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Order-based Manipulator-focused optimization of Warehouse passing

Jan Holáň*

Abstract

The contribution is focused on picking path optimization while passing through warehouse with given specification of the warehouse. The main goal is to make picking items, which have been ordered by customers, faster. The topic is solved along with solving famous mathematical problems, such as Travelling Salesman Problem and Bin Packing Problem. The core of the problem consists in the optimization of grouping items that is extended of the fact, that the items are already clustered to some indivisible groups no matter of their real position. In order to solve this there is proposed some mathematical methods. The main goal is to allow workers collect all the items with the shortest route possible. The rest of the paper focuses on classical approaches for the rest of the problem.

*xholan11@vutbr.cz, *Faculty of Information Technology, Brno University of Technology*

1. Introduction

The finding a subset of items into several disjoint sets that covers the whole set (grouping) in order to minimize the sum of distances necessary to collect all items is a long-standing problem that is still investigated in various modifications. The workers travels through the warehouse while picking the items of customers orders. The workers need to group the items such that the items in the same order are in the same group too (the restriction given by the company due to the following processes).

We assume a warehouse grid and constraints and conditions given by a specific company[1] (that's necessary for making of the right optimization). Logistics related to the warehouse in general consists of three main components - receiving goods, storing and shipping [1]. Here, we focus on shipping. Process of shipping involves workers, whose goal is to pick up all items belonging to some order (made by some customer), as quickly as possible and put them to the packing place and repeat this process until there are some unhandled orders.

Workers are using carts with boxes to collect the items from the store.

First, the company required that all the items belonging to the one customer have to be gathered to only one cart and no exception is allowed. Just in the situation when the whole customer cannot fit the cart, judging by the volume, it can be divided to more carts. Second, it is required that only items of one customer can be in a box. There is an exception when the customer's order consist only of a single item.

Currently, the company solves this problem by assigning items to carts randomly based on total cart volume with a limit of eight customers per cart. Each warehouse address is assigned a fixed order. The items are then sorted according to which address they were located at.

2. Warehouse representation

All the computation consists of components that represent the algorithms used for each part. The two of them - grouping items and sorting items to the shortest path are based on a distance measurement. This requires address mapping, so we assign an address (coordinates) to each place in the warehouse. Then, the Euclidean or Pythagoras distance measurement is performed. The decision element is, what is the mutual position of two addresses as is shown in Figure 1.1.

[1] The company desired to stay anonymous

3. Key word Wave

The **wave** stands for set of N items belonging to Z customers, that is processed together.

4. Used algorithms

As shown in Figure 2.1 there are three types of algorithms - solvers of bin packing problem, grouping customers problem and shortest path problem.

For solving the problem of putting items into boxes are used both 1D and 3D algorithms. In 1D there are implemented FFD (First Fit Decreasing) algorithm or FFDS (First Fit Decreasing using Smallest possible bin sizes) algorithm solving problem of packing items into multiple types of boxes. For solving 3D bin packing problem library 3dbinpacking[2] is used. In addition, the implementation of 3dbinpacking is enhanced by FFDS in 1D, which led to better results in case when multiple types of boxes, each of at least two different dimensions, are used. Results of filling of the created boxes and also the comparison of 1D FFD and pure library implementation of 3D algorithm are shown in Table 5.1.

For grouping items three different methods are used. The first two methods are based on loading all the items of the biggest customer of the remaining customers to the cart, and then filling the rest of the cart by items which are nearest to the firstly loaded one. This task is solved through the average distance between all the items in the first method and through linear regression in the second method. The last approach is based on K-Means clustering and differs from the method mentioned before. Still, all the algorithms give very similar results, as shown in Figure 3.1 and Figure 3.2. Figure 4.1 shows the time complexities for all waves.

In Figure 6.1, it is demonstrated the relaxation of the restriction of the carts' and boxes' sizes. In shown case were defined two types of boxes - one of half width of the second - and the cart was defined twice as large before it was used in the algorithm whose result is shown in the figures 3.1 and 3.2.

The shortest path problem, which consists here in sorting items, loaded in cart, to the shortest distance, are solved with one of the Nearest Neighbor algorithm or Greedy. They give also very similar results, but slightly better come from Greedy. Both the algorithms have also the possibility of enhancement by brute force method, which can be used when the cart has up to ten items.

[2] https://github.com/enzoruiz/3dbinpacking

5. Conclusion

With the above implementation, the average estimated distance travelled per cart was 23.55 % shorter than the company's current solution when the items were situated all around the store. When they were in only two sectors (which create about 40 % of the area of the warehouse), the average path was 39.1 % shorter.

There is still a lot of space for improvement such as the introduction of more precise methods, especially in case of grouping items.

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References

[1] Ryan Key and Anurag Dasgupta. Warehouse pick path optimization algorithm analysis. *The 2015 International Conference on Foundations of Computer Science*, 2015.