Facility Layout Optimization using Craft Algorithm According to Future Demand of Product

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Abstract— A plant layout plays a major role in minimizing the production cost and time. Manufacturing plant layout consist of departments like foundry, machining workshop, inspection and administration department etc. These departments are interconnected and interdependent on each other. Movement from one department to another is a waste as it increases the production cost and time. Production cost and time can be minimized by optimal positioning of different departments in a given area. In this research paper initial layout of the plant is optimized by using Computerized Relative Allocation of Facilities Technique (CRAFT). MATLAB program is developed which take various inputs about the initial given layout from the Excel File and model the final layout in MATLAB.

Keywords: Facility Layout; CRAFT Algorithm; MATLAB Programming; Plant Layout; Exponential Smoothing; Demand

I. Introduction

Facility planning is important for proper and sustainable working of company. It involves varies aspect like factory location, factory layout etc. Factory location depends on closeness to raw material, market, labor supply, roads, power supply, availability of basic necessities like water etc. Next stage in Facility planning is layout planning. In a factory different parts can be manufactured which can require various processes so parts are need to be transported from one part of the factory to another which consumes fuel, need workers, conveyor belts etc. Layout planning is necessary to minimize the non-value added activity transportation and cost incurred due to it.

A. Importance of Facility layout

- Optimal factory layout can minimize the cost and time required to produce a product which led to increase in profit and provide an edge to company over its competitors.
- It reduces non value added activity which can increase the productivity of a company substantially.
- Good factory layout can make the manufacturing process more stream line.

II. Literature review

Earlier, Quadratic Assignment Problem Model was used for solving Layout planning problem. But it considers only few cases of the facility layout and following assumptions were made like equal cell area, fix coordinates etc. This model was proposed by Yavuza A. Bozer and RUSSELL D. Mulle.

Different layout planning techniques like CORELAP and ALDEP don't need initial layout. These algorithms generate initial layout from the relationship matrix between the cells and generate the initial facility layout and further optimize it.

Various layout improvements algorithm like CRAFT and COFAD require initial layout of facility and various other information like cost, flow and distance matrix to optimize the layout.

Two algorithms can also be integrated for facilities planning like combining ALDEP and CRAFT removes the need of initial layout.

Facility location is the critical part of the company success. Various factors need to be considered for location like closeness to raw material, labor, market, power supply etc.

III. Research method

Computerized Relative Allocation of Facilities Technique (CRAFT) algorithm is a layout improvement algorithm. It was proposed in 1964. It is used to generate optimum layout and minimize the material handling cost of factory. It takes Flow between various cells, corresponding cost, and initial layout as inputs. From initial layout the distance between various departments are found. It calculates the material handling cost of initial layout and then optimize the layout by swapping different cells. The aim of this algorithm is to minimize the material handling cost of factory, mathematically represented as:

Total Cost= $\sum_i^n \sum_j^n C_{ij} D_{ij} F_{ij}$

C = Cost matrix

D = Distance matrix

F= Flow matrix

A. Steps in Development of Layout

1) Get the required inputs from the excel file. Input to Matlab function will be given by the excel file. Various information regarding the initial plant layout will be given such as:
   - Number of departments.
   - Initial coordinates, dimensions and area of rectangular cell.
   - Number of parts made in factory
   - Number of processes involved in manufacturing different parts.
   - 5-year Demand and exponential smoothing coefficient.
   - Cost matrix(Identity matrix) for all departments.
2) Calculate the relationship between machines for different parts.
3) Calculate the demand forecast of each part by exponential smoothing.
4) Calculate distance between different departments.
5) Calculate the flow matrix from the demand forecast and the part processes.
6) Calculate the transportation cost of the initial layout and plot the initial layout.
7) Interchange different departments and repeat steps 3) to step 5).

8) These steps are repeated until minimum cost is find out.
9) Plot the final plant layout.

B. Initial Factory layout

Initial Layout consist of different departments with different sizes as shown in figure 1

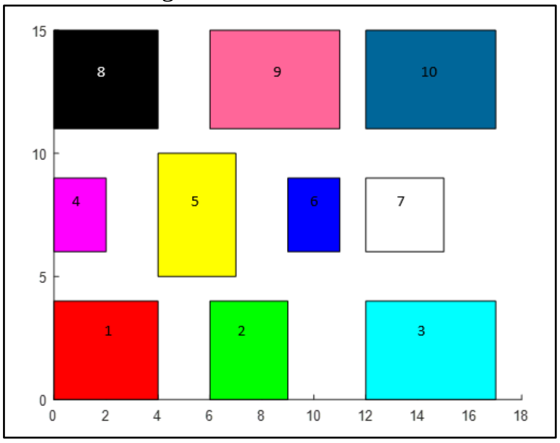


Fig. 1:

Figure 2 given below gives the parts information and their process sequence involved for manufacturing.

Part and Process information

Part1	1	3	5	7	9
Part2	1	8	2		
Part3	1	5	4	10	
Part4	1	2	4	6	8
Part5	1	3	6	8	4

Fig. 2:

Figure 3 gives the demand matrix which is used in calculation of demand forecasting.

	Exponential smoothing coefficient	Year 1	Year 2	Year 3	Year 4
Part1	.5	23	25	19	20
Part2	.7	22	12	17	14
Part3	.3	25	22	20	13
Part4	.6	22	19	17	14
Part5	.8	33	30	25	21

Fig. 3:

C. Flow Matrix

Algorithm uses the above 4-year demand data to calculate the demand forecast. Then it calculates the Flow matrix (figure 4) with the help of demand forecast of each product and their process sequence.

flow =

0	16	43	0	20	0	0	15	0	0
16	0	0	16	0	0	0	15	0	0
43	0	0	0	21	23	0	0	0	0
0	16	0	0	20	16	0	23	0	20
20	0	21	20	0	0	21	0	0	0
0	0	23	16	0	0	0	38	0	0
0	0	0	0	21	0	0	0	21	0
15	15	0	23	0	38	0	0	0	0
0	0	0	0	0	0	21	0	0	0
0	0	0	20	0	0	0	0	0	0

Fig. 4:

D. Distance Matrix

Distance Matrix for initial layout is calculated by calculating the rectilinear distance between the centroid of various departments.

dis =

	1	2	3	4	5
1	0	5.5000	12.5000	6.5000	9.0000
2	5.5000	0	7.0000	12.0000	7.5000
3	12.5000	7.0000	0	19.0000	14.5000
4	6.5000	12.0000	19.0000	0	4.5000
5	9.0000	7.5000	14.5000	4.5000	0
6	13.5000	8.0000	10.0000	9.0000	4.5000
7	17.0000	11.5000	6.5000	12.5000	8.0000
8	11.0000	16.5000	23.5000	6.5000	9.0000
9	17.5000	12.0000	17.0000	13.0000	8.5000
10	23.5000	18.0000	11.0000	19.0000	14.5000

	6	7	8	9	10
1	13.5000	17.0000	11.0000	17.5000	23.5000
2	8.0000	11.5000	16.5000	12.0000	18.0000
3	10.0000	6.5000	23.5000	17.0000	11.0000
4	9.0000	12.5000	6.5000	13.0000	19.0000
5	4.5000	8.0000	9.0000	8.5000	14.5000
6	0	3.5000	13.5000	7.0000	10.0000
7	3.5000	0	17.0000	10.5000	6.5000
8	13.5000	17.0000	0	6.5000	12.5000
9	7.0000	10.5000	6.5000	0	6.0000
10	10.0000	6.5000	12.5000	6.0000	0

Fig. 5:

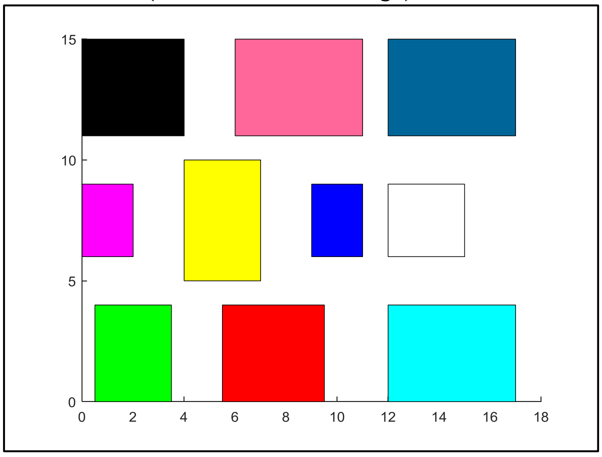
Algorithm uses the distance matrix, flow matrix and cost matrix to calculate the Total cost for each swap between the cell.

IV. RESULTS

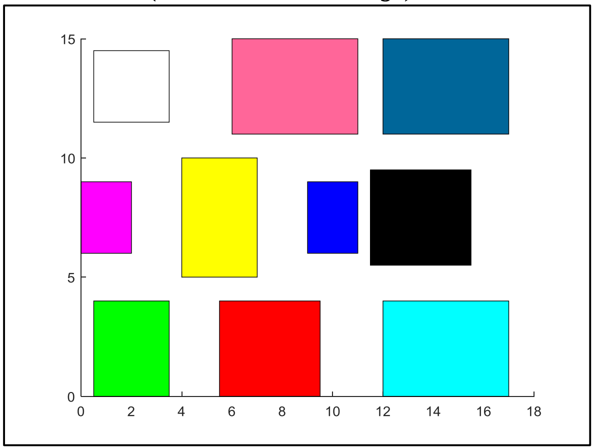
A. Layout Transformation:

Different layouts are generated by interchanging positions of various departments based on the minimum cost in each iteration.

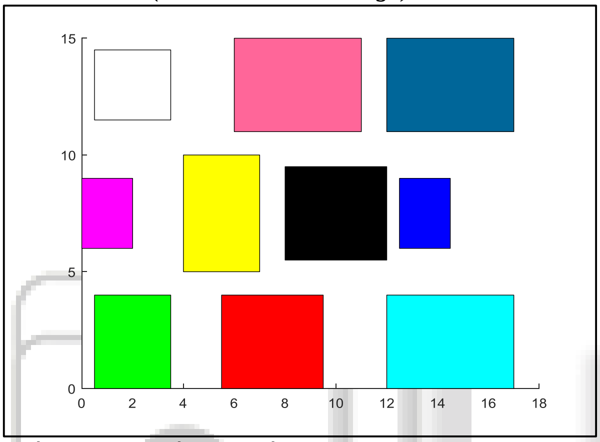
1) 1st iteration (1st and 2nd interchange)



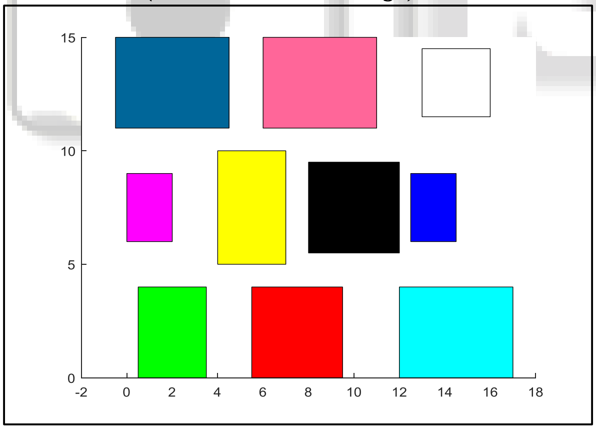
2) *2nd iteration (7th and 8th interchange)*



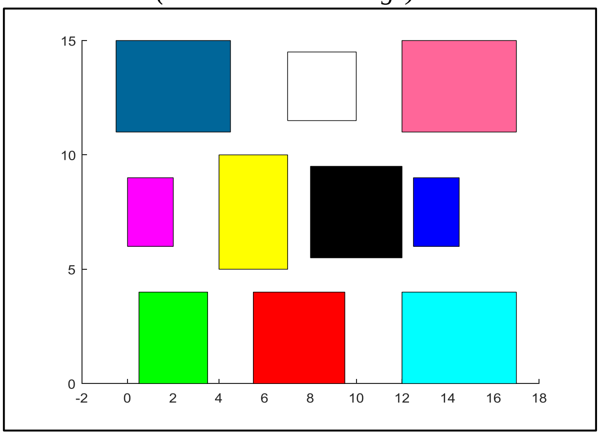
3) *3rd iteration (6th and 8th interchange)*



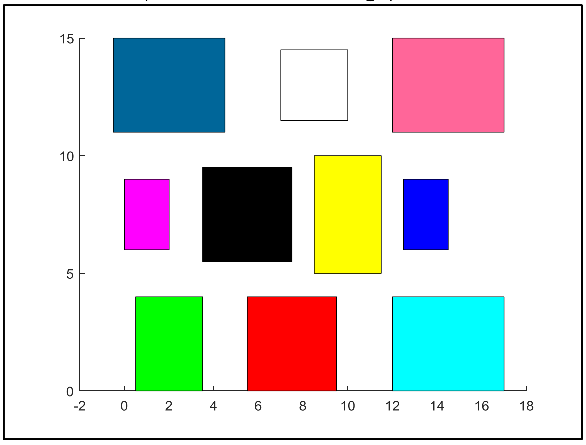
4) *4th iteration (7th and 10th interchange)*



5) *5th iteration (7th and 9th interchange)*



6) *6th iteration (8th and 5th interchange)*



B. Total Cost

Total cost of layout is generated by multiplication of Flow, Distance, and Cost matrix.

	Cost	% reduction w.r.t initial cost
Initial layout	7219	-
1st iteration	6510	9.821
2nd iteration	5930	17.855
3rd iteration	5510	23.67
4th iteration	5220	27.69
5th iteration	4968	31.18
6th iteration	4901	32.11

From the above data it is evident that there is substantial reduction in the initial and optimal layout cost. Transportation cost can be minimized by about 32.11% w.r.t initial layout cost.

V. CONCLUSION

In this paper the material handling cost of factory is minimized by optimizing the layout of the factory. The algorithm finds the demand forecast of each part and accordingly considers the possible department swaps to find the minimum cost. Finally, the optimal layout of the facility is generated. The minimum cost obtained for the above initial layout is 4901 with a %reduction of 32.11% w.r.t initial cost. In this paper the initial input data is taken from excel file and output layout is generated in Matlab.

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