Proceedings of the 2021 Winter Simulation Conference
S. Kim, B. Feng, K. Smith, S. Masoud, Z. Zheng, C. Szabo and M. Loper, eds.

DIGITAL TWIN APPLICATIONS FOR DESIGN AND OPERATION OF AGVS IN SHOP FLOOR

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ABSTRACT

With the introduction of Smart Manufacturing technology in recent years, manufacturers are introducing automated facilities for increasing operational efficiency, productivity, or becoming automated factories, and the representative of them is Automatic Guided Vehicle Systems (AGVs). When designing and operating these AGVs, there are difficulties that abnormal situations cannot be predicted and responded until the system is actually configured and operated. To solve these problems, it is necessary to preview and verify systems in a virtual environment in the design stage, and to introduce a Digital Twin (DT) that can monitor and analyze the configured systems in the operation stage. This paper proposes DT that can be used for diagnosis, analysis, prediction and optimization in the design and operation of AGVs and verify its effectiveness through applying real manufacturer which operates AGV system in South Korea.

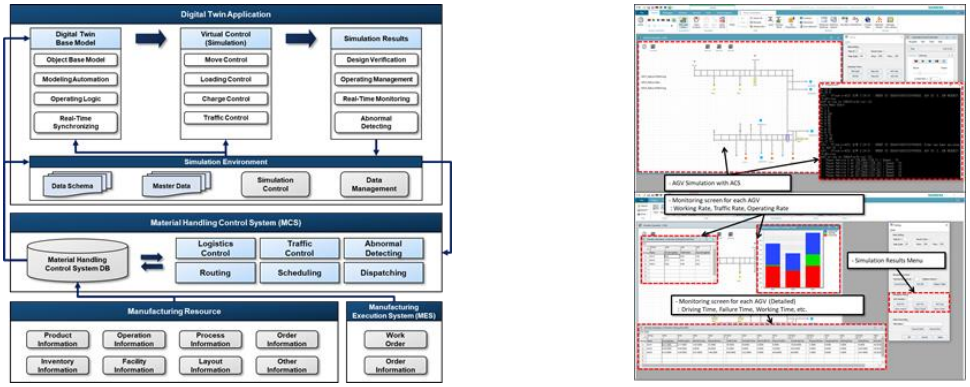
1 INTRODUCTION

With the advent of the 4th Industrial Revolution, many manufacturing companies are making great efforts and developing related technologies to introduce Smart Factory that can flexibly and intelligently respond to changes in demand (L. Chen et al. 2014). In order to increase the workers' safety and production efficiency, a lot of effort is being made to unmanned or automated factories such as Automatic Guided Vehicle Systems (AGVs) (A. Martinez et al. 2021). When designing and operating these AGVs, there are difficulties in predicting and responding to possible abnormal situations until the system is actually configured and operated. Furthermore, as customer needs and product diversity increase in recent years, the design change of production lines and AGVs is also becoming more frequent and difficult. Therefore, for effectively solving problems arising from the design, configuration, and operation of AGVs, the need to introduce Digital Twin (DT) technology that can review, verify, monitor and analyze design and plans in a virtual environment in real time is increasing (KT. Park et al. 2021). This paper proposes the configuration and application of DT that can verify design plans and logistics plans when designing AGVs, and monitor, control, and manage the systems during operation.

2 DESIGN OF DIGITAL TWIN FOR AGV SYSTEMS

Figure 1(a) shows the framework of the DT for design verification and operation management of AGVs proposed in this paper. From legacy systems such as Enterprise Resource Planning (ERP) and Manufacturing Execution System (MES), information on real manufacturing sites and manufacturing activities is transmitted to the AGV Control System (ACS). ACS transmits data such as scheduling, routing,

and logistics control for production commands to the DT application. DT application generates a simulation model by synchronizing data from legacy systems or ACS in real time, and simulates its manufacturing activities in a virtual environment. Through simulating, visualizing, and reporting the simulation events and results, engineers can monitor the operational status of the AGVs and predict abnormal situations or future operating situations by controlling the simulation speed. In addition, if routing and scheduling logic changes of ACS due to layout or product changes are required, the design can be verified by simulating in advance with the DT.



(a) (b)

Figure 1: Digital Twin for AGV systems.

3 APPLICATION OF DIGITAL TWIN

Proposed DT application was implemented to a manufacturing company which operates the AGV system in South Korea. The implemented DT interfaces data directly with the ACS which operated in the real factory and simulates the manufacturing situations commanded by the ACS in the same way as the real factory. Figure 1(b) shows the DT generating a simulation model and executing commands assigned from ACS, and a screen that can monitor the simulation results and AGVs' status in real time. By simulating various situations that may occur in an actual factory, it was possible to verify problems such as the logics and path finding of the current ACS. Also, by supplementing them, it was possible to increase the operating efficiency of the manufacturing system.

ACKNOWLEDGEMENT

This work was supported by the projects of KEIT/ KIAT (20004170, Development of Optimal Productivity Prediction Technology Based on Collaboration of Human and Machine; N0002429, The Competency Development Program for Industry Specialist) and the project of MSS (S2482274, Development of Multi-vehicle Flexible Manufacturing Platform Technology for Future Smart Automotive Body Production).

REFERENCES

Lujie Chen, Jan Olhager, and Ou Tang. 2014. "Manufacturing facility location and sustainability: A literature review and research agenda". *International Journal of Production Economics* 149: 154-163.

A. Martinez-gutierrez, J. Diez-gonzalez, R. Ferrero-guillen, P. Verde, R. Alvarez, and H. Perez. 2021. "Digital twin for automatic transportation in industry 4.0". *Sensors* Vol. 21: 3344.

H. Fazlollahtabar, and M. Saidi-Mehrabad. 2013. "Methodologies to Optimize Automated Guided Vehicle Scheduling and Routing Problems: A Review Study". *Journal of Intelligent and Robotic Systems: Theory and Applications*.

YH. Son, KT. Park, D. Lee, SW. Jeon, and SD. Noh. 2021. "Digital twin-based cyber-physical system for automotive body production lines". *International Journal of Advanced Manufacturing Technology* 115: 291-310.

KT. Park, YH. Son, and SD. Noh. 2020. "The architectural framework of a cyber physical logistics system for digital-twin-based supply chain control". *International Journal of Production Research*.