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Determining the Global Optimal Response for the From/To Chart Using Dynamic Programming Method

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ABSTRACT

One of the effective factors in the establishment of sections and equipment is material transportation and the current flow among the sections. The more this flow is forward and direct and the less the backward moves are, this flow would be more optimized. For this purpose, thefrom/to chart is used. In order to optimize the flow among the sections, this chart is optimized using trial and error method. In this paper, a solution based on the dynamic programming is proposed by which the Global optimal response offrom/to chart is calculated.
KEYWORDS: From/To Chart, Dynamic Programming, Establishment Of Sections, Equipment And Materials

1. INTRODUCTION

By using the from/to chart, the transportation volume among different sections and also the relation between different lines can be realized. In the columns and rows of this chart, the different sections, Machinery and lines are located and the flow among them are determined. By using trial and error method, relocation of columns and rows and calculating the torques, the optimal strategy is chosen. In the from/to chart, the torque is calculated as follows: the summation of the diagonal above the main diagonal are multiplied by natural numbers respectively i.e. the summation of diagonal elements above the main diagonal are multiplied by one, the second diagonal elements above the main one are multiplied by two and so on. The summation of each diagonal above the main one are multiplied by even numbers that is some kind of return-to-back charging[1].

A lot of issues available in the operation research need decisions in different time and local segments. Moreover, a lot of temporary decisions can be converted to consecutive decisions for different stages in a way that the problem solving method is simplified. The dynamic behavior of some problems that the decision making process should be consecutive for them, results in a specific definition called multistage decision-makings. Dynamic programming is a specific mathematical method for problems involving multi-stage decision-makings. This method was proposed and developed by a researcher called Richard Bellman in 1950s[2,3].

Tripathy[4] had used dynamic programming in their paper published in 2015, in order to reach the optimal plan for the interconnection networks. In the aforesaid paper, it is stated that using dynamic programming will always result in Global response and this response is close to the optimal local response which is determined by initiative methods. Bruno[5] had also mentioned the fact that dynamic programming is a technique for solving complicated nonlinear multi-stage problems. This was stated by them in their paper published in 2015 with the topic of improving random dynamic programming in hydrothermal systems using repeating process.'

As it was mentioned before, the from/to chart was optimized by trial and error and random relocation of rows and columns. In the following section, the global optimal solution of the from/to chart is done using dynamic programming based on the proposed features of this method.

2. Proposed Method

The sections in the from/to chart are not located optimally at the beginning and surely the back to back movements may not be minimized. Moreover, the performances may not be direct. In other words, there is no guaranty that this establishment is the optimal one. In this paper, some efforts has been made in order to determine the optimal establishment by using dynamic programming by the retrogressive approach and determining stages, conditions, decision and goal.

Variables and parameters:

n =number of stages, $n \geq 1$
m =number of equipment
α = location of available elements in each permutation, $0 \leq \alpha \leq m-1$
β= the place of each decision element, $0 \leq \beta \leq m$
$c_{Ai(\alpha)BJ(\beta)}$= the flow of number of partswhich moves from the equipment A located in the element place i(α) to equipment B located in the element place j(β)

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$c_{Bj(\beta)Ai(\alpha)}$ = = the flow of number of parts which moves from the equipment B located in the element place j(β) to equipment A located in the element place i(α)

Therefore:

If A=B, the penalty M is considered a large number.

If A≠B, and there is no flow between the two departments, the value is considered zero.

If A≠B, and there is a flow between the two departments, the value is considered the same as the flow amount (number of parts).

n=m-1, Number of stages= number of equipment – 1

State (s): the (n)th permutations from m equipment; p(m ,n)

Decision (x): equipment added to the end of the previous equipment row; 1,2,…,m

$p_{(n,s(n)x(n))}$: The share of the decision-making x(n) when being in state S(n) of the (n)th stage.

Target: choosing the minimum value for $f^*_{(1,s(1))}$; $f^*_{(1,s(1))}$

Decision row: j(0),j(1),…,j(m)

Decision column: i(0),i(1),…,i(m-1)

Mathematical model:

$$f^*_{(n,s(n))} = \sum_{\alpha=0}^{m-1} C_{Ai(\alpha)Bj(\beta)} \times (n-\alpha) + \sum_{\alpha=0}^{m-1} C_{Bj(\beta)Ai(\alpha)} \times 2\,(n-\alpha),\ n\text{-}\alpha\geq 1$$

$$f^*_{(n,s(n))} = \min f^*_{(n,s(n),x(n))}$$

$$f_{(n,s(n)x(n))} = p_{(n,s(n)x(n))} + f^*_{(n+1,s(n+1))}$$

3. Solving a sample problem

If the from/to chart shows the flow among the sections like this:

Table 1.from/to chart among sections

From/To	A	B	C
A	-	20	10
B	3	-	2
C	-	5	-

Calculating the torque for primary from/to chart:

(20+2)+(10×2)+(5+3)×2=112

At the first stage, all the cases are examined in order to determine the torques for all of them. Then the problem is solved using the proposed method which is based on dynamic programming.

Table 2. Trial and error chart N.O. 1

From/To	B	C	A
B	-	2	**30**
C	5	-	-
A	20	10	-

Calculating the torque for the second from/to chart:

(2)+(30×2)+(15×2)+(20×4)=172

Table 3. Trial and error chart N.O. 2

From/To	C	B	A
C	-	5	-
B	2	-	**30**
A	10	20	-

Calculating the torque for the third from/to chart:

(30+5)+(20+2)×2+(10×4)=119

Table 4: Trial and error chart N.O. 3

From/To	A	C	B
A	-	10	**20**
C	-	-	**5**
B	30	2	-

Calculating the torque for the fourth from/to chart:

(10+5)+(20×2)+(2×2)+(30×4)=179

Table 5. Trial and error chart N.O. 4

From/To	B	A	C
B	-	30	**2**
A	20	-	**10**
C	5	-	**-**

Calculating the torque for the fifth from/to chart:

$$(10+30)+(2\times2)+(20\times2)+(5\times4)=104$$

Table 6. Trial and error chart N.O. 5

From/To	C	A	B
C	-	-	**5**
A	10	-	**20**
B	2	30	**-**

Calculating the torque for the sixth from/to chart:

$$20+(5\times2)+(10+30)\times2+(2\times4)=118$$

Therefore, B-A-C produces the least weight and is the optimal establishment. Then, by using the proposed method based on dynamic programming and by the retrogressive approach:

$$m=3 \text{ ، } n=2 \;\; 3\geq\beta\geq0 \text{ ، } 2\geq\alpha\geq0 \text{ ،}$$

Second Stage:

Table 7. Second stage of dynamic programming

S\X	A	B	C	Optimum	Efficient equipment
A,B	-	-	32*	32	**C**
B,A	-	-	34	34	**C**
A,C	-	169	-	169	**B**
C,A	-	98	-	98	**B**
B,C	120	-	-	120	**A**
C,B	110	-	-	110	**A**

$$*f^*_{(2,s(2))}=10\times(2-0)+2\times(2-1)+0+(5\times2\times(2-1))=32$$

First stage:

Table 8. first stage of dynamic programming

S\X	A	B	C	Optimum	Efficient equipment
A	-	112	179	112	**B**
B	104	-	172	104	**A**
C	118	119	-	118	**A**

So, the B-A-C is also the optimal establishment based on this method because it realizes the object minimization problem and this path is the optimal dynamic response based on the above chart. Therefore, it is the global optimal response.

4. Conclusion

As discussed before, from/to chart shows the flow among the sections. Less torque of the establishment plan will result in a more suitable establishment plan. In this paper, efforts was done to find the optimal establishment plan by using dynamic programming with the retrogressive approach instead of trial and error method so that global optimal response is obtained. By this approach, the global response ensures that the flow between sections are in a way that the cost is minimum and this one of the achievements of this proposed method.

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