On the Application of Cyber Physical Production Systems

How a digital twin of physical Systems can be created, updated and utilised in manufacturing automation

20.08.2018

Prof. Dr.-Ing. Michael Weyrich
Agenda

Concept of Cyber-physical Production Systems

Digital Twin

Example of Projects

Research Approach and next steps
Agenda

Concept of Cyber-physical Production Systems

Digital Twin

Example of Projects

Research Approach and next steps
New Approaches are available for Application
Commercial Providers promote methods and procedures which promise an automation of the value chain

... however ... what about research?
Cyber physical Systems - Composition of Software, Data, IT and physical devices

The very large Diversity, e.g. hundreds of sub-systems demand for a standard information model for functional groups, classification of components etc.

Complexity is created in practical application due to the linkage of components and interdependencies between the sub-domains / disciplines.
Body-in-White in Assembly Solutions

Video showing the State-of-the-Art in Industrial Application (Source Daimler 2018)
Agenda

Concept of Cyber-physical Production Systems

Digital Twin

Example of Projects

Research Approach and next steps
Networking of physical Assets results in a diversity of Data

New technologies for the acquisition and analysis

• M2M Communication: 4G / 5G, TSN, …
• Cloud: Amazon Cloud, Microsoft Azure, …
• IoT Operating systems: Siemens MindSphere, PTC Thingworx, Bosch IoT Suite, …
• Engineering PLM Backbone: Teamcenter, Enovia

[based on: Rabaey, Pederson 2008]

© 2018, Prof. Dr.-Ing. Michael Weyrich, IAS, Universität Stuttgart
Steps towards cyber physical Manufacturing (2)

A digital twin means in unison with physical systems, a cyber reproduction is being created.

- The characteristics and functionalities of physical assets are pictured by a Digital Twin along the lifecycle.
Frontiers of the automation technology of today
In Industry, there are numerous frontiers for the usage of automation systems

**Effort for Engineering** requires more interoperability

**Missing Standards**, e.g. for a semantic processing of information

**Problem of Complexity** for very large automation systems

**Limitation in „Self-X functionalities“** (Analytics, Machine Learning, Artificial Intelligence)
Agenda

Concept of Cyber-physical Production Systems

Digital Twin

Example of Projects

Research Approach and next steps
Digital Twin – Design moves to Runtime

How could the interchange be used between the cyber and physical world?

**Today**

- Engineering / Test
- Commissioning / Test
- Operation / Runtime of production
- Retrofit

**Tomorrow**

Example 1:
Configuration of systems and Engineering for Change

Example 2:
Automatic changes in manufacturing

Example 3:
Data driven quality control in Operation
Example 1: Multiple Sub-domains / Disciplines

Manufacturing systems are designed using IT-based Engineering systems which support different views of the various mechatronic elements.

- Discipline mechanical Design
- Discipline Layout of plant
- Discipline Electronics electric
- Discipline Software for control
  ...

**Challenge:**
How to synchronize the multiple legacies of the Engineering systems?

(Source: Siemens AG - Automation Designer)
Example 1: Synchronization of a Digital Twin

Anchor point method for synchronization of the Digital Twin in the PLM Platform

GSaME Project - see: [Ashtari et al 2018]

SIEMENS ARENA 2036

Challenge:

PLM IT platforms entail data of mechatronic components from multiple domains (Software, Mechanical and Electronics) which need to be synchronized in the event of change.
Example 1: Variety of Information in Automotive Body-in-White

A large variety of divers data and information is available and needs to be systematically assigned.

Type of Data:

- Manufacturing planning based on Standards and De-factor Standards
- IT Network Scan of all fieldbus systems
- 3D Scans of the shopfloor
- High-resolution pictures of all installed systems

Challenge: how to create transparency, e.g. by automatic interconnecting fragmented information which can be utilized in planning of retrofits.
Virtual Commissioning  (Source Siemens, 2018 / Arena 2036)
Example 1: Update of a Digital Twin in Operation
Automatic Updates of planning objects in the digital factory based on the data of real Automation IT and 3D-Scans

There is a necessity to adjust existing manufacturing systems to fit the need of new vehicle models.

GSaME Project - see: [Bieisnger et al 2018]
Example 2: Decentral Control of automated manufacturing systems based on agent technology

How could we reduce the effort for configuring and programming in the event of changes?

Interpretation / recognition
"The product steers through production"

Reference project on the Roadmap Industrie 4.0 of the Platform Industrie 4.0, see [Klein, Weyrich 2016]; [Faul et al 2018]
Example 2: Automatic Allocation of suitable Resources to the Process steps

The product chooses its resources depending on the process requirements

Challenges
• Resource communicate the status automatically using a semantic
• Agents control the allocation of process and recourses using the market place approach

[Klein et al 2018]
Verteilte LEGO-Auto-Fabrik
Example 3: Data driven quality control in Operation

Sensor data entail information about the plant and process and can be analyzed to improve process quality

Challenges:

- Capture of data and extraction of unknown patterns
- Generation of action proposals

see: http://www.massivumformung.de/forschung/emudig-40/; Source: Otto Fuchs KG
Example 3: Self-learning of System Components

The System learns about the dynamic and the disturbances based on real process data.

A special learning approach is utilized in order to optimize the cascaded quality controller.

[Lindemann et al 2018]
Agenda

Concept of Cyber-physical Production Systems

Digital Twin

Example of Projects

Research Approach and next steps
Arena 2036: On Campus of the University of Stuttgart

ARENA2036 - “Active Research Environment for the Next Generation of Automobiles”
The largest and leading research platform for mobility in Germany

- More than 300 scientific staff
- Area of 25 000 m²

In ARENA 2036 IAS is involved in the research project "Flexible Production System" as a project leader in cooperation with industrial partners: SIEMENS, KUKA and TRUMPF
Towards the automation of the future …

Characteristics: cyber physical, intelligent, flexible and efficient

Automated Production Management

- Processing of information with Artificial intelligence
- Decision support
- Modular and interoperable Components
- Exchange of Data in Manufacturing
- Autonomy of subsystems

Plug-and-Produce Networks with self-optimization
Summary

- Models for explanation
- Examples from research projects
- Next steps and frontiers

Prof. Dr.-Ing. Michael Weyrich
E-Mail: michael.weyrich@ias.uni-stuttgart.de
Telefon: +49 711 685 67301

Universität Stuttgart
Institut für Automatisierungstechnik und Softwaresysteme
Pfaffenwaldring 47
70550 Stuttgart
References


