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Integrated Berth and Quay Crane Scheduling Under Uncertainty: A Reactive Approach based on MILP

Abstract

Planning of container terminal operations is a complex task which requires the accurate scheduling of operations that are highly interrelated and uncertain. This study aims to investigate the integration of quayside operational planning functions under uncertain parameters, specifically addressing disturbances and disruptions by applying a reactive approach. A mixed integer linear programming (MILP) model is formulated to optimally assign and schedule quay cranes to multiple vessels simultaneously. The model will derive a baseline schedule that minimizes the cost of waiting and departure delays of vessels. To address the disturbances and disruptions, a reactive strategy is formulated to generate a rescheduling plan when two types of disruptions are happening; delays in the vessel arrivals and quay crane (QC) breakdowns occurring during the (un)loading operations. The reactive strategy will take the baseline schedule as input and derives a reactive schedule that minimizes the cost of deviations from the baseline schedule. Conducted numerical experiments highlight the accuracy of the representation of practical constraints including safety margins and non-crossing constraints as well as the development of optimal solutions for small-size problems. The study primarily addresses vessel arrival delays and QC breakdowns as key sources of uncertainty, often arising as disturbances and disruptions. Other factors, such as unscheduled vessel arrivals and variability in vessel handling times, also warrant further investigation. Despite significant progress in optimizing container terminal operations, substantial opportunities for real-time improvement persist. This is driven by the increasing demand for containerized maritime trade, associated disruptions, and the evolving nature of terminal operations as new technologies emerge.