AI (Deep Reinforcement Learning) based Smart Factory Solution

Industrial and Systems Engineering

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The semiconductor fabrication facility (FAB) and advanced production lines are fully automated manufacturing systems and therefore their automated material handling systems (AMHS) play a critical role in the operation of the production lines.

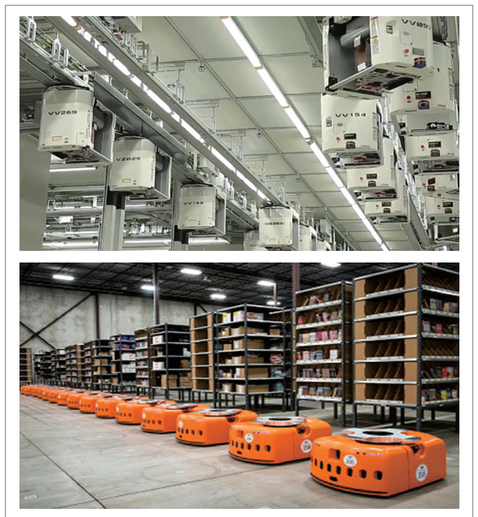
The team of KAIST recently developed a reinforcement learning-based dynamic routing algorithm to control massive fleet of automated guided vehicles (AGVs). The proposed algorithm uses real-time information to effectively guide each vehicle so that it avoids congestion and finds its optimal path. The algorithm is also designed such that the computational burden to find its optimal route is significantly low enough to serve hundreds of vehicles in real time. The performance of the proposed algorithm is compared with various existing method. The results show that the developed algorithm outperforms and is superior to the other benchmarking algorithms including the ones developed by researchers at Georgia Tech [1].

Background (objectives)

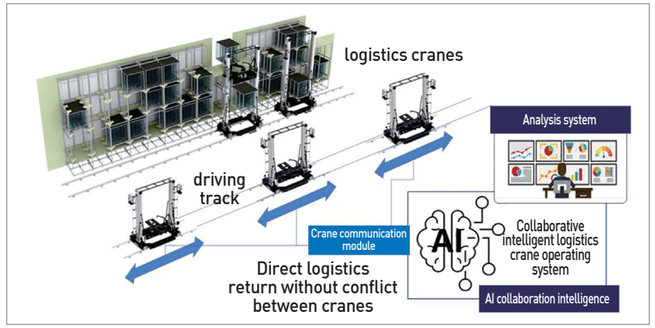
The semiconductor fabrication facility (FAB) and flat panel production lines are fully automated manufacturing systems and therefore their automated material handling systems (AMHS) play a critical role in the operation of the production lines. The team of Prof. Jang in the Department of Industrial and Systems Engineering at KAIST has conducted two industry collaborative development projects developing advanced AI (Deep Reinforcement Learning) based scheduling and controlling algorithm for AMHS targeted to two different production lines. The first one is the overhead transport (OHT) system in the semiconductor FAB; and the second is the stocker (AS/RS) systems in the flat panel display production lines.

Contents

First, the OHT system in the semiconductor FAB consists of OHT vehicles (in short, vehicles) and an OHT track (in short, track), as shown in Figure 1. In the modern large scale FABs, 700-1,000 vehicles operate on tracks. The route guidance for the vehicles is the key feature of the OHT system operation because it determines the overall performance of the system, especially for FABs.



[Figure 1] Semiconductor factory logistics transport robot (top), automatic warehouse warehouse logistics transport robot (bottom)



[Figure 2] LCD / OLED display logistics transportation robot

Due to the large number of vehicles and manufacturing uncertainty, the vehicles can interfere with each other in unpredictable ways.

The team of KAIST developed a reinforcement learning-based dynamic routing algorithm, which consists of a dynamic scheduling and routing policies for the OHT operations. The proposed algorithm uses real-time information to effectively guide each vehicle so that it avoids congestion and finds its optimal path. The algorithm is also designed such that the computational burden to find its optimal route is significantly low enough to serve hundreds of vehicles in real time. The performance of the proposed algorithm is compared with various static and dynamic algorithms with simulation analyses on an actual FAB layout. The results show that the algorithm outperforms and is superior to the other benchmarking algorithms.

The second AMHS development product is the dual stocker (AS/RS) system in flat panel display production lines. The two different cranes are transporting lots between processing machines. Since the two cranes are running on a single rail the collision avoidance control mechanism is a key to the performance. Deep reinforcement algorithm, which is a combination of reinforcement learning and a deep neural network with Digital Twin Technology, is developed for controlling the stocker system.

Expected effect

The OHT algorithm has been developed for an actual FAB environment and proven that it can operate more 1,000 vehicles effectively. The team of KAIST received 2 million USD funding from the industry partner to commercialize the solution for the semiconductor market.

For the dual stocker system, the algorithm has been tested at the LG Display, one of the largest LCD and OLED flat panel makers in the world, and proven the algorithm could improve the productivity of the material handling by more than 20%.

The two successful projects eventually enabled the Prof. Jang's research team to initiate a research area titled "Robot Collaboration Intelligence," which provides a technological foundation of the collaborative algorithm for robots originally developed to perform an individual tasks.

| Research outcomes |

[Paper] • Hwang, Illhoe, and Young Jae Jang. "Q (λ) learning-based dynamic route guidance algorithm for overhead hoist transport systems in semiconductor fabs." International Journal of Production Research (2019): 1-23. (Editor's Pick)

[Technology Transfer] • 2 million USD funding to commercialize the OHT algorithm to the semiconductor market
• 2 million USD research funding to further development of the stocker system algorithm from LG CNS

| Research funding |

• NRF, Team for Individual Research Programs