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Optimizing Work Allocation using Modified Heuristic and Hungarian Methods for Minimum Completion Time

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ABSTRACT: Efficient workforce allocation is crucial for optimizing productivity in any organization. This study focuses on minimizing the total work completion time while ensuring task assignments align with employee capabilities. Two optimization techniques-the Modified Heuristic Method and the Hungarian Method-are applied to solve the assignment problem effectively. This research provides valuable insights into workforce management, highlighting the significance of assignment models in optimizing productivity. The findings confirm that both methods are equally effective in achieving optimal task distribution and can be utilized in diverse industrial and organizational settings.

KEYWORDS: Assignment Model, Modified Heuristic Method, Hungarian Method, Optimal Solution.

I. INTRODUCTION

We often encounter situations where we need to assign n workers to n jobs. All n workers can run all jobs, but at different costs. Our task is therefore to find the simplest task that provides maximum efficiency and minimum cost. Activities to students, subjects to teachers, pizza delivery drivers to different routes, vendors to different regions, jobs to machines, products to factories, research problems to groups, vehicles and drivers to different Assign to root, etc. This kind of problem is called assignment problem

An efficient method was developed by [5] to find the best solution for a problem without directly comparing each solution. This was called the Hungarian method. This method allowed me to reduce the cost matrix to have at least one zero in every row and column. Therefore, an optimal matching with zero opportunity cost is possible. However, [6] developed a computational approach that exploits the duality effectively. He also found that a mapping problem has optimality only if the mapping problem is complete after all possible transmissions. [10] examined the attribution of workers to jobs in economies with adjustment frictions. This was done by matching disparate workers to disparate jobs. He explained that the model is in equilibrium and needs to be extended to a dynamic framework when viewed in quantitative series. [8] used constraint programming and artificial intelligence to provide a new solution that bridges the gap between the need for high-quality matches and the need for timeless matches. In his paper on transport problems [7], he developed a new alternative method for optimally solving the assignment problem. He developed an algorithm for this and used numerical examples to prove that his method yielded results similar to the Hungarian one, but with fewer steps and easier. In work [11], he used a novel fuzzy assignment problem to model driver characteristics related to route selection. [4] tackled the geometry of the simplex method and applied it to the assignment problem. In their study, the Hungarian and Gale-Shapely algorithms were implemented in MATLAB, and the preference matrix from an Excel file was taken as input, yielding optimal and stable results. [13] worked on an extension of the parallel auction algorithm proposed by [1]. Her research focused on the availability of local information and how it always converges to the mapping problem and when utility is maximized within a linear approximation to the optimum. In [9], the quadratic mapping problem is considered to model the local problem of logistics by considering the cost of placing a new item in a particular location and the interactions between all items. I was. He also explained that heuristics, branch-and-bound methods, and perfect enumeration methods can be used to solve quadratic imputations for $n \ge 25$. [3] applied the Hungarian algorithm to baseball team selection. They achieved this by matching the best players for each position on the pitch to create the optimal team.





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II. ASSIGNMENT MODEL

The Assignment Model is a mathematical optimization technique used for assigning tasks to resources in a way that minimizes cost or maximizes efficiency. It is a special case of linear programming. In this model, a set of workers (employees) is assigned to a set of tasks, ensuring that each worker performs only one task, and each task is assigned to only one worker. The goal is to minimize the total time or cost associated with completing all tasks. The given matrix represents the time taken by each employee to complete different tasks, allowing for an optimal allocation based on efficiency.

The mathematical presentation of assignment model is as follows. Let set of employees and set of task are represented by E and T i.e.

$$E = \{E_1, E_2, \cdots, E_n\} T = \{T_1, T_2, \cdots, T_m\}$$

 x_{ii} be a binary decision variable:

$$x_{ij} = \begin{cases} 1 & if \ facility \ E_i \ is \ assigned \ to \ job \ T_j \\ 0 & otherwise \end{cases}$$

 t_{ij} represents the time taken by employee E_i to complete task T_j , given in the assignment matrix Objective Function:

$$Min \ Z = \sum_{i=1}^{n} \sum_{j=1}^{m} t_{ij} x_{ij}$$

Where, aim to minimize the total time taken for all task assignment. Constraints:

1. Each task is assigned to exactly one employee

$$\sum_{i=1}^{n} x_{ii} = 1, \quad \forall j \in \{1, 2, \cdots m\}$$

2. Each employee is assigned to exactly one task

$$\sum_{j=1}^{m} x_{ij} = 1, \qquad \forall i \in \{1, 2, \cdots n\}$$

3. Binary Constraint on Decision Variables

$$x_{ij} \in \{1,0\}$$
 $\forall i,j$

III. MODIFIED HEURISTIC METHOD

The Modified Heuristic Method (minimization case) can be summarized in the following steps:

Step 1: Firstly, Add row and column in given problem with unity number.

Step 2: Determine the penalty cost i.e. the difference between the lowest and highest cost element of that row/column. **Step 3:** Identify the row/column having highest penalty and choose the variable having lowest cost in this selected row/column. Allocate as much as possible to this variable.

Step 4: Cross out the row or column whichever is satisfied and adjust the variable and required quantities.

Step 5: Compute the penalties and repeat procedure till all rows and columns are satisfied.

Step 6: Apply Optimality Test (Modi Method/Stepping Stone Method)

Numerical Problem:

In a cutting-edge smart manufacturing plant, the efficiency of production heavily depends on how tasks are assigned to skilled employees. Each worker (E) has a unique set of abilities, and each task (T) requires a different level of time commitment based on their expertise. Due to growing demands and just-in-time production strategies, the plant





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management aims to minimize the total time taken to complete a set of critical tasks while ensuring an optimal workforce distribution. The challenge is to assign employees to tasks in such a way that overall production efficiency is maximized while avoiding bottlenecks.

an automobile assembly plant, different employees have different proficiencies in performing specific tasks such as welding, painting, assembling, and quality control. Assigning the right employee to the right task can significantly impact production speed and cost. The goal is to minimize total time while ensuring that each task is assigned to exactly one worker.

Table 1

	T1	T2	Т3	T4	T5	T6
E1	12	15	13	17	11	14
E2	10	16	18	14	12	13
E3	17	14	10	18	12	16
E4	13	12	15	10	19	14
E5	14	19	11	15	10	13
E6	18	16	12	14	19	10

To obtained the optimal solution, apply the Modified Heuristic Method. Firstly, applied step 1, then obtained

Table 2

	T1	T2	Т3	T4	T5	T6	D _C
E1	12	15	13	17	11	14	1
E2	10	16	18	14	12	13	1
E3	17	14	10	18	12	16	1
E4	13	12	15	10	19	14	1
E5	14	19	11	15	10	13	1
E6	18	16	12	14	19	10	1
D _R	1	1	1	1	1	1	

Now apply the Step 2 to 4, then obtained

Table 3

	T1	T2	Т3	T4	T5	T6	Dc	Row Penalty
E1	12	15	13	17	11	14	1	15-11=4
E2	10	16	18	14	12	13	1	18-10 = 8
E3	17	14	10	18	12	16	1	17-10 = 7
E4	13	12	15	1 10	19	14	1	-
E5	14	19	11	15	10	13	1	19-10 = 10
E6	18	16	12	14	19	10	1	19-10 = 10





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D_R	1	1	1	1	1	1	
	18-10 = 8	19-14 = 5	18-10 = 8	-	19-10 = 9	16-10 = 6	

According to Step 5, above process apply till to obtained feasible solution

Table 4

	T1	T2	Т3	T4	T5	T6	D _C
E1		1					1
EI	12	15	13	17	11	14	
E2	1						1
ĽΖ	10	16	18	14	12	13	
Е2			1				1
ES	17	14	10	18	12	16	
E4				1			
E4	13	12	15	10	19	14	1
E5					1		1
ЕJ	14	19	11	15	10	13	
EC						1	1
EO	18	16	12	14	19	10	
D _R	1	1	1	1	1	1	

The minimum time to work compellation = 15+10+10+10+10+10=65With the work allocation,

$$E1 \rightarrow T2; E2 \rightarrow T1; E3 \rightarrow T3, E4 \rightarrow T4; E5 \rightarrow T5; E6 \rightarrow T6$$

To verify the answer, Apply MODI Test for the optimality and obtained the Total Time to work compellation is 65 hours along with the work allocation

$$E1 \rightarrow T2; E2 \rightarrow T1; E3 \rightarrow T3, E4 \rightarrow T4; E5 \rightarrow T5; E6 \rightarrow T6$$

Table 5

Name of Method	Work Allocation	Optimal Work Compellation Time
Modified Heuristic Method	$E1 \rightarrow T2; E2 \rightarrow T1; E3 \rightarrow T3, E4 \rightarrow T4; E5 \rightarrow T5; E6 \rightarrow T6$	65
Hungarian method	$E1 \rightarrow T2; E2 \rightarrow T1; E3 \rightarrow T3, E4 \rightarrow T4; E5 \rightarrow T5; E6 \rightarrow T6$	65

The Modified Heuristic Method and the Hungarian Method produced identical work allocations and optimal work completion times of 65 hours. This indicates that both methods are equally effective in assigning tasks to employees efficiently. Since the allocation remains the same, it suggests that the Modified Heuristic Method is as optimal as the Hungarian Method, making it a viable alternative for solving task allocation problems.

IV. CONCLUSION

This study successfully addresses the problem of optimal work allocation by implementing both the Modified Heuristic Method and the Hungarian Method. The objective of minimizing total work completion time while ensuring task allocation aligns with employee capability is effectively achieved. The results demonstrate that both methodologies

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lead to the same optimal assignment, achieving a minimum work completion time of 65 hours with the following task distribution: $E1 \rightarrow T2$; $E2 \rightarrow T1$; $E3 \rightarrow T3$, $E4 \rightarrow T4$; $E5 \rightarrow T5$ and $E6 \rightarrow T6$. These findings validate the efficiency and reliability of structured assignment models in optimizing workforce management. By implementing such systematic approaches, organizations can enhance productivity, balance workloads, and reduce inefficiencies in task allocation. Future research can explore dynamic assignment models incorporating real-time adaptability to changing work conditions. Overall, this study reinforces the importance of mathematical optimization techniques in decision-making processes, providing a robust framework for improving operational efficiency in various industries

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