Education System for Automated Material Handling System Design with Digital Twin and LEGO Robotics*

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I. EXTENDED ABSTRACT

The development and implementation of a LEGO robotics based system engineering platform are presented. In industrial engineering (IE), which includes manufacturing system as a major application domain, advanced IT technology and automation science have recently been integrated with manufacturing system. As modern manufacturing becomes smarter and relies increasingly on automation, a new approach is required for IE education. The Department of Industrial and Systems Engineering at Korea Advanced Institute of Science and Technology (KAIST) has developed a LEGO-based Automated Production System (LAPS) and Automated Material Handling Systems (AMHS) design project module for a manufacturing system class, using a LEGO robotics kit. In this project, students design and develop an automated production systems and AMHS using LEGO. The aim of the project is to motivate the students to learn about the dynamic flow behavior of production systems and about the design and analysis of manufacturing automation system by working through the LAPS design activity. In addition, the process of designing automated guided vehicle (AGV) system algorithm development has been tested with LEGO based AGV system. We develop a testbed for multiple AGV systems withe LEGO robotics. This systems intended to imitate actual AGV systems in an automated warehouse or manufacturing system. With the system, students perform algorithm development controlling multiple AGV such as job allocations and path plannings. Then they test with digital twin which consists of real-time emulator and event-based simulations. With the system they learn the algorithm development process, system design, and concept of digital twin. After two years of pilot trials and official implementation in an undergraduate manufacturing class, it is found that the LAPS project is significantly effective in motivating students. A survey and class evaluation also show that students are very satisfied with the class involving the LAPS project. This paper describes how innovations in IE and systems engineering education are possible with new educational technology such as LEGO robotics kits. It also demonstrates how LEGO robotics can be used to effectively teach the dynamic flow behavior of manufacturing systems and how to design manufacturing systems while taking account of this dynamic behavior. // *Index Terms*—**Manufacturing system, Automated warehouse, Storage assignment problem**