

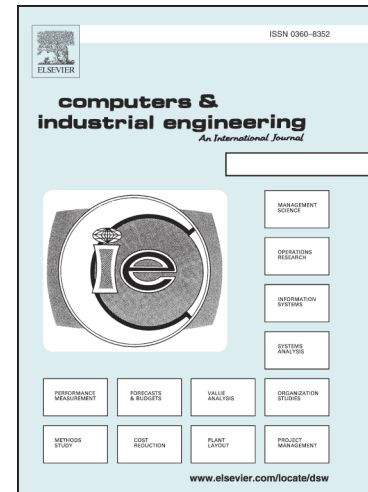
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A Bounded Two-Level Dynamic Programming Algorithm for Quay Crane Scheduling in Container Terminals

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ABSTRACT

One of the optimization problems in terminal operations is the quay crane scheduling problem. The quay crane scheduling algorithm plays a critical role because it directly affects the length of the vessel loading and unloading process, which means vessel turnaround time. We propose a bounded two-level dynamic programming (DP) algorithm which keeps the simplicity of the bay-based approach but overcomes its shortcomings. We also propose a method to estimate the lower bound to quay crane scheduling given the lists of unloading and loading containers and the number of quay cranes assigned to the vessel. This lower bound is used both to reduce computational time of the 2-level DP algorithm and to evaluate our crane scheduling method. Our experiments with real vessel unloading and loading lists for 80 vessels show that the vessel makespan is close to the lower bound. The computational times for the 80 vessels with up to 6600 container moves by cranes in loading and unloading a vessel are all under two minutes.

Keywords: Container terminals, quay crane scheduling, dynamic programming, lower bound

1 Introduction

One of the optimization problems in container terminal operations is the quay crane scheduling problem. A quay crane scheduling solution potentially contributes in a critical way to the operation planning of a terminal. It directly affects the duration of the vessel loading and unloading process, which means vessel turnaround time. In the fiercely competitive container handling business, while bigger and bigger container vessels are built, minimizing the vessel turnaround time has become a top priority for container terminal operators. The capability of producing well-balanced and well-coordinated quay crane operation plans will benefit both a terminal operator and its customers tremendously.

When a vessel arrives at a terminal, quay cranes (QCs) will unload containers and then load containers for the vessel at the quayside. Before a vessel arrives, the list of containers to be unloaded and the list to be loaded, together with their locations on the vessel, are provided to the terminal operator. QCs are allocated to the vessel and a quay crane scheduling plan for the unloading and loading operations is decided. It may happen that not all QCs are able to start the operations for a vessel at the same time. A

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