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A New Approach for Finding Minimization Cost in Transportation Problem – An Algorithm by Using Python Language

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ABSTRACT
In this paper the package Numpy from the programing language Python is presented as a computational tool that can help to solve the initial basic feasible solution involving transportation problem. This is also extension of our previous paper. The objective of this paper is to find how to minimize the transportation cost (TC) and to save a significant amount of time.

KEYWORDS: Transportation Problem (TP), Initial Basic Feasible Solution (IBFS), Operations Research, Python language
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1 INTRODUCTION

The transportation problem is a special kind of the network optimization problem. It is one of the most useful techniques in many branches in pure and Applied Mathematics. Transportation model plays a vital role to ensure the efficient movement and in time availability of raw materials and finished goods from sources to destinations. TP is a Linear Programming Problem (LPP) stemmed from a network structure consisting of a finite number of nodes and arcs attached to them. The objective of the TP is to determine the shipping schedule that minimizes the total shipping cost while satisfying the demand and supply limit. In the transportation problem, the availability can be equal to the demand (balanced problem), the availability may be superior to the demand and the availability may be less than the demand. One of the first and important applications of the linear programming techniques, was the formulation and the solution of the transportation problem. The basic transportation problem was originally stated by Hitchcock [1]. The linear programming formulation and the associated systematic method for solution were first given in Dantzig [2, 3].

Md.Mizanur Rahman, Dr.Md.Bellel Hossain and Dr.Md. Mosharraf Hossain are presented and discussed gives an initial basic feasible solution of the transportation problem with equal constraints, in minimization of time [4]. Mollah Mesbahuddin Ahmed, Aminur Rahman Khan, Md.Sharif Uddin, and Faruque Ahmed deals a new approach named allocation table method (ATM) for finding an initial basic feasible solution of transportation problems is proposed. Efficiency of allocation table method has also been tested by solving several number of cost minimizing transportation problems and it is found that the allocation table method yields comparatively a better result [5]. Z.A.M.S. Juman and N.G.S.A. Nawarathne deals with an alternative technique of attaining an initial feasible solution to a transportation problem [7]. Carlos Sotomayor- Beltran, Alexi Delgado deals with the package PuLP from the programming language Python is presented as a computational tool that can help Peruvian industrial engineering students to solve optimization problems involving linear programming [8]. Roberto Salazar deals with an IpSolve package from R contains specific functions for solving linear programing transportation problems [9] and G. Padma Karthiyayini, S. Ananthalakshmi and R.Usha Parameswari discuss and give an initial basic feasible solution of the transportation problem using proposed algorithm [10].

In this paper, it has been observed to obtain an initial basic feasible solution for the transportation problem using python language for reduce the period of solving problem.

Mathematical Formulation for Transportation Problem:

In this section we further discuss about the mathematical formulation of the TP. The following notations are used in formulating the TP.

Notations

Supply quantity (S_i) in units from i^{th} supply node
The demand (D_j) in units per unit time

C_{ij} *Unit* transportation cost from i^{th} supply node to j^{th} demand node
X_{ij} Number of units transported from i^{th} supply node to j^{th} demand node
m Total number of supply nodes (suppliers)
n Total number of demand nodes (buyers)

The basic problem (sometimes called as the general, classical or Hitchcock transportation problem) can be stated mathematically as follows.

Min $\sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij}X_{ij}$

Subject to

$\sum_{j=1}^{n} X_{ij} \leq S_i$, i=1 to m

$\sum_{i=1}^{m} X_{ij} \geq D_j$, j=1 to n

Where $X_{ij} \geq 0$ for all i, j

A necessary and sufficient condition for the existence of a feasible solution to the transportation problem is;

$\sum_{i=1}^{m} S_i = \sum_{j=1}^{n} D_j$

This means that the total supply is equal to total demand. Then the Transportation problem is called as a Balanced Transportation Problem. If not the problem is called as an Unbalanced Transportation Problem. Although, TP can be solved by the simplex algorithm.

2 PROPOSED ALGORITHM

Step 1:

Construct the transportation matrix from the given transportation problem.

Step 2:

Whether the TP is balanced or not. If not, make it balanced.

Step 3:

Subtract the smallest entry of every row from each of the element of the subsequent row of the transportation table and place them on the left – top of the corresponding elements.

Step 4:

Apply the same operation on each of the column and put the value on the left-bottom of the corresponding elements.

Step 5:

In the next transportation table, the entries are the summation of left-top and left-bottom elements of step 3 and step 4.

Step 6:

From the transportation table choose the minimum cost, and subtract minimum cost from each of the cost valued cells of the transportation table.

Step 7:

Start the allocation from minimum of supply/demand. Allocate this minimum of supply/demand in the place of minimum cost cell. If the demand is satisfied, delete the column. If it is supply, delete the row.

Step 8:

Now identify the minimum allocation cell value and allocate minimum of supply/demand at the place of selected allocation table. Suppose in the case of same allocation cell values, Select the allocation cell value where minimum allocation can be made. Again in the case of same allocation in the allocation cell values, choose the minimum cost cell of transportation table.

Step 9:

Again if the cost cells and the allocations are equal, in such case choose the corresponding cell to the minimum of demand /supply which is to be allocated. Now if demand is satisfied delete the column and if it is supply delete the row.

Step 10:

Repeat step 6 and 7 until the demand and supply are satisfied.

Step 11:

Now transfer this allocation to the original transportation table.

Step 12:

Calculate the total transportation cost is equal to the sum of the product of cost and corresponding allocated value of the transportation table.

The total transportation cost obtained from proposed algorithm is minimum than the cost obtained from NWCM and VAM.

2.1 NUMERICAL EXAMPLES

1) Consider the following Cost minimizing Transportation problem:

	D_1	D_2	D_3	Supply
S_1	6	4	1	50
S_2	3	8	7	40
S_3	4	4	2	60
Demand	20	95	35	150

By applying Proposed method,

$^{5}_{3}$ 6	$^{3}_{0}$ 4	$^{0}_{0}$ 1
$^{0}_{0}$ 3	$^{4}_{5}$ 8	$^{6}_{4}$ 7
$^{1}_{2}$ 4	$^{0}_{2}$ 4	$^{1}_{0}$ 2

The allocation cell values are given in the following transportation table is,

8	3 [15]	0 [35]
0 [20]	9 [20]	10
3	2 [60]	1

Total Cost obtained by new method is as follows,
Total Minimum cost = (15*4) + (35*1) + (20*3) + (20*8) + (60*4)
=555

2.2 Python program:

Initialize Transportation Problem:

Initializing the values and shaping the matrix

```
self.n, self.m = cost.shape

self.table = np.zeros((self.n + 2, self.m + 2), dtype=object)
self.table[1:-1, 1:-1] = cost.copy()
self.table[-1, 1:-1] = demand.copy()
self.table[1:-1, -1] = supply.copy()
self.table[ 0, 1:-1] = [f"C{i}" for i in range(self.m)]
self.table[1:-1,  0] = [f"R{i}" for i in range(self.n)]
```

Allocating the cost value to corresponding rows and columns

```
while self.table.shape != (2, 2):
    cost = self.table[1:-1, 1:-1]
    supply = self.table[1:-1, -1]
    demand = self.table[-1, 1:-1]

    #find index of minimum cost
    mins = np.argwhere(cost == np.min(cost))
    alloc = []
    for i, j in mins:
        alloc.append(min([supply[i], demand[j]]))
    x, y = mins[np.argmin(alloc)]

    #allocated row x to column y or vice versa
    self.allocation(x + 1, y + 1)

    if show_iter:
        self.trans.print_frame(self.table)

return np.array(self.alloc, dtype=object)
```

Pandas library is used to print the data as a table output:

```
def print_frame(self, table):
    df = pd.DataFrame(table[1:, 1:])
    df.columns = table[0, 1:]
    df.index = table[1:, 0]
    print(df, '\n')
```

The main program of the algorithm given below integrates all operators and functions:

```
#initialize transportation problem
trans = Transportation(cost, supply, demand)

#setup transportation table.
#minimize=True for minimization problem, change to False for maximization, default=True.
#ignore this if problem is minimization and already balance
trans.setup_table(minimize=True)

#initialize least cost method with table that has been prepared before.
min_cost = MinCost(trans)

#solve problem and return allocation lists which consist n of (Ri, Cj, v)
#Ri and Cj is table index where cost is allocated and v it's allocated value.
#(R0, C1, 3) means 3 cost is allocated at Row 0 and Column 1.
#show_iter=True will showing table changes per iteration, default=False.
allocation = min_cost.solve(show_iter=False)

#print out allocation table in the form of pandas DataFrame.
#(doesn't work well if problem has large dimension).
trans.print_table(allocation)
```

Input and output:

```
cost = np.array([[ 6,  4,  1],
                 [3, 8, 7],
                 [4, 4, 2]])

supply = np.array([50, 40, 60])
demand = np.array([20, 95, 35])
```

	C0	C1	C2	Supply
R0	6	4(15)	1(35)	50
R1	3(20)	8(20)	7	40
R2	4	4(60)	2	60
Demand	20	95	35	150

TOTAL COST: 555

3 CONCLUSION

In this paper, we have developed an effective method for solving transportation problem using python language. We trust this new idea will help individuals who are working in this field. Still, there exists a rich opportunity for further research in this subject.

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