University of Stuttgart
Institute of Industrial Automation
and Software Engineering

Research and Teaching at IAS

2020

Prof. Dr.-Ing.
Dr. h. c.
Michael Weyrich

Institute of Industrial Automation and Software Engineering (IAS)

Faculty of Computer Science, Electrical Engineering and Information Technology of the University of Stuttgart

Research and teaching at the Institute focuses on the topic of **Software Systems for Automation Engineering**.

We see ourselves as a **bridgehead to Product and Plant Automation** in the research disciplines of **Information Technology, Software Technology and Electronics**.

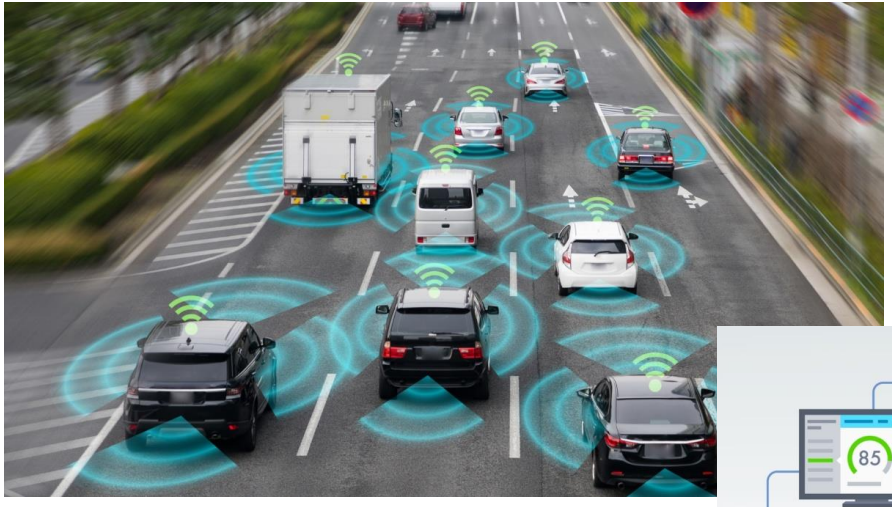
Prof Weyrich was appointed to the University of Stuttgart in April 2013.

Information about IAS

- Institute members
  - Head of institute: 2
  - Doctoral candidates: 15
  - Faculty support staff: 5
  - Apprentices: 1
- PhD graduates 2019: 2
- Undergraduate Projects and Master Theses 2019: 64
- Exams 2019: 947
- Publications 2019: 21
- Student Assistants per annum: 40-50

NEW!! Master of Science Autonomous Systems

Prof. Weyrich is Dean of Studies of the M.Sc. Autonomous Systems



Lectures at the Institute

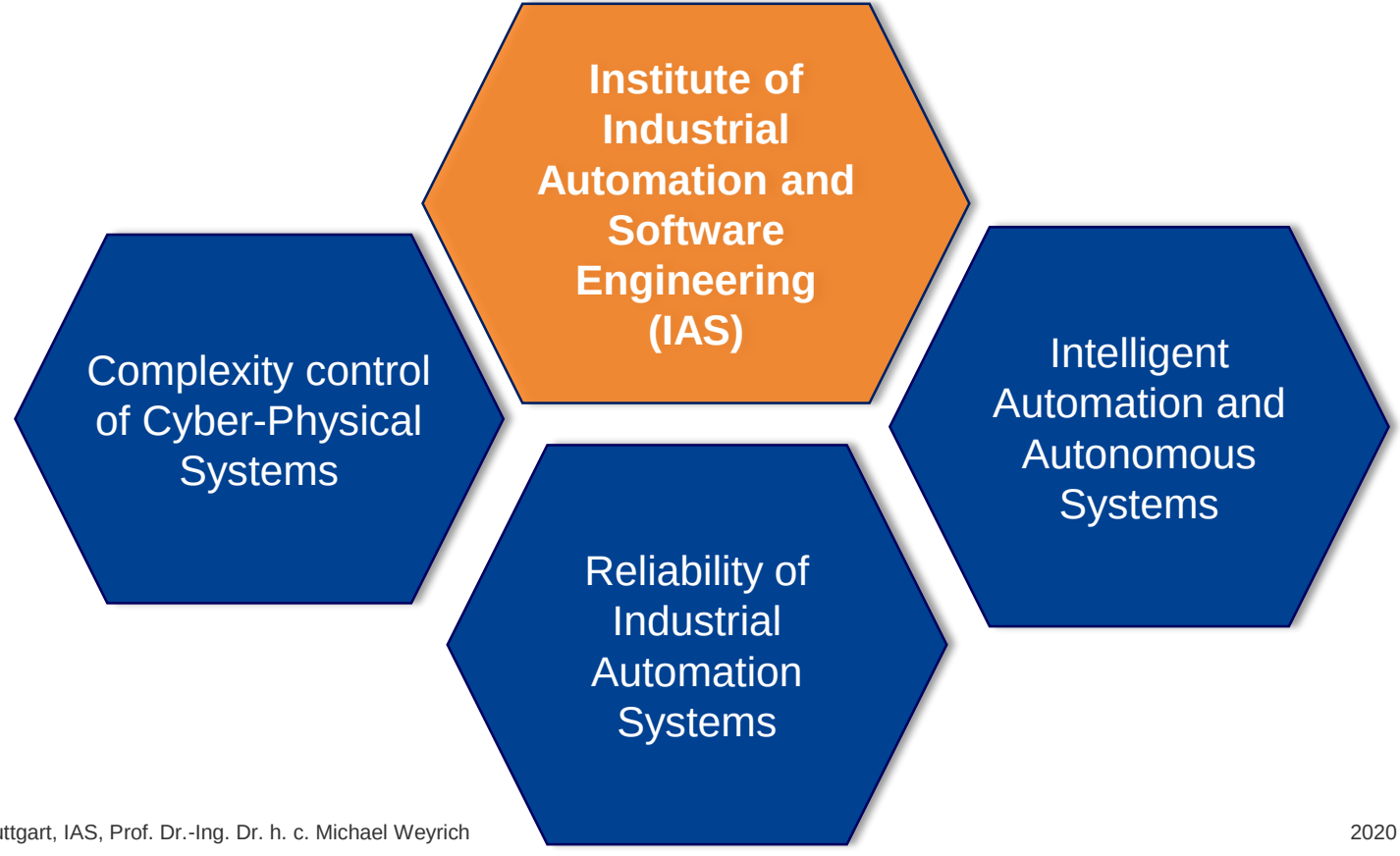
- Industrial Automation I (German)
- Industrial Automation II (German)
- Technologies and Methodologies of Software Systems I
  Technologies and Methodologies of Software Systems II
  (both German)
- Software Engineering for Real-Time Systems
- Industrial Automation Systems
- Networked Automation Systems (German, from WS20/21)
- Basics of Software Systems (German)
- Lecture Series: Software and Automation
- Reliability of intelligent distributed Automation Systems (German)
- Seminar Intelligent Cyber-Physical Systems (German, from WS20/21)
- Laboratory Course Software Engineering
- Laboratory Course Industrial Automation
- Laboratory Introduction in Microcontroller Programming

Courses for Degree Programmes

- Prof. Weyrich is **Dean of Studies** of the M.Sc. Autonomous Systems
- B. Sc. Elektrotechnik und Informationstechnik
- B. Sc. Mechatronik
- B. Sc. Medizintechnik
- B. Sc. Erneuerbare Energien
- B. Sc. Technische Kybernetik
- B. Sc. Technikpädagogik
- B. Sc. Informatik
- M. Sc. Autonome Systeme
- M. Sc. Elektrotechnik und Informationstechnik
- M. Sc. Mechatronik
- M. Sc. Medizintechnik
- M. Sc. Information Technology
- M. Sc. Electrical Engineering
- M. Sc. Elektromobilität
- M. Sc. Nachhaltige Elektrische Energieversorgung
- M. Sc. Technikpädagogik
- M. Sc. Verkehrsingenieurwesen

Research at IAS

The research of Automation Technology is based on applications in the manufacturing industry, automotive and urban life.

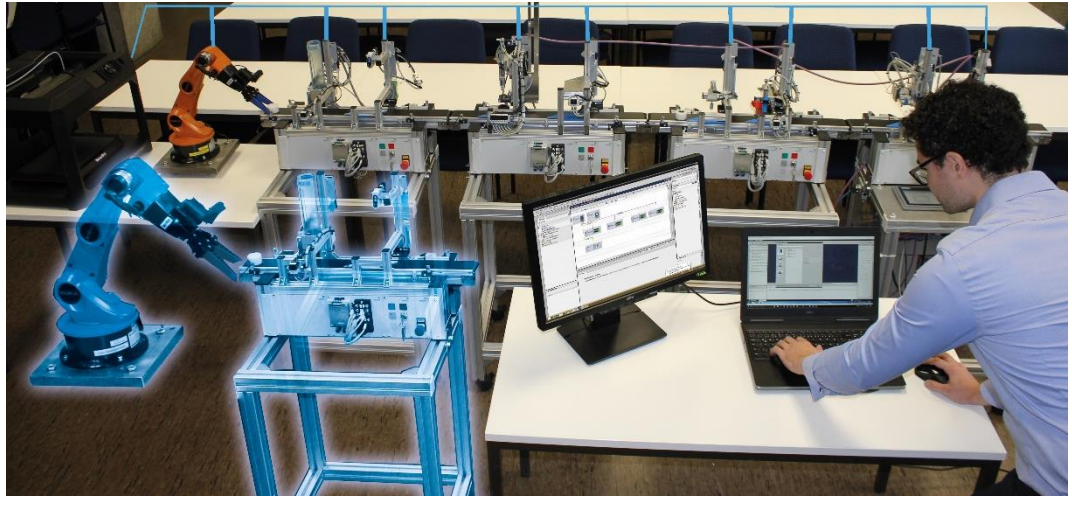


Research area: Complexity control of Cyber-Physical Systems

How can we manage and control the complexity of Cyber-Physical Systems in engineering and operation?

Research topics at the IAS

- Digital twin and its applications
- Co-Simulation of Cyber-Physical Systems in industrial automation
- Model-driven development and testing of dynamically changing software and hardware systems
- Autonomous reconfiguration management

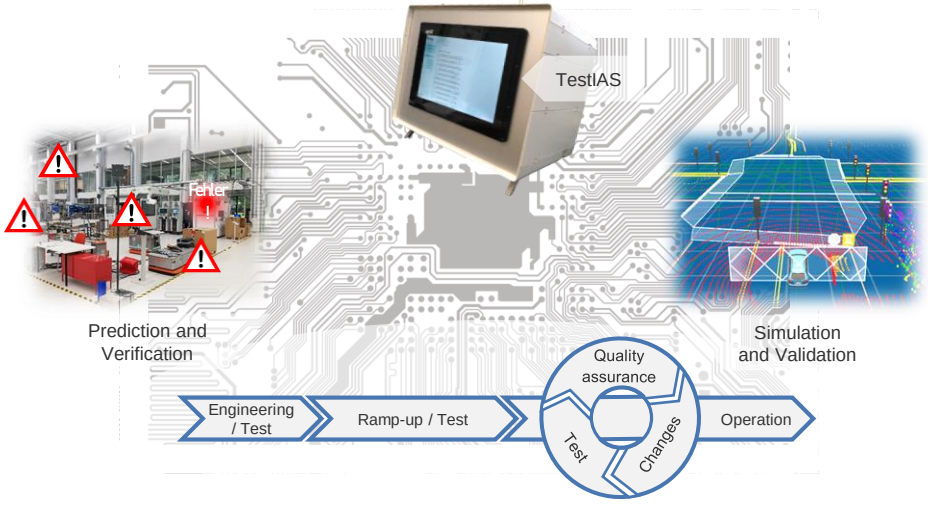


Research area: Reliability of Industrial Automation Systems

How can we rely on the quality of automated systems in terms of reliability, security and availability?

Research topics at the IAS

- Test for verification and validation at system and component level
- Assessment and evaluation of the reliability of automated systems in the Internet of Things
- Test of automated systems and anomaly detection

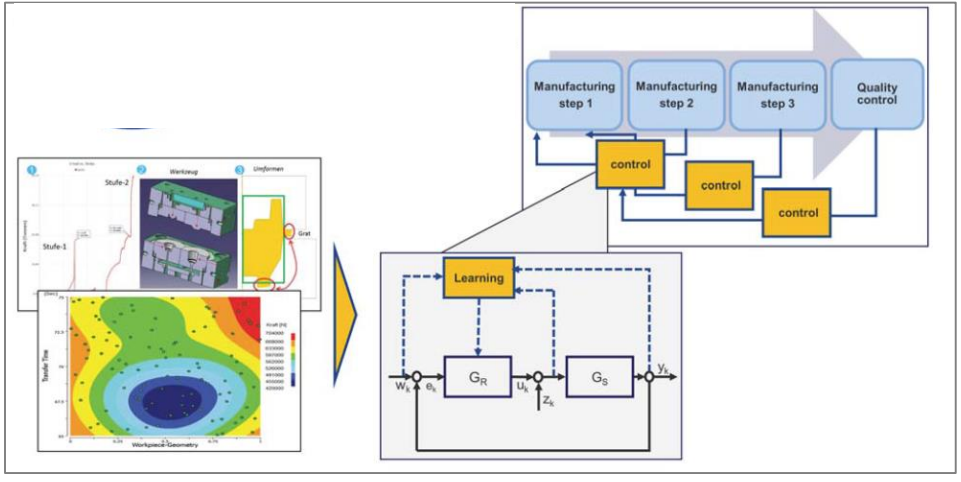


Research area: Intelligent Automation and Autonomous Systems

Will tomorrow's technical systems automate themselves?

Research topics at the IAS

- Optimization of automation systems based on process data (Machine Learning, Big Data, Data Analytics)
- Intelligent automation for user-oriented support of elderly people
- Decentralized, cooperative machine learning in automation
- Simulation of autonomy concepts



IAS in the research environment of Stuttgart

The Institute follows the mission statement "**Intelligent Systems for a Sustainable Society**" and is part of the **Excellence Strategy of the University of Stuttgart**.

Institute of Industrial Automation and Software Engineering

We are part of the profile areas and emerging fields of the **excellence strategy**:

- Autonomous Systems
- **Architecture and Adaptive Building**
- Production Technologies

Universität Stuttgart

ARENA2036 Research Factory

CyberValley Intelligent Systems

Technology transfer

Model processes at IAS

The model processes are used to represent special automation technology and to demonstrate the capabilities of software systems.

Intelligent Automation & Autonomous Systems

Intelligent Warehouse (ARENA 2036)

Data Analytics in Manufacturing

Industry 4.0 Assembly plant

Context-aware pill dispenser

OPC-UA for production control

Complexity control of CPS

Digital Truck Twin

Plug & Simulate

Simulation of plant modernization

eProduction System

Modular Production System

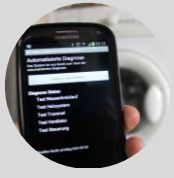
Reliability of Automation Systems

Intelligent Test of autonomous systems

Blockchain Application scenarios

TestIAS with Virtual Reality

Smartphone-based Fault Diagnosis



Assistance system Test case prioritization

Cooperation with the following companies

- CompWare Medical GmbH
- Daimler AG
- Diffblue Ltd.
- Festo AG & Co. KG
- Hirschvogel Umformtechnik GmbH
- iss (Innovative Software Services GmbH)
- OTTO FUCHS KG
- Robert Bosch GmbH
- Siemens AG
- SMS group GmbH
- Vector Consulting GmbH
- Vector Informatik GmbH

Maker Space

IAS supports various start-up companies and cooperates in research projects

RoboTest	Validation and verification of highly automated and autonomous systems	since 2020	**VC**
NAiSE INDOOR NAVIGATION SYSTEMS	Indoor Navigation Systems	Jan. 2017 – Dec. 2017 Aug. 2019 – July 2022	**EXIST** **EUREKA project**
truphysics	Simulation and commissioning of robots in virtual reality	Apr. 2014 – March 2015 March 2016 – Feb. 2018	**EXIST** **Junge Innovatoren**
EKU POWER DRIVES	Create technologies that combine power generation with efficient control systems.	June 2014 – May 2015 June 2015 – May 2016	**EXIST** **Junge Innovatoren**

Anchor point method for synchronizing the Digital Twin

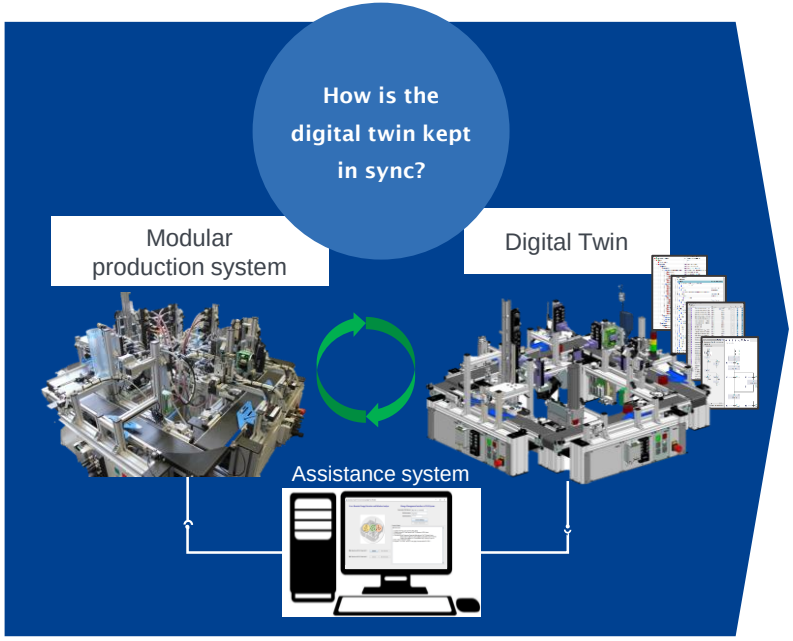
Synchronization of digital models with the real system as the basis of intelligent systems

Requirements:

- Cross-domain synchronization of engineering models with real systems in operation

Core technologies:

- Engineering and simulation models
- Robot / PLC code analysis
- Decision Tree in Assistance System



Approach

- Discipline-specific change detection in automation technology (anchor points)
- Consistency check between detected anchor points using a decision tree
- Software-assisted synchronization of changes in the Digital Twin

➢ Time and cost savings in engineering during the operational phase

Adaptable quality control

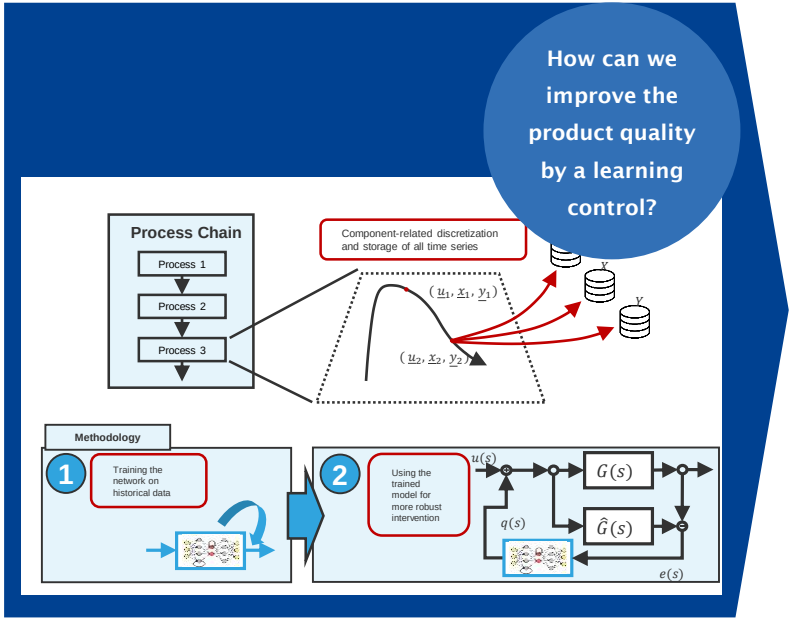
Control of discrete manufacturing machines based on Long Short-Term Memory networks

Requirements:

- Analysis of process data for compliance with defined quality characteristics
- Real-time recommendations to the worker

Core technologies:

- PLC-based data acquisition
- Feature extraction
- Data Analytics (online/offline)



Motivation

- Sensor data contains information about the plant and process status and can be used to improve the process quality

Approach

- Systematic extraction of unknown relationships and patterns
- Data acquisition and integration, dimension reduction, data analysis, recommendations

➢ Data-driven quality optimization

Co-Simulation (Cooperation with Vector Informatik)

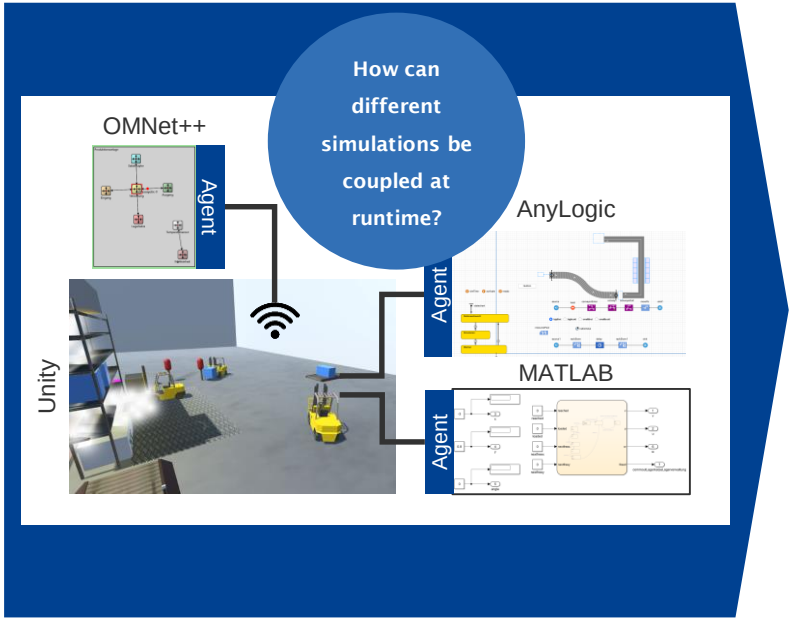
Dynamic Co-Simulation of heterogeneous Internet of Things Systems

Requirements:

- „Plug-and-Simulate“-capable Co-Simulation of heterogeneous and dynamically changing IoT systems

Core technologies:

- Agent-based Co-Simulation
- Component- and Process modeling with MATLAB, AnyLogic, Unity, OMNet++, …



Approach

- Framework for coupling simulations via an agent system
- Connection of the simulations via interface adapters
- Service-oriented modeling of communication and physical processes
- Synchronization of the partial simulations via a central clock agent

Assistance in the modernization process of industrial automation systems

How can we support the modernization of old plants?

Requirements:

- Software tool which supports the modernization process of machines or plants
- Generation and evaluation of adaptation options based on given requirements

Core technologies:

- Product-, process-, resource-model of the machine
- Agent-based assistance system

Approach

- Modeling of the machine with little effort, software agents represent components of the machine
- Automated evaluation of production requests
- Generation and evaluation of adaptation options using the model of the machine

➢ Decision support and assistance in the modernization planning process

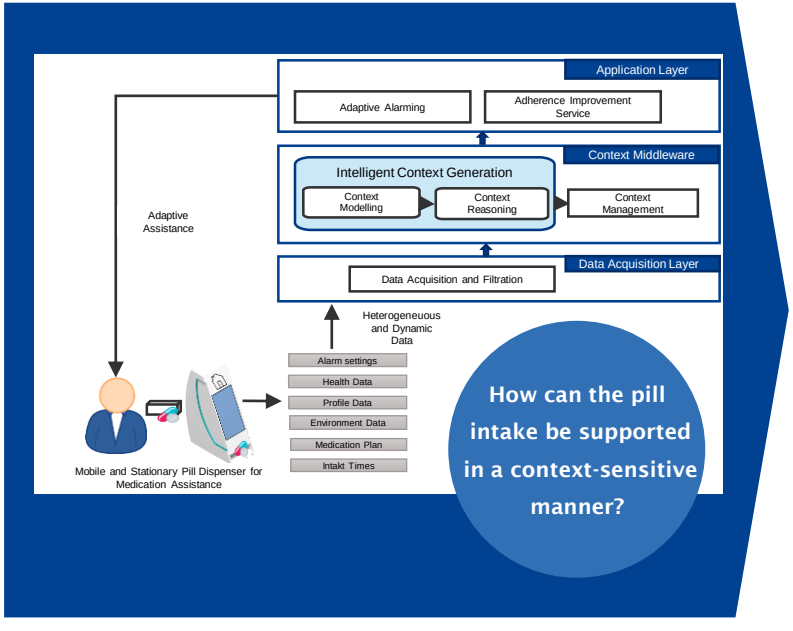
Assistance system for adaptive user support in the context of Ambient Assisted Living

Requirements:

- Reusable concept for the adaptive support of elderly people with the help of intelligent assistance systems

Core technologies:

- Context-aware automation systems
- Middleware-based architecture
- Hybrid learning methods for heterogeneous data processing



Approach

- Development of a pill dispenser as an IoT approach for stationary and mobile use
- Automatic capturing of the medication plan, alarms and pill dispensing as well as intake detection
- Personalized support through alarm settings and adaptive alarming
- User-specific recommendations based on the determined context

Self-organized reconfiguration management

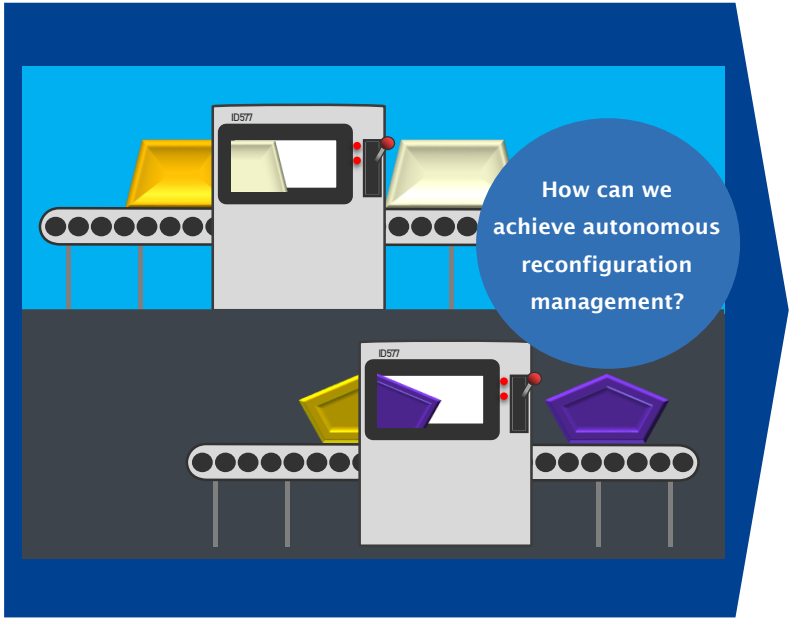
Decentralized, self-organized planning of automation systems

Requirements:

- Support of the planner in the rough planning phase of industrial automation systems

Core technologies:

- Agent technology (Self-organisation)
- Metaheuristics (layout optimization)



Approach

- Planning of an industrial automation system is modelled as a dialog-based process and applied to an agent system
- Agents represent resources and try to integrate them into the planned automation system

➢ Determination of possible constellations for the automation system to be planned

Verification of automation systems after software updates

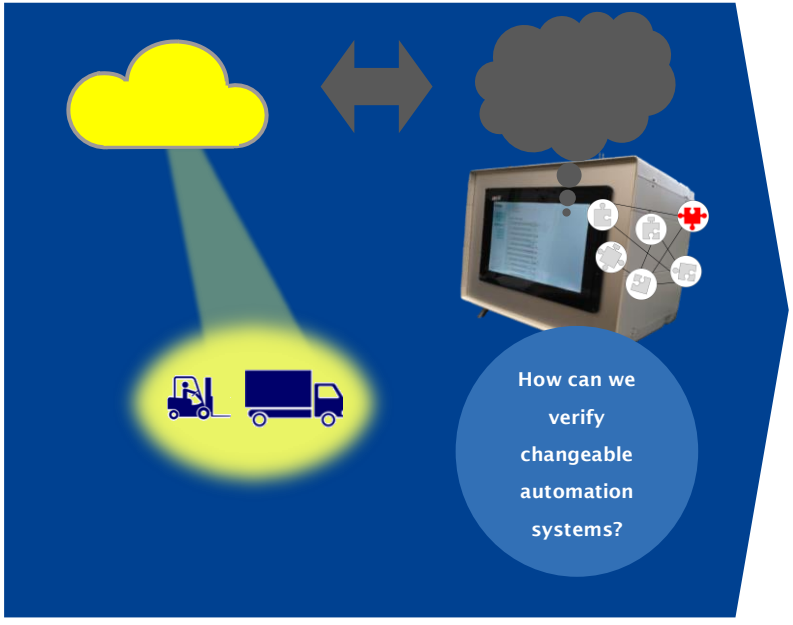
Model-based analysis of control software for efficient verification of changeable automation systems

Requirements:

- Effects of software function changes in the operation phase must be verified by tests before commissioning

Core technologies:

- Modeling methods to support operators in securing software changes



Approach

- Interdependency modelling
- Automated Model Checking
- Functional verification

AI for intelligent testing of autonomous systems

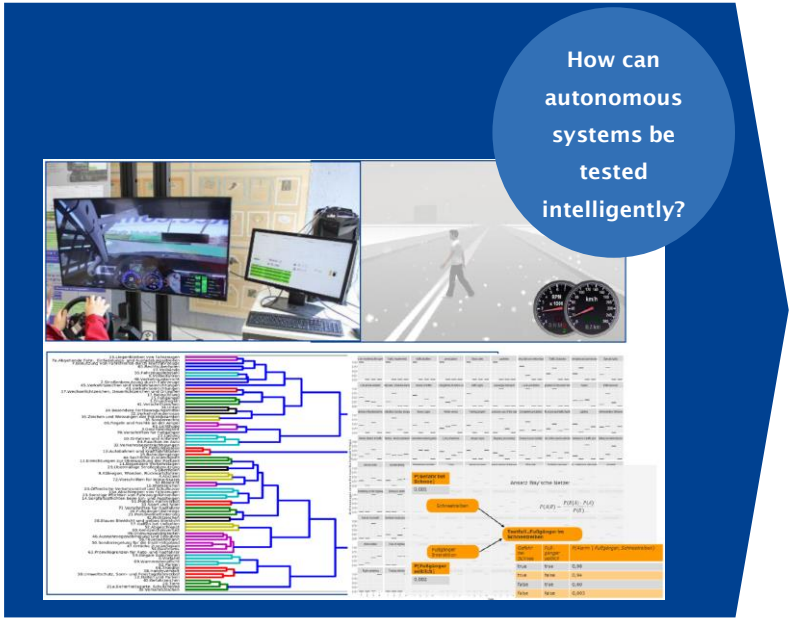
Validation and verification of autonomous systems and their components

Requirements:

- Manufacturers announce concepts for autonomous systems, but tools for verification and validation are needed

Core technologies:

- Computational Intelligence
- Probabilistic methods (e.g. Bayesian networks)



Approach

- Test cases are grouped with AI
- Deep Rule learning for transparent rules
- Prioritization of test cases

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Thank you!

Prof. Dr.-Ing. Dr. h. c. Michael Weyrich

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