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CYBER-PHYSICAL PRODUCTION SYSTEM OF WORKERS FOR DESIGN AND OPERATION OF PRODUCT ASSEMBLY LINES

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ABSTRACT

Recently, many production lines have become smarter and more automated since German industrial policy Industry 4.0. However, humans still make up a large portion of production lines that do not have standardized work or require difficult assembly skills. To improve the productivity of processes in which workers play an essential role, ergonomic studies use motion capture equipment to measure and evaluate worker posture. However, most of the research remains in the process design stage. In this study, a cyber-physical production system of workers is proposed for process design and operation. To implement this method, the study designs an architecture and conducts a pilot implementation at assembly lines in South Korea for verification and validation.

1 INTRODUCTION

In the recent Industry 4.0 paradigm, studies on decision support system have been active that collect and analyze data by synchronizing the production line to the cyber world (Delmas et al. 2013). Among them, workers still play an essential role in production lines, which are complex or difficult to standardize. Ergonomics studies using motion capture (MOCAP) technology have also been employed to improve the productivity of these production lines (Y-K. Joung et al. 2014; C. Jun et al. 2019). However, these ergonomic studies remain in the production line design stage (Tee et al. 2017). In this study, architecture for the cyber-physical production system of workers for production line design and operation is designed, and demo software is implemented for worker data collection and analysis. In addition, a pilot test is conducted on the assembly line, and an improvement plan is discussed.

2 CYBER-PHYSICAL SYSTEM OF WORKERS

This chapter introduces the architecture for cyber-physical production system of workers, which consists of the physical world, information, and cyber world layers. Figure1 shows the data flow between modules at each layer. At the physical world layer, worker data are collected using MOCAP. The information layer collects and provides the data needed for workers' analysis and stores the analysis results. In particular, worker behavior data are provided in the human database and other data required for analysis are provided in the enterprise resource storage. At the cyber world layer, the system purpose and time is set, sensor data and synchronized digital model are created, and the work criteria are created in the digital environment model. Using this, the ergonomic analysis module performs workload analysis. The results of the analysis are visible in the user interface.

3 IMPLEMENTATION

To verify the system developed in this study, a pilot test was conducted at a factory in Yongin, South Korea. The workload of the assemble process workers was measured by algorithmizing the rapid upper limb assessment (RULA). The worker data were collected using international mathematical union (IMU) sensors, and a demonstration program was built using the Unity game engine. The measured workload data measured are stored in the manufacturing execution system (MES) to evaluate the productivity by analyzing their relationship to the product defect rate and throughput.

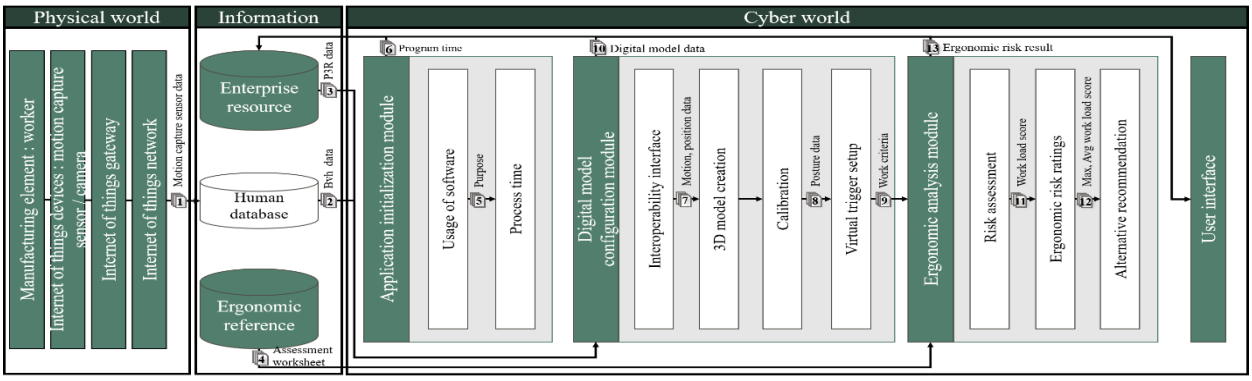

Figure 1: The architecture of a cyber-physical production system of workers.

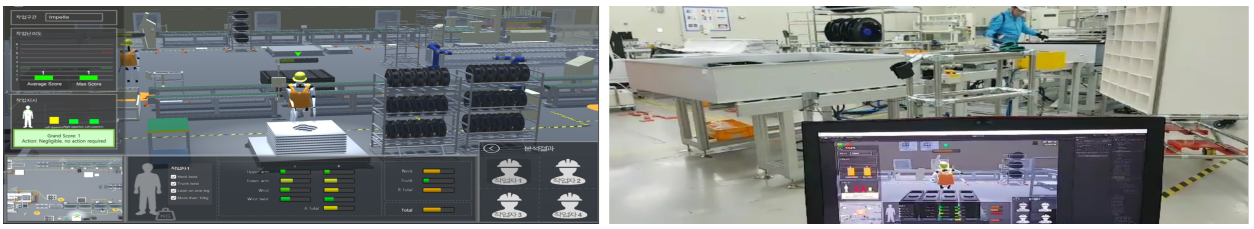

Figure 2: Dashboard of demo program (left), and its verification (right).

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