

Optimization Solution of Equal Dimension Boxes in Container Loading Problem using a Permutation Block Algorithm

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Abstract

The Container Loading Problem consists of packing boxes of similar sizes into available Containers in such a way to optimize an objective function. In this paper we apply the concept of Permutation Block Algorithm (PBA) in the wall layer approach for the Load Optimization of Equal Dimension Boxes in the Container Loading Problem. The vehicle is loaded by means of either top side only or by any sides possible. The main objective of this paper is to increase the use of space while filling loads into the container.

Keywords: Logistics, Load Optimization, Vehicle Parameters, Box Parameters, Container Loading Problem

1. Introduction

Logistics is the management of the flow of resources between the point of origin and the point of consumption. Logistics Optimization is the biggest opportunity for the most companies to significantly to satisfy the customer¹.

The single Container Loading Problem (CLP) is a three dimension packing problem in which a large parallelepiped has to be filled with smaller parallelepipeds². The resources managed in logistics can include physical items, such as food, materials, equipment, liquids, and staffs, as well as abstract items such as time, information, particles, and energy.

The new special logistic process used for the efficient containerization involves number of technologies, logistics plans and automated systems to handle a great number of containers. To fulfill specific requirements, computation appears as important tool. For example, software can “determine the order in which the containers are

to be charged and discharged, to speed the process without destabilizing the container”⁴.

Logistics Automation improves the efficiency of logistics operations. Typically it refers to operations within a warehouse or distribution center, with broader works undertaken by supply chain management systems and enterprise resource planning systems.

The container loading problems are grouped together in different ways. First of all it is differentiated into four different segments such as single container loading problem with same type boxes, multiple container loading problem with same type of boxes, Single container loading problem with multiple type boxes and multiple container loading problem with different type of boxes.

The algorithm used in the single and multiple container loading problems is similar in packing the amount of boxes inside the containers. There are two inbuilt approach used to solve the single and multiple container loading problem. They are solving the problem by layers and solving the problem by stacks³.

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1.1 Solving the Problem by Layers

Firstly, horizontal layers of size (L, B) are arranged with boxes that have same height and finally these layers are chosen to be piled up along the height H. This scheme of solving problem generalizes the method of Gilmore and Gomory (1965) for two-dimensional problems with a 2-staged cutting pattern.

1.2 Solving the Problem by Stacks

Similarly to the above method, we first define stacks of height H by piling up boxes and then we choose which stacks should build the loading pattern by arranging them over the floor (L, B) of the container. This procedure was initially proposed by Gilmore and Gomory (1965) but we did not find computational experiences using it in literature. Figure 1 portrays sample Container with Load.

The objective function of this method is to use PBA algorithm to define the most suitable space allocation to arrange the boxes in the container.

2. Problem Description

In Logistics, the Container Loading Problem plays a vital role during Load assembly⁵. It is a complex task in reducing the unused space to accommodate the full usage space for goods in the truck. Here the goods were packed in same dimension and loaded into the vehicle without the elimination of the unused space. And there is no specific method or approach for loading the similar type of boxes into the vehicle¹. So we proposed to use five step algorithmic approaches in which the first step acquires the values of Truck and Goods to be filled in it, the second step will decide which approach to choose to apply the method, while the third and fourth step involves in primary and secondary filling, and the last one finds the maximum suitability of arranging the Boxes.



Figure 1. Sample Container with Load.

3. Problem Architecture

In this approach, the total goods weight and tonnage of the vehicle is compared, from this the suitable matching vehicle is selected¹. And then the boxes are best fitted in to the vehicle based on the evolution of five Algorithms. From each algorithm we calculate with the different dimensions to find out the best match that suits the vehicle load filling. During the first algorithm we first initialize the parameters of the truck and the goods or boxes that are to be filled inside the truck. Now we must be known how we are orienting the boxes. After obtaining the box placement option, we do all permutations and combinations methods for the primary filling. After that we will find any unused spaces available in the container or not. If there is any gap in the container we can seal with the help of secondary filling. Secondary Filling will now make further more permutation concept which reduces the unused space in the container so as to fill the container to the fullest level. The total filling is checked at last to see whichever combination is most occupied in the container. Now the software program shows the output with the method of filling and the total number of boxes packaged inside the container. Figure 2. Represents the Proposed Flowcharts.

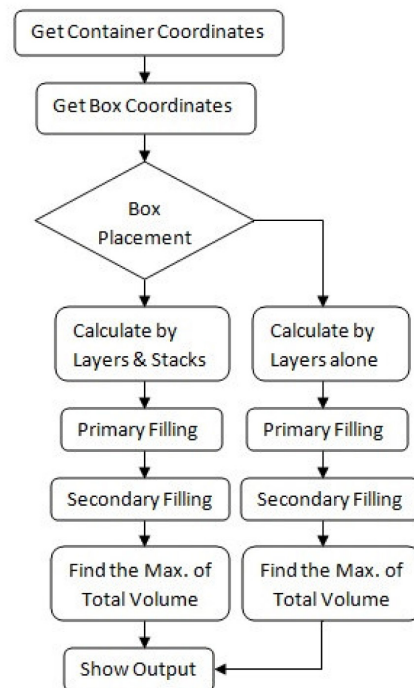


Figure 2. Proposed Flowcharts.

4. Proposed Algorithm and Analysis

4.1 Algorithmic Approach

This algorithm is to find the maximum block accommodation into the container by using permutation and combination technique. Our proposed method consists of five different algorithmic steps.

- Initializing the parameters
- Primary Filling
- Secondary Filling
- Total Filling
- Find the best fit

Step 1: Initializing Parameters

L, 2. B, 3. H, 4. l, 5. b, 6. h, 7. x, 8. y, 9. z, 10. Pf1-Pf6, 11. Tf1-Tf6, 12. M1-M4, 13. N1-N4, 14. O1-O4.

Step 2: Primary Filling

$Pf1 = ((L/l) * (B/b) * (H/h))$

Repeat step 2 with different combinations to get the Perfect or Maximum filling like Pf2, Pf3,...f6.

Step 3: Secondary Filling

Find the remaining gaps to be filled in the container.

$X = L \% l; \quad Y = B \% b; \quad Z = H \% h;$

if $((x/b) >= 1)$

$M1 = ((X/b) * (B/b) * (H/h));$

elseif $((Y/l) >= 1)$

$N1 = ((L/b) * (y/l) * (H/h));$

if $((Y/l) >= 1)$

$N1 = (((L-x)/b) * (Y/l) * (H/h));$

Step 4: Total Filling

$Tf1 = Pf1 + M1 + N1;$

$Tf2 = Pf2 + M2 + N2;$

...

$Tf6 = Pf6 + M6 + N6;$

Step 5: Finding best out of it

If $((Tf1 > Tf2) \&\& (Tf1 > Tf3) \&\& (Tf1 > Tf4) \&\& (Tf1 > Tf5) \&\& (Tf1 > Tf6))$

Printf("\nTf1 fills more than any other combinations");

ElseIf $((Tf2 > Tf3) \&\& (Tf2 > Tf4) \&\& (Tf2 > Tf5) \&\& (Tf2 > Tf6))$

Printf("\nTf2 fills more than any other combinations");

ElseIf $((Tf3 > Tf4) \&\& (Tf3 > Tf5) \&\& (Tf3 > Tf6))$

Printf("\nTf3 fills more than any other combinations");

ElseIf $((Tf4 > Tf5) \&\& (Tf4 > Tf6))$

Printf("\nTf4 fills more than any other combinations");

ElseIf $(Tf5 > Tf6)$

Printf("\nTf5 fills more than any other combinations");

Else

Printf("\nTf6 fills more than any other combinations");

4.2 Explanation

4.2.1 Initializing Parameter

In this step, the Vehicle parameters, Box parameters and other computational parameters are being initialized.

L – Container Length,

B – Container Breadth,

H – Container Height,

l – Box Length,

b – Box Breadth,

h – Box Height,

x, y, z – Modulo of L, B, H

Pf1, Pf2,...Pf6 – Primary Filling from 1 to 6,

m1 to m4 – Secondary Length Filling,

n1 to n4 – Secondary Breadth Filling,

o1 to o4 – Secondary Height Filling,

Tf1, Tf2,...Tf6 – Total Filling.

4.2.2 Primary Filling

In general algorithm the box algorithm is not interchanged, i.e. l, b, h will be same in all the cases. But in the solving the problem by layers and stacks, it is often changed to check the maximum utilization of the container.

Here we are going to divide the container parameters by the value of box parameters for the primary filling of boxes into the container (e.g. L/l, B/b, H/h). This method is done in six different combinations for getting the maximum utilization of the container space.

4.2.3 Secondary Filling

The secondary filling involves filling of remaining space after primary filling is done. It consists of three coordinates such as Length (L), Width (B) and Height (H); four different combination in each coordinate is to find which combination performs the maximum utilization of boxes in the single container.

In this method we need to find the values of m1-m4, n1-n4, and o1-o4. For this we first find the remaining spaces that need to be filled in the container before it

needs to be filled. To find it we use modulo division concept and get the remaining spaces.

Now it is filled by means of four different combinations at three coordinates to obtain the values of (m1-m4, n1-n4, o1-o4).

4.2.4 Total Filling

Total filling is the sum of primary filling and secondary filling. Here all the combinations of the coordinates were added together to find the maximum utilization factor.

4.2.5 Finding Best Out of it

At the end of the algorithm we must find out the maximum utilization factor in the overall combinations. Now by comparing six different combinations we can get the maximum utilized permutation approach for the container loading problem and is produced at the output.

5. Simulation Result and Discussion

The following are the screenshots (Figure. 3-7) which show the simulated results of the proposed algorithm done using the help of C-Program with different permutation

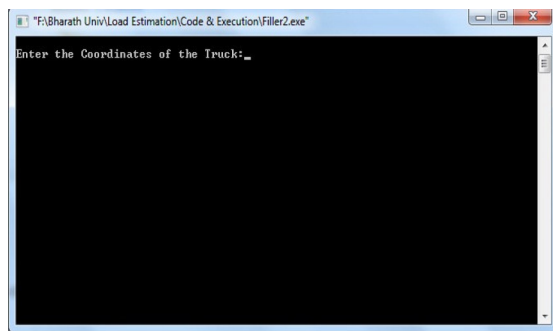


Figure 3. Simulated output form 1.

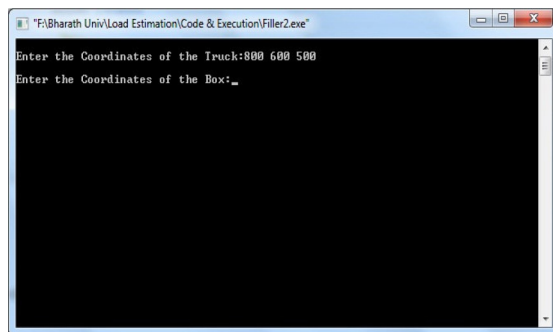


Figure 4. Simulated output form 2.

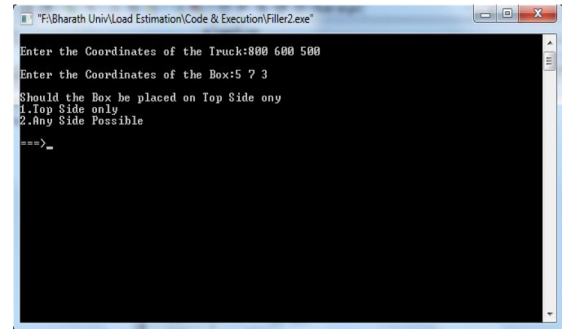


Figure 5. Simulated output form 3.

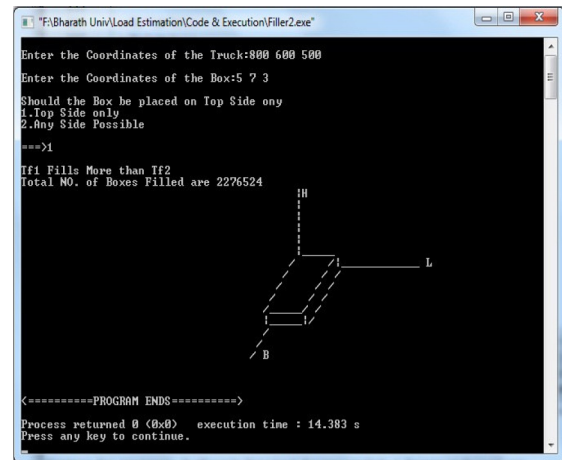


Figure 6. Simulated output form 4.

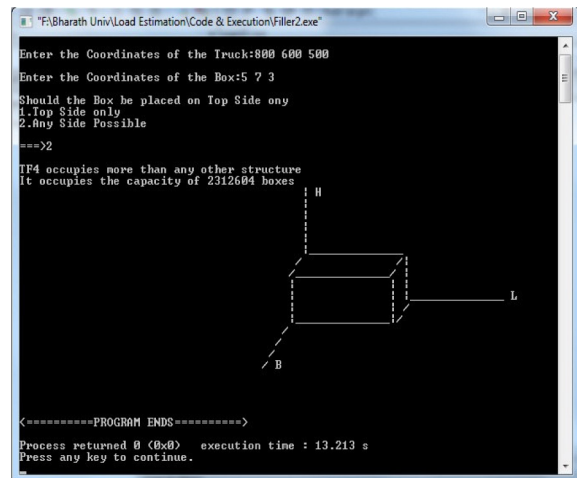


Figure 7. Simulated output form 5.

and combination approach for comparison and obtaining the maximum utilization of Container space.

In the first and second screenshot the program requests the user to enter the value of coordinates of the truck and the value of coordinates of the box to be filled inside the container. The initialization of the values is

done here and the program starts to evaluate the kind of flow for the execution purpose whether to continue the execution based on the orientation of the boxes. They are by building wall layer approach by interchanging the values of Height or by fixing the value of height as constant and not by varying it.

During the third step the program asks the user whether the boxes are arranged only by placing on the box top side only or otherwise.

If the user enters the value 1 (i.e. top side only) means the program will start evaluating the model by doing the different combinations only by the horizontal manner, by interchanging the values of Length and Breadth (L, B) with the box kept on the top side only and not interchanging the parameters of height H.

When the user enters the value 2 (any sides possible) during the third step, then the program will execute in such a way by interchanging all the parameters of the box, such as Length, Breadth and Height (L, B, H) so that the boxes will fill more spaces than the previous approach. But it makes orientation on Height (H) too, which some logistics did not use.

6. Conclusion

The PBA tells us that this works only for the Equal Dimension Boxes. By obtaining the coordinates of the container and coordinates of the box, we can get the maximum utilized space inside the container by reducing the unused space.

7. Future Work

The real time work only for the Equal Dimension Boxes. So we are in research for the project to function in Multi-Dimension Boxes and Multi Vehicle Loading.

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9. References

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