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Scheduling of Intelligent Autonomous Vehicle

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***Abstract*—We take into account the collaborative behaviour of IAVs and propose a mathematical model for scheduling of collection/drop operations inside the container terminals. The model takes into account the coupling/decoupling operations. We then propose efficient solution method to solve instances of problem. This work has been realized in a online optimization platform simulating the behaviour of system.**

Keywords*—Intelligent Autonomous Vehicle; Automated Guided Vehicle; Mixed Integer Programming; Scheduling; Lagrangian Relaxation; Tabu Search; Variable Neighborhood Search.

A new class of Intelligent and Autonomous Vehicles (IAVs) has been designed in the framework of Intelligent Transportation for Dynamic Environment (InTraDE) project funded by European Commission. These vehicles which are technologically superior to the existing Automated Guided Vehicles (AGV) in different technical aspects offer more flexibility and intelligence in manoeuver in the area where the logistics operations take place. This includes the ability of pairing/unpairing enabling a pair of 1-TEU (Twenty-foot Equivalent Unit) IAVs join and transport any size between a 1-TEU and a 1-FFE (Forty-foot Equivalent) containers. To accommodate this feature, in this article, we extend the classical mixed integer programming model of AGV scheduling in order to minimize the makespan of operations to transport a set of containers of different size between quay cranes and yard cranes. In particular, a case study on Dublin Ferryport Terminal is carried out. In order to cope with the complexity of the scheduling model, we design a Lagrangian decomposition approach utilized with variable fixing procedure and a primal solution heuristics to obtain high quality solution of instances of the problem.

This paper first extends the application of the model presented in [9] for AGVs. We show that while the model is infeasible, it can still be improved and generalized to be applicable for both AGVs and IAVs. We then examine the impact of a class of valid inequalities on the computational performance of a general-purpose solver for solving instances of model. As an inherent property of most of the scheduling problems, only instances of very small size are solvable by general-purpose solvers and we propose a lagrangian decomposition approach equipped with a variable fixing and primal bound generation heuristic to solve instances of the problem for high quality solutions and in reasonable time. Several class of violated valid inequalities are identified and relaxed in Lagrangian fashion to accelerate the convergence. As a case study, we apply the model on the Dublin Ferryport Terminal in Ireland —one of the terminals for which IAVs are designed.

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A. Literature review

The literature is aware of several works dealing with scheduling of AGVs in container terminals and also in manufacturing systems. [7], [6] proposed a heuristic algorithm for combined AGV and crane allocation problems.

In AGV routing, Van der Meer (2000) studies the control of automated guided vehicles in automated container terminals. Bose et al. (2002) solve the problem by finding an initial solution using either a job based or vehicle-based approach and subsequently improving it via an evolutionary algorithm.

[1] proposed a MIP formulation for an integrated yard truck and yard crane scheduling problems while only the import containers were taken into account. They applied a combinatorial Benders decomposition on their model.

[5] studied a transshipment port where both loading and discharging containers are considered. While it has been often simplified by other authors, [5] consider the delays at yard crane as well.

[9] proposes a MIP model for scheduling a fleet of trucks at a container terminal and the fleet size is assumed to be given exogenously.

However, as we show later, the model in [9] does not always produce a feasible solution to the problem of scheduling AGVs.

Other works on dispatching different equipments at container terminals can be found in [3], [4] for AGV dispatching problem while [4] employs a look-ahead strategy which considers local and temporal information of future tasks and assumes a dual cycle operations of AGVs; [10] extended [4] for automated lifting vehicles (ALVs); [2] for a wider range of equipments; [8] in which every truck is dedicated to a particular quay crane as opposed to the approach in [4].

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II. CONCLUSION

The conclusion goes here.

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