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Implementing Hungarian Algorithm In A Paint Factory

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Abstract

This paper was motivated by the fact that Effective resource allocation is a vital factor in optimizing production processes. This project aim, is to apply the Hungarian Algorithm in minimizing production time and costs by optimizing workers task and machine use. The methodologies used were the combination of structured system analysis and design Methodology (SSADM) with simple calculations via the Hungarian Algorithm, as the most dominated technique for resolving assignment problems, this is to allocate workers to specific tasks based on skill levels, efficiency, and workload balance. The researcher modelled the assignment problem by describing cost matrices using the parameters such as worker proficiency, task complexity, and production deadlines. When Putting the Algorithm into use, the best assignment of workers on tasks is determined, safeguarding minimal idle time and improved efficacy in the production of paint. Additionally, the algorithm is extended to machine allocation, where different production stages such as mixing, grinding, and packaging are assigned to accessible machines based on their ability and operational efficacy. An expected results gotten shows that the application of the Hungarian Algorithm meaningfully improves productivity by dropping delays and proper resource utilization. Thus integrating this algorithm into paint production leads to better workforce management, reduced operational costs, and higher output adeptness.

Keywords:* *Allocation, Efficacy, Hungarian Algorithm, Operational, Optimizing, Minimization.

I. Introduction

In modern manufacturing environments, the production of operators and competent allocation of resources to each operator play a vital role in the production process, optimization of productivity and minimization of costs. The optimization of productivity and minimization of costs in any manufacturing environment mainly depend on the assignment of each job to an operator [6]. If jobs are not properly assigned to operators, it will lead to inefficiencies that will result in delay and high productivity cost, therefore the assignment of each job assigned to each operator can provide a reasonable optimal results for a company [5]. More so, one of the most remarkable challenges faced by factory managers are the assignment of tasks to operators in a way to maximizes efficiency and minimizing operational expenses. This task placement problem could be modeled as an optimization problem where the goal is to allocate jobs to a group of operators, each with varying costs and capabilities.

Therefore, there is need to control the manufacture procedure in the paint factory so as to reduce the production time and minimize the production cost. To put light on the above mentioned unbearable challenges, this paper is to assign task to operators in a paint factory using **Hungarian Algorithm,** to provide an optimal assignment of tasks to operators with a minimum total cost.

II. Literature Review

A few selected notably, and novel literature Review about Hungarian algorithm and its application were reviewed by the researcher. Bearing in mind that the algorithm, which is a classic method for resolving assignment glitches, has been the subject of recent research aimed at enhancing its efficiency and applicability.

[1] Addressed the limitations of the traditional Hungarian algorithm when dealing with unbalanced assignment problems, where the number of tasks and agents differ. They proposed an improved version that avoids the need for adding dummy tasks or agents, thereby reducing computational complexity and preventing overloading of any single agent.

According to [9] Current advancements have combined the Hungarian algorithm into multi-robot systems for task allocation. For instance, [12] established a communication-free task allocation technique on ground incomplete information game theory, utilizing the Hungarian algorithm to optimize task delivery among robots.

According to [2] they applied the Hungarian algorithm to the selective assembly process in manufacturing. By changing the assembly problem into a mathematical model and using a ranking function, they optimized the pairing of components, minimizing the denial of non-conforming parts and ensuring high-quality products. [10] Enhanced labor allocation by integrating multi objective decision-making techniques with an enhanced Hungarian algorithm. This method permissible for a more efficient distribution of human resources, balancing various objectives and constraints.

[3] Introduced a new assignment algorithm that incorporates ordered weighted averaging (OWA) operators into the Hungarian algorithm. This integration provides a parameterized family of aggregation operators, offering a more comprehensive representation of information in decision-making processes.

Hungarian Algorithm

The **Hungarian Algorithm** is a powerful combinatorial optimization method specifically designed to solve the assignment problem. It provides an efficient way to find the optimal assignment of tasks to operators by minimizing the total cost associated with the assignments. Developed by Hungarian mathematicians in the 1950s, this algorithm systematically analyzes the cost matrix, which represents the costs associated with assigning each operator to each task.

Furthermore, the Hungarian method is a method that has modified rows and columns to form an effectiveness matrix so that a single zero component appears for each row or column that can be selected as an assignment allocation. All assignments will be made as optimal allocations, and when placed in the initial effectiveness matrix, it can find the most minimal assignments.

By employing the Hungarian Algorithm, factory managers can certify that tasks are shared in a way that maximizes the utilization of human resources while reducing idle time and operational costs. This will not only increases productivity but also contributes to better worker satisfaction as responsibilities are assigned based on skill sets and cost efficiency.

Optimization of Assignment Problems By the Hungarian Method, research on assignment problems includes allocating sources of work that 1 (one) person can carry out at a certain time . The relationship between the number of workers and financing is described in a one-way assignment that is maximized for profit [8]. The profits earned by each person are directed to completing one job in a specified time according to the financing (paid) and the column (time for completion of work) [7].

In this paper, we explored the prominence of task assignment in factory settings and outlined the principles of the Hungarian Process. Through this exploration, we highlighted the significance of mathematical optimization techniques in streamlining factory operations and driving overall efficiency in NEDLUX Paint factory. To implement Hungarian Algorithm, the numbers of assigned operators were made identical to the total of tasks to be completed. Each operator was assigned to only one task [4].

NEDLUX Paint factory, a growing company has criteria in determining the type of employee work, such as physical condition, knowledge, experience, interests, and personality. Overtime pay and wages are calculated differently from the monthly salary. The division of work (assignment problem) is part of a linear program. Factory management often has problems assigning tasks to individual worker, which caused increase in their production cost and delay in productivity time.

Importance of Task Assignment in Factory Settings

Task assignment in factory settings is a serious constituent of operational efficiency and productivity. Properly assigning tasks to operators can meaningfully influence various aspects of manufacturing processes. Below are key points highlighting the importance of effective task assignment.

1. **Maximizing Productivity:** This can lead to optimal utilization of resources and minimizing downtime.
2. **Cost Efficiency:** This can lead to reduction of Labour cost and optimization of operational expenses.
3. **Improving Quality of Work:** This can lead to skill matching and focusing of specialization.
4. **Improving Employee Satisfaction:** This involves job satisfaction and reduction of turnover.
5. **Streamlining Operations:** This is enhances the overall efficiency of manufacturing processes and the responsive to changes in production demands or unexpected disruptions.
6. **Facilitating Performance Monitoring:** This will help to track the productivity process and enhances vital decision making by the management of the factory.
7. **Supporting Continuous Improvement:** This will help to identify skill gaps and offer targeted training for works to enhance workforce capabilities. It will also encourage innovation.

III Methods

Research design was through quantitative data with applied research. The analysis method uses an assignment model with the Hungarian method. Our sources data were taken from four (4) employees with four (4) jobs at NEDLUX Paint factory. Analyses of the data collected from personal interview at the company coupled with the consultation of various operational reports and publication of the paint manufacturing company. The interview provided information on the production planning and product mix process techniques used in the establishment. This information in adding with the sales and other operating data were examined to provide estimates for task assignment. The product mix optimization was obtained by evaluating the Hungarian algorithm model, the solution of which included the sensitivity analysis [11]
However, in other to have an idea of what is obtainable in a particular company for the purpose of generalization of idea; NEDLUX Company was chosen as a case study. The choice of this organization depends on the willingness of this establishment to release relevant information just for this study.

Hungarian Algorithm Steps

This Algorithm is a combinatorial optimization process used to elucidate the assignment problem, aims to find the finest way to assign tasks to agents (or operators) while minimizing total cost[14] . Here are the key principles that underpin the Hungarian Algorithm:

1. **Cost Matrix Representation**

- The problem is represented as a cost matrix, where each component cij represents the cost of assigning task j to operator i.
- The aim is to get a one-to-one transfer of tasks to operators that reduces the total cost.

2. **Row and Column Reduction**

- Row Reduction: For each row in the cost matrix, subtract the least element in that row from all elements of the row. This guarantees that there is at least one zero in each row.
- Column Reduction: After row reduction, subtract the smallest section in each column from all elements of that column. This attests at least one zero in each column as well.

3. Covering Zeros

- The next step involves covering all zeros in the matrix using the minimum number of horizontal and vertical lines.
- Assuming the number of lines used to shade all zeros equals the number of rows (or columns), an optimal assignment can be achieved. If not, modifications need to be made.

4. **Adjusting the Matrix**

- If fewer lines are used than the number of rows, identify the smallest open value in the matrix.
- Subtract this smallest uncovered value from all uncovered elements and add it to the elements that are covered twice. This adjustment creates new zeros and potentially allows for a new optimal assignment.

5. Finding the Optimal Assignment

- Once the matrix has been attuned, such that the number of covering lines equals the number of rows, an optimal assignment can be made.
- Select zeros by a way that each row and each column has one selected zero. This selection represents the optimal task assignment.

6. Iterative Process

- The algorithm iteratively applies the above steps until an optimal assignment is reached. The process is efficient and can be completed in polynomial time, making it suitable for practical applications.

7. Complexity and Performance

- The Hungarian Algorithm possess a time complexity of O (n^3), where n is the number of tasks or operators. This led to its efficient for reasonably sized problems, typically up to a few hundred tasks or operators.

VII. Result and Discussion

Regarding on the problem of assigning tasks, where each worker has different skills and work experience, the following is data on cost (in NEDLUX Paint factory) of completing the work process of each operator in each work process.

Table 1: Work Assignment

Assignment	Work Description
Job I	Raw material selection and preparation
Job II	Formulation and Blending
Job III	Filtering and Fining
Job IV	Packaging and Labeling

In table 1 the number of employees employed is 4 (four) workers/operators with 4 (four) jobs that differ from one job to another, the calculation for assigning employees uses the Hungarian method. The work costs (₦) of each operator or worker are grouped in the table [13]

***Step 1 of Hungarian* Algorithm:** The problem is represented as a cost matrix, meaning each element cij represents the cost of assigning task j to operator i.

Table 2: Assignment Financing

Operator	**Job I**	**Job II**	**Job III**	**Job IV**
A	24	72	22	91
B	62	48	35	91
C	52	91	47	91
D	75	54	32	91

Note: In table 2 the entries in the matrix represent each man's processing time in hours, With 4 jobs and 4 men, the stated problem is balanced [14]

Forming an Assignment Matrix
Step 2:

Changing the financing matrix into an opportunity cost matrix by deducting the least element in that row from all elements of the row. This ensures that there is at least one zero in each row. Then also subtract the smallest element in each column from all elements of that column. This ensures at least one zero in each column as well [5]

Table 3: Subtracting the least value in each row

Operator	Job I	Job II	Job III	Job IV
A	24-22=2	72-22=50	22-22=0	91-22=69
B	62-35=27	48-35=13	35-35=0	91-35=56
C	52-47=5	91-47=44	47-47=0	91-47=44
D	75-32=43	54-32=22	32-32=0	91-32=59

Note : In Table 3 it shows Subtract row minima For each row, find the lowest element and subtract it from each element in that row. [14]

Table 4:

Operator	Job I	Job II	Job III	Job IV
A	2	50	0	69
B	27	13	0	56
C	5	44	0	44
D	43	22	0	59

Table 4 is the result of the above subtraction in each row [14]

Step 3: Subtracting the smallest value in each Column in Table 4 above

Table 5: Subtracting the smallest value in each Column

Operator	Job I	Job II	Job III	Job IV
A	2-2=0	50-13-37	0-0=0	69-44=25
B	27-2=25	13-13=0	0-0=0	56-44=12
C	5-2=3	44-13=31	0-0=0	44-44=0
D	43-2=41	22-13=9	0-0=0	59-44=15

Note: In table 5, is Subtract column minima, similarly, for each column, find the lowest element and subtract it from each element in that column [14]

Table 6:

Operator	Job I	Job II	Job III	Job IV
A	0	37	0	25
B	25	0	0	12
C	3	31	0	0
D	41	9	0	15

Note: The Table 6 Shows the results of the above subtraction in each Column [14]

Step 4:

Covering Zeros

The next step involves covering all zeros in the matrix in Table 6 using the minimum number of horizontal and vertical lines. If the number of lines used to cover all zeros equals the number of rows (or columns), an optimal assignment can be made. Outside it, adjustments should to be made.

Table 7: Cover Zeros

Operator	Job I	Job	Job	Job

		II	III	IV
A	0	37	0	25
B	25	0	0	12
C	3	31	0	0
D	41	9	0	15

NOTE: In Table 7 we covered all zeros with a minimum number of lines Cover all zeros in the resulting matrix using a minimum number of horizontal and vertical lines. If *n* lines are required, an optimal assignment exists among the zeros. The algorithm stops. If less than *n* lines are required, continue with Step 4 [13]

The above table shows that best assignment has are made because the figure of line in the horizontal and vertical are equal.

Step 5:

Finding the Optimal Assignment

Once the matrix has been attuned with the number of covering lines equals the total of rows, an optimal assignment can be made. Then select zeros in manner that each row and each column has precisely one designated zero. This selection represents the optimal task assignment. The selected zeros are shown in the table below:

Table 8: **Optimal Assignment**

Operator	**Job I**	**Job II**	**Job III**	**Job IV**
A	0	37	0	25
B	25	0	0	12
C	3	31	0	0
D	41	9	0	15

Note: In table 8 the zeros are selected and use to determine the optimal assignment that assists in deploying job to operators [13]

Assign Job 1 to Operator A (0) which 24
Assign Job 2 to Operator B (0) which 48
Assign Job 4 to Operator C (0) which 91
Assign Job 3 to Operator D (0) which 32

Table 9:

Operator	**Job I**	**Job II**	**Job III**	**Job IV**
A	24			
B		48		
C				91
D			32	

Table 9 shows it corresponding Matching in Table 2 [14]
The total Optimal Cost
24 + 48 + 91 + 32 = 195
Therefore the minimum cost for assigning jobs to operators using the Hungarian Algorithm is ₦195

IV. Conclusion

With regards to the above results and discussion, the notion of allocating one job to each operator using the Hungarian Algorithm, the minimization results are **Assign Job 1 to Operator A** (0) which 24, **Assign Job 2 to Operator B** (0) which 48, **Assign Job 4 to Operator C** (0) which 91, **Assign Job 3 to Operator D** (0) which 32, Based on the study sample **the minimum cost for assigning jobs to operators using the Hungarian Algorithm is ₦195.**

Effective task assignment in factory settings is paramount for reducing costs, improving quality, and enhancing employee satisfaction. By leveraging optimization techniques like Hungarian Algorithm, factories can ensure that duties are allocated efficiently, ultimately driving operational success and effectiveness in the manufacturing industry.

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