An Application of Assignment Problem in Laptop Selection Problem Using MATLAB

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ABSTRACT

The assignment – selection problem used to find one-to- one match of given "Users" to "Laptops", the main objective is to minimize the cost as per user requirement. This paper presents satisfactory solution for real assignment – Laptop selection problem using MATLAB coding.

KEYWORD

Assignment problem, linear integer programming, Revised Ones Assignment Method (ROA), MATLAB programming

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1 INTRODUCTION

Now a day's laptop is very essential equipment for college, university students as well as faculties. It is also common to observe that at each home having either laptop or PC. Consider that an individual want to purchase laptop, but in market various types of product & companies available, where anyone can be confused. If we want to purchase laptop seller gives us latest high configured system, which cost approximately between Rs. 45,000 to Rs 90,000. So problem arises here, if owner is general user and his purpose and requirement are basic then whether he should purchase given amount laptop? To overcome this problem we defined four categories of users, and also recommended which laptop he should purchase as per his category and basic requirement. To solve this laptop selection problem an Assignment Model used.

Assignment Problem (AP) is known as degenerate form of a transportation problem, in AP total number of assign element is 'n'. It appears in some decision-making situations. The typical problems are to assign activities to resources, 'n' workers to 'n' jobs etc.

Laptop selection problem is in unbalanced form, where four types of users have to choose four laptops from 21 described laptops (see table 3). To solve this problem ROA method is used which gives some ones in Assignment matrix and using "Ghadle and Muley rule" will find out optimal solution. To verify the result MATLAB Program is used which will save calculating time of problem and give accurate optimal solution within sec.

MATLAB is specially used for matrix, using MATLAB software various matrix operations can be performed for e.g. matrix addition, subtraction, multiplication, element to element multiplication, inverse etc and various functions available for solving matrix. In unbalanced laptop selection problem ROA algorithm is used as program. The time complexity for this algorithm is less than O (n^2 log n). MATLAB programming is stronger and sophisticated than

conventional computer languages (e.g. C, FORTRAN) for solving technical problems. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning.

2 MATHEMATICAL MODELS FOR ASSIGNMENT PROBLEM

To minimize the overall cost or time, let consider Assignment Problem of 'n' resources to 'n' activities in such a way that one and only one job should assign to each resources. Where C_{ij} is cost matrix given as,

		Activity				
		A_1	A_2	$\cdots$	A_n	Available
Resource	R_1	C_{11}	C_{12}	$\cdots$	C_{1n}	1
	R_2	C_{21}	C_{22}	$\cdots$	C_{2n}	1
	$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$
	R_n	C_{n1}	C_{n2}	$\cdots$	C_{nn}	1
	Required	1	1	$\cdots$	1	

In Assignment Model, the availability at each of the resources and the requirement at each of the destinations is unity.

Let x_{ij} – Assign i^{th} resources to j^{th} activity such that,

$$x_{ij} = \begin{cases} 1; \text{ if assignment of } i^{th} \text{ resources to } j^{th} \text{ activity.} \\ 0 \text{ ; otherwise} \end{cases}$$

Then the mathematical model for assignment problem is,

$$Mininmize\ z = \sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}x_{ij} \tag{1}$$

Subject to,

$$\sum_{i=1}^{n} x_{ij} = 1 \ \ and \ \sum_{j=1}^{n} x_{ij} = 1 \ : \ \ x_{ij} = 0 \ or \ 1 \tag{2}$$

For all i=1, 2, …, n and j= 1,2,…,n.

Preliminaries:

Balance Assignment Problem: In balanced model activities equal resources.

Unbalance Assignment Problem: In an unbalanced model activity does not equal resource.

3 Revised Ones Assignment Method (ROA) for Assignment Problem. [1, 3]

In ROA method, by dividing minimum element from each row and column to corresponding rows and column we get at least one value in each rows and columns. Then find complete assignment in terms of ones.

Now, in assignment matrix C_{ij} is the cost or effectiveness of assigning i^{th} machine.

$$\begin{array}{c} \\ 1 \\ 2 \\ \vdots \\ n \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & \cdots & n \end{array} \\ \begin{pmatrix} C_{11} & C_{12} & \cdots & C_{1n} \\ C_{21} & C_{22} & \cdots & C_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ C_{n1} & C_{n2} & \cdots & C_{nn} \end{pmatrix} \end{array}$$

The new algorithm is as follows.

Let (1-2) be an assignment problem in which the objective function can be minimized or maximized.

Step 1

In a minimization case, find the minimum element of each row (say a_i) and write it on the right hand side of the matrix.

$$\begin{array}{c} \begin{array}{cccc} 1 & 2 & \cdots & n \end{array} \\ \begin{pmatrix} C_{11} & C_{12} & \cdots & C_{1n} \\ C_{21} & C_{22} & \cdots & C_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ C_{n1} & C_{n2} & \cdots & C_{nn} \end{pmatrix} \end{array} \begin{array}{c} a_1 \\ a_2 \\ \vdots \\ a_n \end{array}$$

After dividing each element of i^{th} row of the matrix by a_i. We get at least one ones in each rows. In term of one for each row and one for each column, do assignment. Otherwise go to step 2.

Step 2

Find the minimum element of each column (say b_j), and write it below j^{th} column, by dividing each element of j^{th} column of the matrix by b_j. We get at least one ones in each columns. This gives assignment matrix in terms of ones. If no feasible assignment can be achieved from step (1) and (2) then go to step 3.

$$\begin{array}{c} \\ 1 \\ 2 \\ \vdots \\ n \\ \\ \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & \cdots & n \end{array} \\ \begin{pmatrix} C_{11}/a_1 & C_{12}/a_1 & \cdots & C_{1n}/a_1 \\ C_{21}/a_2 & C_{22}/a_2 & \cdots & C_{2n}/a_2 \\ \vdots & \vdots & \ddots & \vdots \\ C_{n1}/a_n & C_{n2}/a_n & \cdots & C_{nn}/a_n \end{pmatrix} \\ \begin{array}{cccc} b_1 & b_2 & \cdots & b_n \end{array} \end{array}$$

Note: In a maximization case, the end of step 2 we have a fuzzy matrix. Which all elements are belong to [0, 1], and the greatest is one [2].

Step 3

To find optimality test draw the minimum number of lines which cover all the ones in the Assignment matrix. If the numbers of drawn lines are less than 'n', then optimality condition fails i.e. complete assignment is not possible. While optimality condition satisfied, if the number of lines is exactly equal to 'n', then the complete assignment is possible.

Step 4

If optimality condition fails in step 3, then select the smallest element (say d_{ij}) out of those which do not lie on any of the lines in the above matrix. By dividing smallest element d_{ij} to each element of the uncovered rows or columns. This gives some new ones to this row or column.

If still optimality condition fails in this new matrix, then use step 4 and 3 iteratively. By repeating the same procedure the optimal assignment will be obtained.

(To assign one Ghadle and Muley Rule is used, which is mentioned below.)

Step 5 (Ghadle and Muley Rule to assign one in Assignment Matrix)

i) For minimization problem select max value from calculated matrix and write it on right hand side as well as bottom side.

- To assign one, start from min value of columns (mentioned at bottom side) and select ones.
- If there are more than one ones in any column then ignore temporarily, and give last priority to that column.
- If still there are identical ones in column then give the priority to max value of rows (mentioned at right hand side).

Or Vice – Versa.

Remarks: In Unbalanced Assignment Problem, if there are more than one ones in any row then give priority to first element**.**

Priority rule

To solve Unbalanced Assignment Problem (non square matrix), we convert it into Balanced Assignment Matrix form by adding artificial row or column, which having all elements one. Hence we can solve the problem using ROA method. After performing the steps reduces to a matrix which has ones in each rows and columns. So, the optimal assignment has been reached.

4 APPLICATIONS:

Now a day various techniques have been used to attract candidates in colleges and universities for admission. Let consider that a college management decide to give the laptops to admitted students as per their requirements and courses. To reduce laptop purchase cost we have select laptop as per courses and there requirement, for laptop configuration we divide users into four categories, like General users, Professionals, Programmers, Engineers.

Requirements of Users:

As per our observations we conclude following

1. General Users:

- Like science, commerce, and arts student, used laptop for preparing notes, presentation and also using some software like Ms-office, Tally, DTP etc. for that sufficient configuration is : asus/ dual core processor, 1 or 2 GB RAM, 500 GB HDD, 512 GD (for high graphics, like games).

2. Professional Users:

- Like MBA (all courses), ICWA, CA, used laptop for accounting, presentation and also using some software like Ms-office, Tally, SAP and some online software which required high configuration than General users. For that sufficient configuration is: dual core processor, 1 or 2 GB RAM, 500 GB HDD.

3. Programmers:

- Like MCA, MCS, M.E / B.E (Computer) used laptop for programming, making software's. Generally they used software like C- programming, VB, VB.net, Oracle, Java, SAP etc. which required high configuration than Professional users. For that sufficient configuration is: core i3 processor, 2 or 4 GB RAM, 500 GB HDD, 1GB GD (for high graphics).

4. Engineers:

- Like Mechanical, Electrical, Civil etc. used laptop for graphics design. Generally they used software like Auto Cad, UG, PRO –E, CATIA which required higher graphics resolution. For that sufficient configuration is: Core i5 or i7 processor, 4 or 8 GB RAM, 500 GB HDD, 1 or 2 GB GD (for high graphics).

To overcome this situation there are several credit points under consideration, firstly consider the competencies necessary to develop the users. Obviously some competencies like processor, RAM having more importance and some competencies like HDD, Screen size, Graphics Card having less important compare to first one. Moreover, usually the users are not independent; therefore a relationship among them could appear. Finally, all particular with credit points are shown in table 1 as per their necessary requirements.

Particulars	Credit Points
Essential	5
Fairly High	4
High	3
Moderate	2
Low	1
Fairly Low	0

Table 1

	Particulars\ Users	General	Professionals	Programmers	Engineers
Processor	Dual Core	5	5	0	0
	Core i3	0	4	5	0
	Core i5	0	0	4	5
	Core i7	0	0	0	4
	Asus Brazo	5	0	0	0
	Asus Intel Dual Core	4	5	0	0
	Asus Core i3	0	4	5	0
	Asus Core i5	0	0	4	5
RAM	2 GB	3	3	3	0
	4 GB	0	2	2	3
	8 GB	0	0	0	2
HDD	500 GB	3	3	3	3
	1 TB	0	0	2	2
Screen	15.6"	3	3	3	3
Graphics Card	512 MB	3	2	3	0
	1 GB	0	0	2	3
	2 GB	0	0	0	2

Once the users involved in the selection procedure have been determined, the laptops must next to be considered. Let it be imagined that there are 21 laptops (see table 3) that might be able to select for different Users.

Laptops	Name
Laptop1	L1
Laptop2	L2
..	

Laptop21 L21

For each one it is necessary to find out by some appropriate, means the levels in each of the particular required for the users. Finally as there are links between the users and laptops (using table1 credit points in table 3) must be looked at in order to find out the relationships that there would be among them, as shown in table 2.

Table 2

Users\ Code No.	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15	L16	L17	L18	L19	L20	L21
General	17	14	14	9	9	3	6	9	9	6	6	9	6	6	6	6	6	6	3	3	3
Professionals	11	14	14	13	13	10	12	9	13	12	12	13	12	8	8	12	8	8	5	5	6
Programmers	12	9	9	14	14	13	13	13	16	15	15	14	13	12	14	15	12	14	13	11	5
Engineers	6	6	6	6	6	5	9	11	9	12	12	6	11	14	17	12	16	17	16	15	13

Unbalanced Assignment Problem is solved by using ROA method and MATLAB Programming (See Appendix 1). This gives final optimal solution as:

Users	Laptop
General	L1
Professionals	L2
Programmers	L9
Engineers	L15

5 CONCLUSIONS:

To select appropriate laptops as per user's requirement and basic needs. The given problem converted into Assignment Model. The given information in table 3 is converted into numerical by using credit points given in table 1, to solve this realistic problem ROA method is used and at last it verified by MATLAB program which gives optimal solution within 0.005256 sec.

6 REFERENCES

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Table 3

BRANDS	Asus	Dell	Asus	Asus	Lenovo	Lenovo	Dell	Asus	Sony vaio	Dell	Lenovo
PROCESSOR	Asus Brazo	Dual Core	Dual Core	Asus - Core i3	core i3	core i3	core i3	Asus - Core i5	core i3	core i3	core i3
RAM (GB)	2	2	2	2	2	2	4	2	2	4	4
HDD (GB)	500	500	500	500	500	1	500	500	500	500	500
SCREEN	15.6"	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
GRAPHICS	512	0	0	0	0	0	0	0	1	1	1
RS	21900	24900	27600	28100	29950	31950	32900	33900	34341	35900	35900
Code No.	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11

Table 3: (shows various types of laptops with specifications and cost)

Table 3

BRANDS	Lenovo	Dell	Lenovo	Dell	Sony vaio	Lenovo	Sony vaio	Dell	Dell	Dell
PROCESSOR	core i3	core i3	core i5	core i5	core i3	core i5	core i5	core i5	core i5	core i7
RAM (GB)	2	4	4	4	4	4	4	4	4	8
HDD (GB)	500	500	500	500	500	500	500	1	1	1
SCREEN	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
GRAPHICS	0	2	0	1	1	2	1	1	2	2
RS	36241	37500	37500	40600	40991	41500	43841	43950	52900	60800
Code No.	L12	L13	L14	L15	L16	L17	L18	L19	L20	L21

Appendix 1:

```
% MATLAB PROGRAM FOR ASSIGNMENT - LAPTOP SELECTION PROBLEM.
% DEVELOPED BY : Dr. Kirtiwant Ghadle , Mr. Yogesh Muley
clc
tic;
x= [17  14  14  9   9   3   6   9   9   6   6   9   6   6   6   6   6   6   3   3   3
11  14  14  13  13  10  12  9   13  12  12  13  12  8   8   12  8   8   5   5   6
12  9   9   14  14  13  13  13  16  15  15  14  13  12  14  15  12  14  13  11  5
6   6   6   6   6   5   9   11  9   12  12  6   11  14  17  12  16  17  16  15  13 ]
% matrix x is copied in xnv and x1 variable
 xnv=x;
 x1=x;
 % calculating each row minimum no.
 maxr= nnmaxr(x)
 % find row and column no
[r c]=size(x)
% dividing each element of row
```

```
for i=1:r
   for j=1:c
      x(i,j)=x(i,j)/maxr(i);
   end
end
x

 y=x;
for i=1:r
   for j=1:c
      if x(i,j)<1
         x(i,j)=0;
      end
   end
end
x
l=1;
for i=1:r
  for j=1:c
     [xr xc]= find(x==l,'1');
     k1=length(xr);

        for m=1:k1
           x(xr(m),xc(m))=1;
        if x(xr(m),j)~= x(xr(m),xc(m))
           x(xr(m),j)=0;
        end
        end
  end
end

 x;
 z=xnv.*x
 toc;
```

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