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Planning and Evaluation of Digital Assistance Systems

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Abstract

Education and training for industrial engineering focus on developing professional competence for the design, analysis and optimization of work systems, characterized mostly by either manual or automated processes and include determination of process, tasks and equipment based on given product requirements. In future production scenarios, human work can be assisted by digital information in regard to create work systems which remain flexible towards changing products and volatile demands through human adaptability while still making use of cost-efficient improvement potentials. Planning and evaluation of digital assistance systems in the context of cyber-physical assembly systems requires both classical industrial engineering competencies but also basic knowledge of information systems design. The paper proposes a learning design for a course in Cyber-Physical Assembly Systems Design which will be offered within the environment of the Industry 4.0 Pilot Factory at TU Wien where students can learn the basics of Cyber-Physical Assembly Systems Design both on a theoretical and practical level.

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1. Cyber-Physical Assembly Systems and Digital Assistance Systems

Manufacturing companies with a strong focus on assembly processes are facing the challenge of rising product and process complexity. The rising process complexity is a consequence of individualization of customer needs and the acceleration of fulfilment processes. An increasingly aging and diverse workforce poses additional challenges on management of process complexity. State-of-the-art assembly systems in industry reach their economic and technical limits when encountering these challenges. However, a new generation of assembly systems is currently on its way that is based on the concept of cyber-physical systems (CPS) [1]. CPS realize the connection between the physical and the digital world. CPS are composed of embedded systems, which detect physical objects directly by sensors and interact with physical processes via actuators. These systems are linked through digital networks and exchange data

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and services globally. CPS are not (technically) closed units, they are defined as open socio-technical systems, which are characterized by a high degree of cross-linking of the physical, social and virtual world as well as by the intelligent use of information and communication systems [2]. By integrating CPS into assembly systems new forms of assembly processes will be possible [3].

So called Cyber-Physical Assembly Systems (CPAS) are expected to meet the challenge of flexibility towards volatile customer demand and workforce diversity [4, 5]. Flexibility regarding product and process variations ("lot-size 1") will lead to frequent changes of work content and respective information needs and will impose excessive physical and mental stress on the operator [6]. As a consequence, similarity of assembly tasks will decrease and building up of relevant work routine will not be possible anymore. Erroneous material and tool are an inevitable consequence. The risk of unmanageable work situations for the operator are likely to increase [7].

Within a CPAS digital assistance systems (DAS) are the primary interface to optimally integrate human agents into the assembly system during task execution. Thus, DAS compensate the gap between required competencies at the work place to perform a work task (performance requirements) and the capability of a human worker (worker capability). The primary objectives of DAS are the increase of productivity [8], e.g. reduction of training time, search times, operating errors and supporting the work force in stressful situations [9, 10].

Features of modern DAS come far beyond a sheer representation of information. They provide situational support through process-aware assembly periphery (tools, material, work piece etc.). Work instructions are automatically provided in accordance with physical work progress and without any manual interaction with the system, e.g. through adequate sensory equipment [3]. Order specific assembly instructions facilitate the worker in choosing the correct work place set-up, materials, tools and tool configurations. In case of assembly mistakes, a DAS suggests activities in order to have the mistake corrected at the right moment and at the right location to achieve product quality as desired [11].

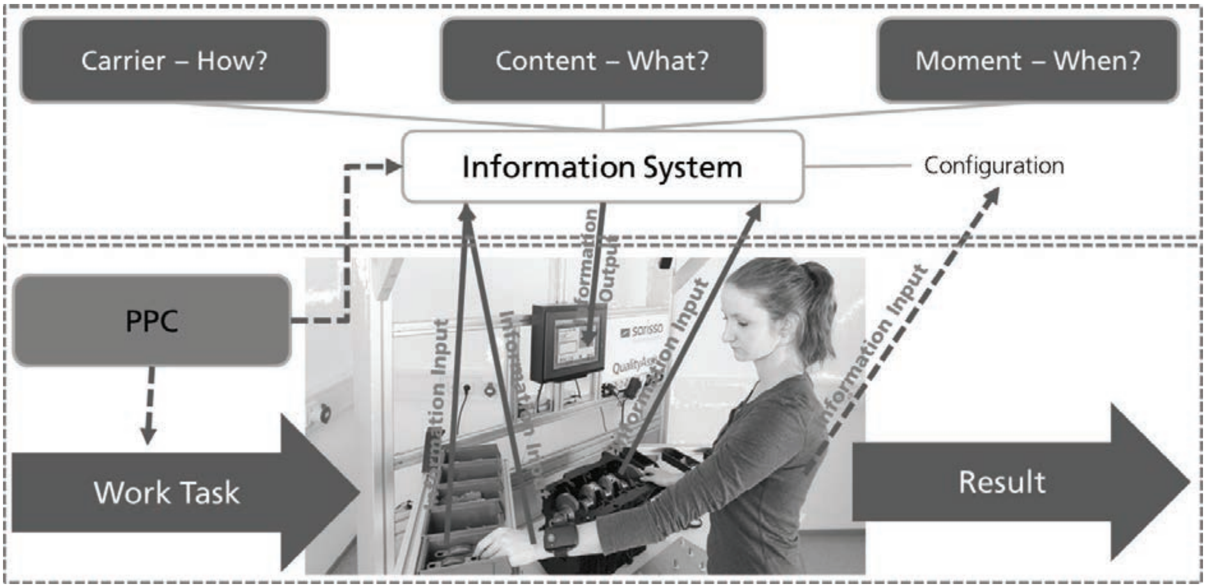

Figure 1: Digital Assistances in CPAS

In addition to the above outlined general features of DAS also domain and process-specific requirements of assembly processes must be addressed. Advantageous features of DAS must be determined already during the planning phase of an assembly system. It is necessary to systematically identify specific needs, to derive requirements for appropriate technical systems, and to evaluate the productivity impact of single digital assistance features on the entire assembly system.

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