The Berth-Quay Cranes and Trucks Scheduling Optimization Problem by Hybrid Intelligence Swam Algorithm

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ABSTRACT

Considered the cooperation of the container truck and quayside container crane in the container terminal, this paper constructs the model of the quay cranes operation and trucks scheduling problem in the container terminal. And the hybrid intelligence swarm algorithm combined the particle swarm optimization algorithm (PSO) with artificial fish swarm algorithm (AFSA) was proposed. The hybrid algorithm (PSO-AFSA) adopt the particle swarm optimization algorithm to produce diverse original paths, optimization of the choice nodes set of the problem, use AFSA’s preying and chasing behavior improved the ability of PSO to avoid being premature. The proposed algorithm has more effectiveness, quick convergence and feasibility in solving the problem. The results of stimulation show that the scheduling operation efficiency of container terminal is improved and optimized.

KEYWORDS

Artificial Fish Swarm Algorithm, Bioinformatics, Computational Intelligence, Container Truck Scheduling Problem, Particle Swarm Optimization Algorithm, Quay Crane Scheduling Problem

INTRODUCTION

The port container terminal mainly is composed by container ships, loading bridges, container trucks, etc. The container truck is responsible for the transportation between the wharf and container yard in container yard, which its efficiency directly affects the working time of the transportation and storage tasks. The whole dock operation should be coordinated and the handling time of berthing ships should shorten as far as possible, in order to improve the service quality and efficiency of the container terminal. The scheduling problem of the quay cranes operation and yard trucks is a key point to improve the operation efficiency of container terminals. At the same time, the quay cranes operation and yard trucks scheduling problem in the container terminal is a NP-hard problem. So, it has the extremely vital significance to research how to optimization this problem.

The container truck and quay crane scheduling problem has been widely studied. Kim (1999) study on the optimization problem of loading forklift and field bridge taking box path, using integer programming method to make modeling and solving (Kim, 1999). Ebru et al. (2001) established the dispatch model of the container port truck vehicle, and proposes a heuristic algorithm to make the ship stay in the port at the shortest time. Etsuko Nishimura and Akio Imai (2005) proposed the truck dispatching method of container terminal under the “dynamic path”, and defined the cooperation of the “crane → yard → crane” as the truck operation route, and proposed the truck scheduling method of container terminal under the “dynamic path” by heuristic algorithm. Bish (2005) focused on the truck scheduling and storage allocation problem but did not consider the travel time and waiting time.
of trucks explicitly. In practice, during peak hours, trucks need to wait for an idle yard crane to unload the containers from them, after which they can proceed to new jobs. Nishimura (2005) established the optimization model of truck dynamic path using genetic algorithm to solve the model by compared static and dynamic scheduling method of truck. Ming Jun Ji and Zhi Hong Le (2007) established the truck route optimization model considered the shortest crane operation time and truck transport time, to research truck scheduling problem under the loading and unloading container operations at the same time. Mauro (2007) studied the truck routing problem with time window constraints and proposed the heuristic algorithm in detailed.

In this paper, particle swarm optimization algorithm and artificial fish school algorithm are combined to solve the quay cranes operation and yard trucks scheduling combined problem. In the outer cycle, the particle swarm optimization algorithm to analysis the crane scheduling problem, while in the inner cycle, the artificial fish school algorithm is used to find the global optimum of truck routing problem.

This paper is organized as follows. Section 1 gives background and related work of container truck routing problems in container Terminal. Section 2 describe the container truck scheduling problem and presents its corresponding mixed integer programming model. Section 3 presents the PSO–AFSA hybrid algorithm, and demonstrates how it solves the container truck scheduling problem. Section 4 provides computational experiments and the global optimum analysis of the PSO-AFSA algorithms in detail.

INTRODUCTION OF THE OPERATION MODE OF “WORKING GROUP”

This paper discusses the optimization problem of truck path scheduling based on the mode of “working group”, which each truck can dynamically server in different shore berths and quay cranes. When the truck is in the idle state, the path of the truck will be changed to the nearest or needed operation line according to the certain scheduling rules.

The “working group” operation mode of the truck is that container ships arrive at the import berth, the quayside crane unloading the containers to the truck, the truck transports the containers to the import container area, and fetches the containers from the export container area to the export berth. The whole process constitutes truck traveling loop. The Figure 1 shows the “working group” operation mode of truck:

Due to the number of import and export containers aren’t always the same, the truck needs to transport the import or the export containers separately as the “working line” operation at the berth, after the operation mode of “working group”. Figure 2 and Figure 3 show the operation as in the following:

In Figures 1 to 3, \( t_i \) is the average unloading time in the \( i \) import container area, \( t_j \) is the average loading time in the \( j \) export container area, \( t_a \) is the average loading time in the \( a \) import berth, \( t_b \) is the transport time of loading truck from the \( a \) import berth to the \( i \) import container area, \( t_{ii} \) is the transport time of no-loading truck from the \( a \) import container area to the \( a \) import berth, \( t_{bj} \) is the transport time of no-loading truck from the \( b \) export berth to the \( j \) export container area, \( t_{ji} \) is the transport time of loading truck from the \( j \) export container area to the \( b \) export berth, \( t_{bj} \) is the transport time of no-loading truck from the \( i \) import container area to the \( j \) export container area, \( t_{bj} \) is the transport time of loading truck from the \( a \) export berth to the \( b \) import berth.

Normally, the working time is constant between the loading and the unloading point. The key factor influence the total time of truck is the distance of truck without container between the loading
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