Comparison of efficient algorithms to solve the container stacking problem at seaport terminal

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1 Introduction

In the last decades, the container storage problem is studied under various aspects. Due to the variety of the storage policies and the kinds of handling and transfer equipments, research are continuously performed in order to optimize the resources such as the storage space and more generally the ports' productivities. This problem is known to be NP-hard [1, 2], therefore it can be hardly solved by exact algorithms during polynomial times. Therefore, heuristic and meta-heuristic algorithms are more and more proposed to solve it quickly. These kinds of algorithms include as well local search as population based algorithms.

In the second section a more detailed description of the container storage problem is given. Next, in the third section the meta-heuristic algorithms and the hybrid algorithms that we propose to solve the container storage problem are described. After that, a conclusion is given in the fourth section.

2 Description of the problem

In a container terminal, there are mainly three kinds of containers, which are: inbound, outbound, and transshipment containers. Inbound containers are unloaded from the ships by the quays cranes, then are transferred and placed into their storage locations by the straddle carriers, and, at the end, are claimed by external trucks. Outbound containers are brought by external trucks, also are temporarily stored in the container yard, and after their dwell time, they are loaded onto ships. Transshipment containers are unloaded from ships, then temporarily stacked in the storage areas, before being loaded onto other vessels. In most of the published papers, the storage of these kinds of containers are tackled separately, this means a storage area is dedicated to each kind of containers. However, there is a risk of space waste with this strategy. Therefore we propose a shared strategy, wherein containers can be mixed each other without increasing the required handling work for storage or retrieving. For this, we propose a linear mathematical model, with takes into account the arrival order of the containers and also their departure times. This mathematical model determines the exact location assigned to each container and takes into account the different dimensions of containers. Since, we consider a multi-modal container terminal, the containers can leave the port by different exits depending on their transfer modes (trucks, trains, or ships). So, we aim to minimize simultaneously the total expected distance between the storage locations and the exits, and the total number of reshuffles. In order to ensure quick deliveries, we attempt to regroup containers per destination. In a first time, we solved this linear program by the CPLEX solver, and we remarked it need long execution times. Therefore we propose the meta-heuristic algorithms described in the following section.

3 Numerical resolution methods

We propose different algorithms to solve the container stacking problem. The first is a local search algorithm named simulated annealing. This algorithm is discovered by Kirkpatrick [4] to solve optimization problems. It is based on the annealing procedures in metallurgy, which consists to heat a metal and then gradually decrease its temperature in order to improve its structure.

The second algorithm that we propose to solve the container stacking problem is a bee algorithm. It is initiated by Pham et al. [5], and is based on the actions performed by the natural bees when they are making honey. This algorithm is an population based algorithm, this means it provides simultaneously several solutions.

The third algorithm, is an ant colony algorithm. Historically, this algorithm was created by Dorigo et al. [3], in order to solve the travelling salesman problem. Thereafter, it is used to solve various optimization problem. Ant colony algorithm follows from the observation of the manner that natural ants communicate each other in order to find the shortest path connecting there anthill and a location where there is food.

The last algorithms are hybridizations which combine the previous algorithms. The first of them includes a bee algorithm and a simulated annealing algorithm, while the second is made up of an ant colony algorithm and a simulated annealing algorithm.

4 Conclusion

We proposed a mixed integer linear mathematical model to solve the container stacking problem. We solved this model using the CPLEX solver, but we remarked that the execution times are too long for the small instances, in addition to this the execution of large instances failed because requiring to much computer memory. So, we proposed meta-heuristic and hybrid algorithms, and realised several simulations in order to test their effectiveness. For this, we compared their results to those supplied by the CPLEX solver. Then we observe that all these algorithms are suitable to solve the container storage problem. However we notice that the hybrid algorithms provide the best results.

In the future we plan to deal with the dynamic case of the storage container problem, and to propose other efficient resolution methods.

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