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SHIPYARD BLOCK TRANSPORT SCHEDULING OPTIMIZATION VIA SIMULATION AND REINFROCEMENT LEARNING

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ABSTRACT

The blocks, which are fundamental units of ship construction, can only be transported using specialized vehicles known as transporters due to their weight and size. Therefore, optimizing the block transportation schedule at shipyards is of high importance. Previous studies have extensively addressed the optimization of block transportation scheduling based on metaheuristic approaches. This study proposes an effective optimization methodology capable of dynamic scheduling by combining reinforcement learning with graph neural networks. First, we construct a block transportation simulation that can calculate the empty travel time and tardiness of each block, which are the objectives of our research. Second, the Crystal Graph Convolutional Neural Network (CGCNN) and Proximal Policy Optimization (PPO) are combined to calculate the optimized policy for the block transportation schedule. The effectiveness of the proposed algorithm is demonstrated through simulations by comparing the results with heuristic and metaheuristic algorithms presented in previous research.

1 INTRODUCTION

In systems with complex production processes, logistics optimization problems hold high importance. This study focuses on optimizing the internal block logistics in a shipyard where large vessels are constructed. Each vessel is built by dividing it into parts and assembling them together. The individual units of ship construction, known as blocks, are moved multiple times through different processes and storage yards. Due to their size and weight, blocks require a specialized transport vehicle called a transporter for movement. Therefore, minimizing the empty runs of these transporters and scheduling block movements to meet deadlines is of high significance.

Transporter scheduling optimization has been primarily based on metaheuristic methodologies in existing studies. For example, Roh and Cha (2011) aimed to optimize transporter schedules by combining GA and ACO algorithms. Metaheuristic methodologies show high performance efficiency compared to exact algorithms like MIP in problems of appropriate size. However, as the problem size increases, their efficiency begins to decrease, and they have limitations for use as dynamic optimization algorithms. Therefore, this study proposes an efficient dynamic scheduling optimization algorithm based on reinforcement learning.

2 OPTIMIZATION STRATEGY

In this study, optimization was implemented using a PPO algorithm combined with simulation and GNN. The simulation serves as the environment in which the reinforcement learning agent conducts its training. When the given agent proceeds with an episode according to the current policy, the simulation performs in a virtual environment to determine what reward the agent would receive, representing reality. A DES simulation was built with the main events being the departure and arrival of each transporter, as well as the loading and unloading of blocks. The algorithm proposed in this study assigns the next block to the idle transporter, so the simulation was conducted by placing the completion of each transporter's block transport into the event queue. The framework of the reinforcement learning conducted in this study is shown in Figure 1.

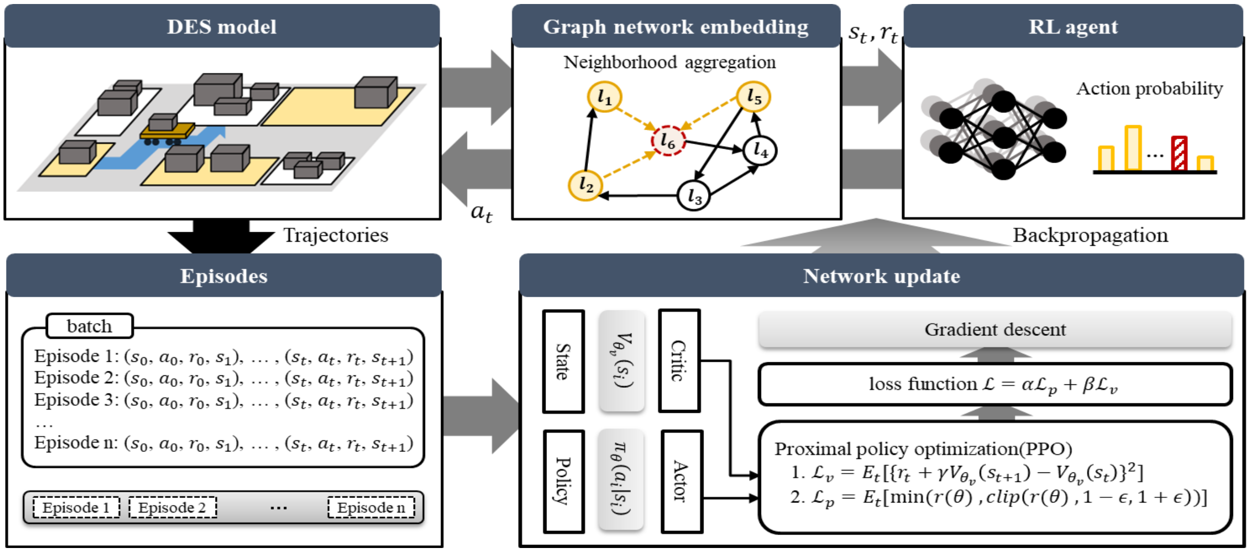

Figure 1. Reinforcement learning algorithm framework

The current state in the simulation is converted into a graph and embedded, and this embedding is used by the actor network to determine the current action to be taken. This process is repeated until all blocks are transported, forming a single episode. Multiple episodes are then collected to update the policy through the PPO algorithm.

3 EXPERIMENT

A virtual shipyard was assumed, and experiments were conducted by dividing the problem into two cases: a small problem (case 1) with 30 blocks and 6 transporters, and a large problem (case 2) with 50 blocks and 10 transporters. The sum of empty travel time and tardiness was used as the objective function. Therefore, the aim of algorithm is to minimize the objective value. The performances of each algorithms are shown in Table 1, where O denotes the relative objective value, and CT represents the computation time(sec).

Table 1: Algorithm performances.

		RL	ACO	ACO RS	GA & ACO	GA	Random	SPT	SST	SRT	ATC	EDD
	O	**0.834**	1.428	1.348	1.020	1.670	3.268	1.366	1.467	2.124	1.568	1.435
	CT	0.17	147.8	146.0	121.5	156.3	**0.03**	0.08	0.08	0.06	0.11	0.05
	O	**1.184**	2.891	2.765	4.566	3.000	5.093	2.175	2.091	3.302	2.548	2.351
	CT	0.23	611.3	597.8	452.7	623.3	**0.05**	0.09	0.1	0.09	0.13	0.08

4 CONCLUSION

The proposed algorithm showed the best results compared to the metaheuristic and heuristic algorithms.

REFERENCES

Roh, M. I. and J. H. Cha. 2011. A block transportation scheduling system considering a minimisation of travel distance without loading of and interference between multiple transporters. *International journal of production research* 49(11):3231-3250.