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IDLE VEHICLE ALLOCATION PROBLEM IN AUTOMATED MATERIAL HANDLING SYSTEMS: A CASE STUDY IN RECHARGEABLE BATTERY PRODUCTION

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ABSTRACT

In this paper, we investigate the issue of determining and allocating park locations for idle vehicles in Automated Material Handling Systems (AMHSs) within manufacturing industries. We introduce a case study on an AGV system in a rechargeable battery production facility, confirming the effectiveness of heuristic proposed by Bruno et al. (2000) in enhancing AMHS performance.

1 INTRODUCTION

The significance of Automated Material Handling Systems (AMHSs) has grown substantially in tandem with the expansion of the high-value-added manufacturing sector on a global scale. Among the various types of AMHSs, Overhead Hoist Transport (OHT) systems and Automated Guided Vehicle (AGV) systems are particularly noteworthy. Historically, OHT systems have been predominantly employed in semiconductor fabrication plants. Furthermore, their utilization has recently extended to the production facilities of rechargeable batteries.

In real-world applications, it is standard practice to maintain a slightly higher number of vehicles than the minimum required to handle variations in production demand. This strategy is designed to minimize waiting times due to delays in responding to transportation requests. Consequently, idle vehicles are a common sight within the system. When production demand drops due to external factors, the proportion of idle vehicles can increase further. These vehicles often wait at specific locations after completing their tasks or move to designated areas before becoming idle.

In this paper, we validate the heuristic policy for park location allocation proposed by Bruno et al. (2000) and demonstrate its effectiveness in improving performance through a case study using commercial software from DAIM Research Corporation.

2 THE ROBOT ORCHESTRATION PLATFORM (ROP) OF DAIM RESEARCH CORP.

Figure 1: Factory Emulator environment of DAIM Research Corp.

This section details the validation process through the use of Robot Orchestration Platform (ROP), known as xMS, developed by DAIM Research Corp., a KAIST spin-off. The xMS platform is designed to manage and control logistics robot fleets utilizing collaborative intelligence technology. The heuristics developed in this study were incorporated into the xMS system, and evaluations were performed using actual data from a production facility specializing in rechargeable batteries. The validation experiments took place within the Factory Emulator for xMS (FEX) environment, also provided by DAIM Research Corp. (see Figure 1). These experiments simulated real-world scenarios, including parameters for charging and discharging, vehicle interactions, transport times, and batch order processing.

3 VERIFICATION OF THE PERFORMANCE IMPROVEMENT

We verified the performance improvement of park location allocation policy in the AGV system of a rechargeable battery production facility, one of the clients of DAIM Research Corp. The AGV system consists of a uni-directional layout with approximately 200 nodes, 100 ports, and 4 charging stations. Additionally, there are a total of 9 AGVs operating on-site.

We compared the performance of the Greedy policy, which has been commonly used in industry, with the heuristic policy proposed by Bruno et al. (2000). The Greedy policy refers to a strategy where idle vehicles are assigned to the nearest park location from their current position among a predefined set of park location, based on the prior experience of workers in the industry. When implementing Bruno's heuristic policy, equal weights were assigned to all vertices, including those without demand, to determine the optimal k-median solution. This approach is based on the premise that, in real-world industrial environments, it is often difficult to accurately estimate parameters associated with transportation requests from each demand node. Consequently, the goal is to ensure a uniform distribution of vehicles across the entire track, rather than focusing solely on specific demand nodes.

To obtain the transport request scenario, we utilized job occurrence records from an actual site over a specific period. We measured the average waiting time (AWT), average transport time (ATT), average delivery time (ADT), and utilization. Additionally, we also measured *charging*, which represents the proportion of time allocated to charging during the entire operational period (Table 1).

As a results, the AWT decreased by approximately 17% compared to the Greedy policy, leading to an improvement of approximately 9% in the ADT. Furthermore, when employing the Bruno's heuristic policy, we noticed a slight decrease in the ATT, which we speculate could be attributed to the more even distribution of vehicles across the entire track, reducing congestion caused by interference between vehicles. Meanwhile, we observed a slight increase in the Charging compared to the existing policy. This seems to be because more battery power was utilized to move to the park locations during idle states after completing jobs. Therefore, it is important to be cautious of excessive movements during idle states, as they may require more charging time, potentially reducing the available time for job execution.

Table 1: Validation results on the real-world AGV system.

Policy	AWT (sec.)	ATT (sec.)	ADT (sec.)	Utilization (%)	Charging (%)
Greedy	136.38	139.48	275.85	33.84	17.20
Bruno et al. (2000)	113.23	136.6	249.83	30.79	20.89

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REFERENCES

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