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Learning in the AutFab – the fully automated Industrie 4.0 learning factory of the University of Applied Sciences Darmstadt

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Abstract

The manufacturing industry is currently changing from mass production to customized production, which results in challenges concerning different production aspects. Industrie 4.0, a German strategy, combines several technologies, to meet these challenges. This implies that students need to acquire new competences. Therefore the University of Applied Sciences Darmstadt has established a holistic, fully automated learning factory covering most areas of Industry 4.0. Students of different degree courses learn very successfully in projects as well as in lab courses taught in this smart factory. This paper describes the challenges for production and the technologies proposed by Industrie 4.0 to meet these challenges. It presents the fully automated Industrie 4.0 learning factory and the education within this production facility as problem-based lab work and project-based courses.

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1. Introduction

The manufacturing industry faces the challenge of switching from mass production to customized production with a high production cost pressure at the same time. The productivity, the product quality and the flexibility of the production have to be increased, while the delivery times and the inventory must be reduced. In this context, flexibility means both the flexibility for different production quantities as well as the flexibility to produce different

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types or differently configured products with the same production system without or with only very short setup times. This also includes the flexibility to quickly switch productions for different customer orders from one production unit to another, for example either when a unit fails or to reduce delivery times. Additionally, the time to market of new products has to be shortened, which results, amongst others, in shorter times for the installation of production facilities. At the same time, the complexity of production facilities increases in consequence of an increasing intelligence of the products. To meet the growing complexity of work, workers should be assisted by electronic systems to improve their efficiency. Furthermore, the engineering costs for the development of the production units shall be reduced, for instance, by automatic engineering or by synchronous engineering of the mechanical, the electrical and the automation department throughout the total lifecycle of the product and the production facility.

Since plants of global companies are located worldwide, there is also a need for a secure remote access to the plants in order to enable a remote diagnosis of failures as well as the possibility to update the control software remotely. Connecting a plant to the Internet provides the opportunity to use services and storage in the cloud, thereby reducing or scaling the costs to the actual needs. These include big data analytics for preventive maintenance or web shops, in which the customer can configure the product by himself during the ordering process. In addition, to all these aspects, the energy efficiency of the plant shall be improved.

2. Industrie 4.0 technology

In order to meet all these challenges the strategic initiative Industrie 4.0 was launched in Germany. Industrie 4.0 is part of the Federal Government’s high-tech strategy [1]. The key technologies to meet these challenges are an increase of automation technology in the production plants and a seamless integration of IT systems and automation technology.

According to [2], the five central paradigms of Industrie 4.0 are a vertical and horizontal integration, a decentralized intelligence, a decentralized control, a fully integrated digital engineering and a cyber-physical production system. The vertical and horizontal integration is implemented by connecting the production systems with each other, so that there is a seamless data flow between all systems and even to the Internet. Decentralized intelligence describes the ability to deliver relevant production information to decentralized control systems. The fully digital engineering makes it possible to simulate the production system using digital twins. Cyber-physical production systems (CPPS) consist of cyber-physical systems (CPS) which are embedded systems that use sensors and actors to interact with the physical word. They are connected to each other thereby can interact also with the digital world, use data and services worldwide, and have multimodal human machine interfaces [3]. Very often it is assumed that they are consumer goods. However, production systems must operate reliable for decades. At the same time, new programmable logic controllers (PLCs), the classic system used in production, are introduced to the market with additional features for Industrie 4.0, making it attractive to use a hybrid approach of PLCs and embedded systems [4].

The paradigms of Industrie 4.0 are implemented with different technologies. The customized production with batch size one can be implemented by using radio frequency identification systems (RFID) or data matrix codes (DMCs) in order to identify the product individually. By this each workstation can perform exactly the task required for the actual order. The production-relevant data from the identification systems and other intelligent sensors and actuators can be passed on to decentralized control systems of the work stations, typically PLCs, or directly into a connected cloud. The decentralized intelligence increases the flexibility of the production with regard to the type or configurations of products, which is supported by self-configuring work stations. The decentralized control systems also enable a self-learning production, which automatically adjusts its parameters if the quality deteriorates.

The fully horizontal and vertical integration makes it possible to record runtime data as well as quality data both locally or in the private or the external cloud. This allows to optimize the production and to avoid unexpected, operational downtimes by means of predictive maintenance, which increases the availability of the plant. Furthermore, the complete networking enables automatic documentation, for example of scrap reasons, which could reduce the time for changes when quality issues occur. Moreover, the assembled parts can be tracked automatically to reduce the number of units in an eventual callback and the inspection results can be tracked as a proof of the