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APPLICATION OF IOT-AIDED SIMULATION FOR A CYBER-PHYSICAL SYSTEM

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ABSTRACT

Internet of Things (IoT) has been attracting much attention due to its economic impacts and high expectations for drastically changing the competitive domain in various industries in the recent year. Digital Twin (DT) has been proposed as a tool for collecting and synchronizing real-world information in real time on the cyber side. However, it is still at the conceptual stage and only a few studies have specifically discussed methods for their construction and implementation. In this study, a framework for constructing DT in an IoT-aided manufacturing environment was proposed. As a case study, we constructed and implemented a DT-oriented simulation model for a sensor-equipped manufacturing system to verify the effectiveness of the framework.

1 INTRODUCTION

When referring to the IoT and Industrie 4.0, related terms such as cyber-physical systems (CPS) and digital twin (DT) are often mentioned. A CPS implies a system that includes gathering data in the real world (physical space) through the IoT, automatically analyzing the data using large-scale data processing technologies in cyberspace and feeding the results back to physical space to solve problems in the real world. The DT has been proposed as a tool for collecting and synchronizing real-world information in real time on the cyber side. This tool facilitates the cyber-physical integration of manufacturing, which is an important bottleneck to achieving smart manufacturing (Qi and Tao 2018). Although the DT is considered a challenging technology, it is still at the conceptual stage (Negri et al. 2017) and only a few studies have specifically discussed methods for its construction and implementation in the manufacturing domain. In this case study, we propose a framework for constructing a DT in an IoT-aided manufacturing environment and validate the framework by constructing a DT-oriented prototype simulation model for a CPS-based manufacturing system.

2 DIGITAL TWIN-ORIENTED MODELING FRAMEWORK

DT can be divided into three modes, which are the evaluation mode, experimental mode, and synchronization mode. Evaluation mode and experimental mode are also provided in conventional simulation models, but the synchronization mode is a function unique to the DT. The DT always uses the latest information to synchronize the mirroring of real-world behaviors so that the virtual models can be closer to reality and perform more complex simulations. With the utilization of DTs, it is possible to visually check and inspect the states of manufacturing plants even from remote areas.

To construct a DT-oriented simulation model, the first step is to design the concept. Next, similarly to the typical process of constructing a conventional simulation model, after performing the input analysis, a simulation model using stochastic data is constructed and validated. This simulation model can be used for the evaluation mode and experimental mode for prediction and optimization. After constructing a model using stochastic parameters, a simulation model is built for the synchronization mode. To use the real-time data of the IoT to synchronize the physical world, it is necessary to convert the stochastic parameters in the model into deterministic parameters to reconfigure the model. We can use the synchronization mode to monitor behaviors in physical space and save the historical data gathered from the IoT. Those historical data can be converted into stochastic distributions assigned to the simulation models of the evaluation and experimental modes, of which the results are fed back to the model of the synchronization mode.

3 CASE STUDY

The distributed model used in this study is an adoption of the Fischertechnik® Factory Simulation 9V model (Factory Model). To convert this factory model into an IoT-aided manufacturing system, we added eight sets of light sensors wirelessly connected to the Internet. We receive data from the light sensors in real time through an Arduino microcomputer with sensors and Microsoft Excel VBA programs and utilize the data to build a DT-driven simulation model.

The simulation model was overlaid on a scaled layout and programmed in Arena following the described steps. After building the DT model, it was validated by an interactive process between the factory model and the simulation model modelers. This process compared the model's output with the actual sensory data. After confirming the reliability of the model, the simulation models were run and the results were analyzed. The DT schematic diagram of the model is shown in Figure 1.

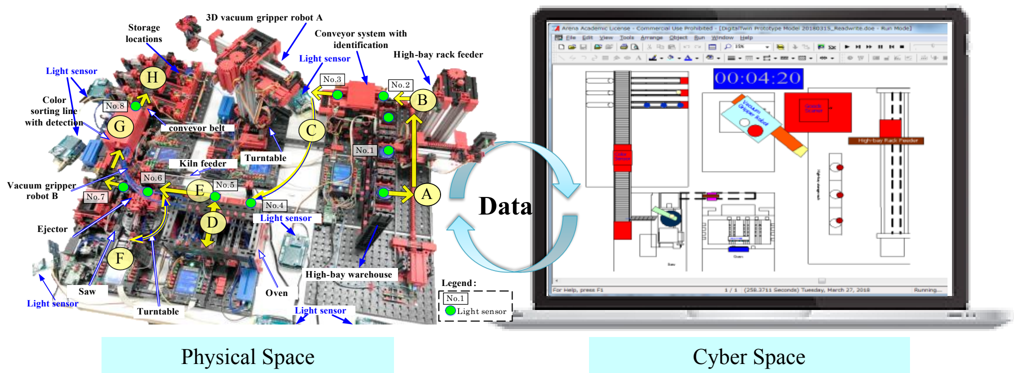

Figure 1: A DT schematic diagram of the factory model.

4 SUMMARY

This study described a framework for constructing a DT-oriented model. With the proposed framework, we were able to receive real-time data from an IoT-aided manufacturing system and construct a DT model that successfully reflected the real situation of the physical system.

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REFERENCES

Negri, E., L. Fumagalli and M. Macchi. 2017. "A Review of the Roles of Digital Twin in CPS-based Production Systems". *Procedia Manufacturing* 11: 939-948.

Qi, Q., and F. Tao. 2018 "Digital Twin and Big Data Towards Smart Manufacturing and Industry 4.0: 360 Degree Comparison". *IEEE Access* 6: 3585-3593.