0[28.5]
C	13	0 [68.67]	63	7	7	0[31.25]
D	47	15	0[160.5]	20	2	0[29.25]
E	25	0[101]	46	9	4	2
F	0[79.33]	53	50	26	4	20

1605 is the highest suffix of the above table so that J₃ is allocated to person D.

Next, detach from the table the fourth and third column and use the same method as the following table:

	J ₁	J ₂	J ₄	J ₅	J ₆
A	0[12.8]	13	0[24.33]	0[17]	13
B	0[22]	35	5	10	0[28.33]
C	13	0[42.66]	7	7	0[20.66]
E	25	0[70.5]	9	4	2
F	0[47]	53	26	4	20

70.7 is the maximum suffix so that J₂ is allocated to the person E. Next, remove from the table the fourth row and the second column and apply the same method. The following table is open to:

	J ₁	J ₄	J ₅	J ₆
A	0[5.2]	0[17]	0[11.33]	13
B	0[7]	5	10	0[16]
C	13	7	7	0[30]
F	0[21]	26	4	20

30 is the maximum suffix so that J₆ is allocated to the person C. Next, the third row and fourth column from the above table and apply the same process until all the allocations are exhausted, we get the following final allocation.

Finally, the assignments are as follows $D \rightarrow J3, E \rightarrow J2, C \rightarrow J6, F \rightarrow J5, A \rightarrow J4, B \rightarrow J1$
 & the minimum assignment cost = Rs $(27+11+33+17+11+43) = 142/-$

(i) Consider the following travelling salesman problem

	D ₁	D ₂	D ₃	D ₄
D ₁	∞	4	7	3
D ₂	4	∞	6	3
D ₃	7	6	∞	7
D ₄	3	3	7	∞

Solution: Row reduction:

	D ₁	D ₂	D ₃	D ₄
D ₁	∞	1	4	0
D ₂	1	∞	3	0
D ₃	1	0	∞	1
D ₄	0	0	4	∞

Column Reduction:

	D ₁	D ₂	D ₃	D ₄
D ₁	∞	1	1	0
D ₂	1	∞	0	0
D ₃	1	0	∞	1
D ₄	0	0	1	∞

	D ₁	D ₂	D ₃	D ₄
D ₁	∞	1	1	0[1.5]
D ₂	1	∞	0[1.5]	0[0.66]
D ₃	1	0[1.5]	∞	1
D ₄	0[1.5]	0[0.66]	1	∞

Now figure out each element with its value zero and type in the bracket the suffix value []. The value of the suffix is calculated using the formula

$$s = \frac{\text{(Sum of non - zero costs in the } i - \text{th row and } j - \text{th column)}}{\text{(No of zeros in the } i - \text{th row and } j - \text{th column)}}$$

From the entire above suffix, 1.5 is maximum, so assign the origin D₄ to D₁, D₃ to D₂, D₂ to D₃ and D₁ to D₄.

The optimum assignment is $D_1 \rightarrow D_4, D_2 \rightarrow D_3, D_3 \rightarrow D_2, D_4 \rightarrow D_1$
 & the minimum cost = Rs $(3+6+6+3)$

=Rs 18

Hence, the Optimum assignment Cost is 18/- units. The route of the salesman is $D1 \rightarrow D4 \rightarrow D1, D2 \rightarrow D3 \rightarrow D2$. However, the route does not satisfy the 'route condition'. We try to find next best solution that satisfies the route conditions also.

Thus, we give the assignments at the next maximum suffix value. We try to start next in a solution with the next minimum (non-zero) cost element in the cost matrix. This is possible in the following ways:

(i) By using zero suffix method, making an assignment at (2, 1) instead of zero assignment at (2, 4). Similarly, we give assignment to (4, 3) instead of (4, 1) to satisfy route condition. The resulting optimum assignment will be then $D1 \rightarrow D4 \rightarrow D3 \rightarrow D2 \rightarrow D1$.

(ii) By using zero suffix method, making an assignment at (1, 2) instead of zero assignment at (1,4). Similarly, we give assignment to (3,2) instead of (3,4) to satisfy route condition. The resulting optimum assignment will be then $D1 \rightarrow D4 \rightarrow D3 \rightarrow D2 \rightarrow D1$.

Therefore, the optimal routes are $D1 \rightarrow D4 \rightarrow D3 \rightarrow D2 \rightarrow D1$ or $D1 \rightarrow D4 \rightarrow D3 \rightarrow D2 \rightarrow D1$. In both the cases the total minimum cost is $Rs(7+6+3+3) = Rs. 19$.

Conclusion

This method is very easily understandable and systematic than the previous methods. From this paper, it can be concluded that Enhanced Zero Suffix Method is a more convenient method than previous methods and much faster, efficient to find optimal solutions directly in fewer iterations. To the best of our knowledge, besides very laborious methods, this method is the first for providing a direct optimal solution with less iteration. Thus, a computer program needs to be built with this approach, since the real-world problems consist of many manually difficult sources and destinations.

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