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An Optimization Methodology for Container Handling Using Genetic Algorithm

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Abstract

Container handling problems at container terminals are considered as NP-hard combinatorial optimization problems. In this paper, we propose an optimization methodology for solving container handling problems using genetic algorithm. The proposed methodology is applied on a real case study data of container terminal at Port-said Port in Egypt. The computational results show the effectiveness of the proposed methodology for container terminal where 56% reduction in ship service time (loading/unloading) in port is achieved.

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Keywords: container handling problems; genetic algorithm; combinatorial optimization.

1. Introduction

The increasing number of container shipments causes higher demands on the seaport container terminals. The competitiveness of a container seaport is marked by different success factors, particularly the time in port for ships (service time). A container terminal is a zone of the port where sea-freight dock on a berth and containers are loaded, unloaded and stored in a buffer area called yard. Container terminal operations and their optimization have received

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increasing interest in the scientific literature over the last years. Container terminals can be described as open systems of material flow with two external interfaces. These interfaces are the quayside with loading and unloading of ships, and the landside where containers are loaded and unloaded on/off trucks. The need for optimization in container terminal operation has become more and more important in recent years. This is because the logistics especially of large container terminals has already reached a degree of complexity that further improvements require scientific methods [1].

In general there are three types of equipment employed in container terminals, namely quay cranes (QCs), trucks, and yard cranes (YCs). QCs operate at the quayside for loading containers onto and unloading containers from container vessels. Before arrival, each container vessel sends its loading and unloading plan to the container terminal. Terminal operators will designate a QC plan which indicates the number of QCs required to (load/discharge) containers to/from the ship. YCs work at the yard side staking containers onto their allocated storage locations and picking up containers from their current storage locations in the yard. Trucks transport containers between the quayside and the yard side [2]. The whole terminal operation is very complex and involves different types of equipments. A terminal can therefore be ideally divided into two areas, the quayside and the yard. The quayside is made up of berths for vessels and quay cranes (QC). The yard serves as a buffer for loading, unloading and transshipping containers and it is typically divided into blocks: each container block is served by one or more yard cranes (YC) [3].

If the search space is large, it will become difficult to solve the optimization problem by using conventional mathematics or using numerical induction techniques. For this reason, many meta-heuristic optimization methods have been developed to solve such difficult optimization problems. Because of the computational complexity of solving container terminal problems, heuristic methods are used to solve these models to obtain an approximate (near-optimal) solution [4]. The meta-heuristic approaches are not guaranteed to find the optimal solution since they evaluate only a subset of the feasible solutions, but they try to explore different areas in the search space in a smart way to get a near-optimal solution in less cost and time [5].

Met-heuristics algorithms have been used to solve optimization problems, among all of the heuristic algorithms such as: genetic algorithm, tabu Search (TS), and simulated annealing (SA), genetic algorithms (GAs) are in wide application because of their ability to locate the optimal solution in the global solution space [6], [7], [8]. Abd El-Nasser et al. (2014) presents a comparative study between Meta-heuristic algorithms: Genetic Algorithm, Tabu Search, and Simulated Annealing for solving Quadratic Assignment Problem. The computational results show that genetic algorithm has a better solution quality than the other Meta-heuristic algorithms for solving Quadratic Assignment Problems [9].

Because operations in container terminals run synchronously, optimizing a particular aspect of the system cannot guarantee the improvement in the overall productivity of container terminal operations. Integrated scheduling of container handling equipment is essential in improving the efficiency of container terminals [4]. In this study, the container terminal is considered as a global system instead of single optimization problems; the container handling problems; quay crane assignment problem (QCAP), yard crane assignment problem (YCAP), and truck assignment problem are considered and optimized.

The rest of this paper is organized as follows: A literature review of the methodologies for solving the container handling problems are provided in section 2. Section 3 contains the proposed methodology and framework using genetic algorithm to optimize solution for container handling problems. Testing and computational results are given in section 4. Conclusion and future work are given in section 5.