Planning and Evaluation of Digital Assistance Systems

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Planning and Evaluation of Digital Assistance Systems

Agenda

1. Cyber-Physical Assembly Systems and Digital Assistance Systems
2. Planning and Evaluation of Digital Assistance Systems
3. Learning Design for Planning and Evaluation of Digital Assistance Systems
4. Summary & Outlook
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Planning and Evaluation of Digital Assistance Systems
Mixed Model Assembly Systems (MMAS) - Cyber-Physical Assembly System (CPAS)

- “Mixed Model Assembly Systems” (MMAS): (Fässberg et al., 2011; Zeltzer et al., 2012; Fast-Berglund et al., 2013)
- High requirements on flexibility
- High effort to coordinate a high complexity
- Imposing challenges on the operator:
  - Flexibility requirements of the operator decreases
  - Decision-making becomes less trivial
  - Working skills are hard to built up prospectively
  - Risk of rising cognitive, physical and psychological stress
  - …

Assistance Systems as a component of Cyber-Physical Assembly Systems: (Erol et al., 2016)

Assistance Support System: Operators are supported by the execution of their activities with the aim to minimize a possible discrepancy between skill, stress (work load) requirements of a work task and the human (operator) capability in order to increase the productivity thought-out representation of information. (Zäh et al., 2007; Spillner, 2014; Hirsch-Kreinsen, 2014; Wiesbeck, 2014)
Digital Assistance Systems provide a real-time, synchronous, and thus situational support through networking with the assembly periphery (tools, material, work piece, etc.):

- Work instructions are automatically synchronized with the work progress and without any manual interaction
- Assembly sequences can provide information to use of the correct work piece, the correct fastener tools in the correct configuration, materials etc. - monitored by sensors and cameras and controlled by actuators
- Through logical relations of these signals with corresponding process data, the proper work instruction is provided to the operator
- In case of assembly mistakes, appropriate software identifies the adequate support and generates a specific information in order to have the mistake corrected right in the moment, at the right location to achieve product quality as desired

Intelligent Digital Assistance Systems:
- Selected components (Sarissa, 2016):

Local Positioning Components for Operator (left) and Facilities (right)
Planning and Evaluation of Digital Assistance Systems

General Planning and Evaluation Problem of Digital Assistance Systems

Carrier – How? (Tool/Technology to represent Information)

Content – What? (Context/Performance/Knowledge/Communication)

Moment – When? (Demand/Need of Information)

Information System

Configuration

PPC

Work Task (Production-oriented Order)

Result (Assembled Product)

Impact on the Performance (Productivity) of the Work System and of the Operator?
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The comparison of different variants of typical assembly and production planning approaches demonstrates:

Planning and analysis of digital assistance support systems or the decision, if the integration of such a system makes an economic advantageous in regard of the productivity of the work system, takes only minor consideration (Wiesbeck, 2015; Spillner, 2014; Konols, 2003; Lotter, 1992; Bullinger, 1986).

Current methods used for assembly planning and analyzing (e.g. lean methods) shows significant weaknesses in the context of planning and evaluation of digital assistance systems in assembly systems particular in the field of CPAS:

Methods do not deal with the necessaries of information and communication technology requirements, like self-configuration of control, regulation and data processing functions.
Planning and Evaluation of Digital Assistance Systems
Planning and Evaluation Approach of Digital (cognitive) Support

For determining the specific need of cognitive (digital) support and to determine the specific components of digital support systems (sensors, actuators, devices,...), the framework is to evolve deeper in terms of a operational level.
Planning and Evaluation of Digital Assistance Systems
Method for Planning and Evaluation

**Approach of Assembly Planning**

**Preparation**
- Requirements analysis

**Draft Planning**
- Product analysis
- Assembly sequence analysis
- Functional analysis
- Cycle time determination
- Layout planning

**Detail Planning**
- Personal capacity analysis
- Availability determination
- Specification sheet
- Investment calculation
- Evaluation and selection

**Implementation**

**Operation**

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**Planning and Evaluation of Digital Assistance Systems (DAS)**

- Working method description (MTM)
- Product and material information
- Information on working and capacity allocation
- Production quantities

**Technology database**

**Step 1: Determining the Needs for Digital Assistance Systems**
- Evaluation of component/product complexity
- Evaluation of workstation complexity
- Evaluation of the human work load
- Evaluation of human reliability

**Step 2: Configuration of the Digital Assistance Systems**
- Identification of the technical possibilities and components
  - Investment
  - Evaluation of residual risk of human error
- Decision support in regard of configuration and investment of DAS
Planning and Evaluation of Digital Assistance Systems
Methodology for Planning and Evaluation

<table>
<thead>
<tr>
<th>Description Parameters and Identification of Digital Assistance System Needs</th>
<th>Requirements correlated with technical Components of Digital Assistance Systems</th>
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<tr>
<td>MTM-Structure</td>
<td>Human-Error Probability (HEP) „Current-Status“</td>
</tr>
<tr>
<td>Product Complexity</td>
<td>Expression of Digital Assistance Systems</td>
</tr>
<tr>
<td>Workstation Complexity</td>
<td>Component 1</td>
</tr>
<tr>
<td>Operator</td>
<td>Component n</td>
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<td>Experiences Factors</td>
<td>QFD</td>
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<tr>
<td>Conditional Factors</td>
<td>Quality Function Deployment</td>
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Information Input
Information Output
Dialog Components

Gain of Productivity
Investment Decision Support

Human-Error Probability (HEP) „Soil-States“

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Learning Design for Planning and Evaluation of Digital Assistance Systems

- **Target Audience:**
  - Master program of Industrial Engineering
  - Professionals from industry

- **Learning Objects:**
  - Bloom’s taxonomy of learning objectives
    - Level 1 (theory): **Knowledge transfer** of the basic theories and principles of assembly systems planning and designing
    - Level 2 (practice and reflection): **Using the transferred theories and methods** in order to our method for planning and evaluation Digital Assistance Systems.
  - **Features and components of Digital Assistance Systems** are identified and technical requirements are determined.
  - **Evaluation of technical features and components** in terms of economic measures, e.g. productivity in practical training environment.

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<th><strong>MTM-1 and MTM-UAS</strong></th>
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<td>- Methodology MTM-1 and MTM-UAS</td>
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<td>- Understanding the use of the methodology</td>
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<th><strong>Digital Assistance Systems</strong></th>
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<tr>
<td>- Technical effects and functions of digital assistance systems</td>
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<tr>
<td>- Methods for the identification of needs and productivity of assistants</td>
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<td>- Methods for the quantitative assessment of human reliability</td>
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<td>- Methods for assessing the complexity of mounting systems</td>
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<td>- Methods for supporting technology decisions</td>
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<th><strong>Assembly and Workplace Analyzing and Planning</strong></th>
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<td>- MTM-based assembly planning and optimization</td>
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<td>- Development of an assembly concept</td>
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<th><strong>Commodities and Productivity Identification of Digital Assistance Systems</strong></th>
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<tr>
<td>- Analyzing the required mobility degree of the digital assistance system / system device</td>
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<td>- Analyzing the human reliability with regard to the defined MTM method and deduction of bottlenecks</td>
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<td>- Analyzing the complexity of the assembly work stations with regard to possible cognitive stress situations</td>
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<td>- Derivation of the required information representation (signal, ..., augmented reality)</td>
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<td>- Derivation of requirements in regard to synchronize operating instructions with the assembly task</td>
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<td>- Analyzing dialogue needs within the assistance system</td>
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<td>- Information technology interaction with the assistance system</td>
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<td>- Interaction with technical systems of the assembly system</td>
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<td>- Documentation of process and measured key figures</td>
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<tr>
<td>- Comprehensive formulation of the functional requirements for the digital assistance system with regard to information output and display, information processing and information creation</td>
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<tr>
<td>- Variants building of digital assistance systems with simultaneous use of a cost / benefit analysis</td>
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<td>- Selection of visual and digital assistance systems taking into account investment / implementation costs and potential for error prevention</td>
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<th><strong>Test Series</strong></th>
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<td>- Construction of a corresponding assembly system (mock-up)</td>
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<td>- Configuration and implementation of the substantively evaluated variant of the digital assistance system</td>
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<tr>
<td>- Critical evaluation of the assembly system and the digital assistance system</td>
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<tr>
<td>- Conducting test series with the help of a standardized questionnaire for the efficiency analysis of the assembly system and the implemented assistance system and its functions</td>
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Planning and Evaluation of Digital Assistance Systems
Learning Design for Planning and Evaluation of Digital Assistance Systems

- **Learning Materials and Environment**

  - Study materials will be provided mainly through our [e-learning platform TUWEL](#) which is based on Moodle open-source software.

  - Study materials include text books and also several [Excel based tools](#) to perform the planning of tasks (MTM-based analysis) and the subsequent steps of the method for planning and evaluation of Digital Assistance Systems.

  - The course will take place both in lecture halls (see learning objectives on level 1) and in [TU Wien Pilot Factory Industry 4.0](#) where an ideal practical training environment for assembly systems design is implemented.
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Summary & Outlook

- Cyber-physical assembly systems allow to benefit from capabilities of humans and machines in joint assembly environments. Technological progress has made such systems economically feasible.

- Detailed planning and evaluation of such systems, especially with regard to digital assistance systems is a prerequisite for increasing productivity and at the same time decreasing unit costs.

- Industrial Engineers of the future have to be educated with regard to planning and evaluation of such systems.

- The learning design presented in this paper describes a recently developed course for Master students of Industrial Engineering. The course takes into account methods to plan and evaluate complex cyber-physical assembly systems and respective digital assistance systems.

- The Industry 4.0 Pilot Factory is an ideal learning environment that allows students to practically evaluate planning outcomes under realistic conditions.

- In addition, the concept serves a continuous evaluation of the presented method in regard to deeper specifications of productivity effects and on order to transpose fundamental basis to transfer the method into an algorithm- and software-based industrial application solution.
Thank you for your attention!

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