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A LEGO® MANUFACTURING SYSTEM FOR REAL-TIME SIMULATION

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ABSTRACT

This poster shows the development and the application of a LEGO® Manufacturing System (LMS) at the Department of Mechanical Engineering of Politecnico di Milano (Milan, Italy). The LMS exploits LEGO® MINDSTORMS® components to model a production line. The miniaturized system is an innovative platform both for research and didactic purposes thanks to high flexibility and easy reconfiguration.

1 INTRODUCTION

Recent economic developments pushed manufacturers to invest in Industry 4.0 applications and Cyber Physical Systems (Negri et al. 2017). Real-Time Simulation (RTS) is a relatively recent concept aiming at the exploitation of simulation models for short term decision making (Lugaresi and Matta 2018). Most of the approaches of the related research propose to exploit the coupling between a real system and its digital model. However, demonstrating the research directly using a real manufacturing system can become costly and inconvenient. Recently, some examples of LEGO®-based miniaturized systems can be found in the literature, and have been used to teach control systems (Sanchez and Bucio 2012), systems performance evaluation (Syberfeldt 2010), and stochastic systems (Jang and Yosephine 2017). In this poster, we present a LEGO® Manufacturing System (LMS) that has been realized at the Mechanical Engineering Department of Politecnico di Milano. The poster will show how the LMS can be used as testbed for RTS research.

2 REAL TIME SIMULATION APPLICATION

With the aim to test an RTS framework proposed in a previous work (Lugaresi et al.), an LMS has been built in the Department of Mechanical Engineering of Politecnico di Milano. The LMS is composed by four parallel stations with intermediate conveyors that operate also as buffers. All the stations are controlled by LEGO® EV3® bricks. Wooden circles tagged with red plates represent pallets that load the workpieces which must be processed by all the stations (single-product line). Buffer capacities are defined by the position of a sensor on the downstream conveyor of each station. The total buffer capacity is limited and the blocking after service rule is applied. The processing times are represented by a time $T_W(s)$ that each workpiece has to wait in the s-th station before being released on the downstream conveyor.

Figure 1 shows the physical system that has been developed. Stations 2 and 3 are parallel workstations that process pallets with a certain splitting policy (the number of pallets of a certain type going to station 2 or 3, respectively). The optimal policy is depending on the system status, hence simulations have to be performed to evaluate the best solutions. A proof-of-concept has been performed on the system of Figure 1 (Lugaresi et al.). The optimal policy has been obtained exploiting alternative simulations starting from

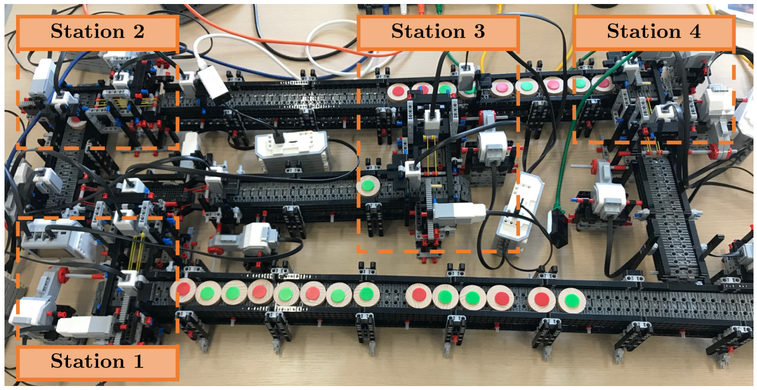

Figure 1: The 4-station closed-loop production line developed for the RTS proof-of-concept (Lugaresi et al. 2019).

the same system status, and it has been applied on the physical system. The average increase of system efficiency ranged between 2 and 4 % in comparison with the scenario in which no action was taken.

3 ORIGINALITY AND FUTURE RESEARCH

The application of a LEGO®-based miniaturized manufacturing system for real-time simulation is innovative as it allows for testing research involving the coupling of a real system and its digital counterpart. Further, the development of such a platform is also beneficial for didactic purposes (Lugaresi et al.).

Future research will aim at reaching a higher integration level between the hardware and software components. In order to better demonstrate real-time capabilities, initialization and synchronization have to be enhanced. Moreover, a software architecture able to control both the LMS both other components (e.g., PLCs, IoT devices) has to be developed and tested.

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