Temporary subject description
Master Mechatronic and Cyber-Physical Systems

Modules semester 1

Module MCS-1 – Cyber-Physical Systems

MCS1101 – Structures and Functions of Cyber-Physical Systems (4 SWS, 4 CP)

This module illustrates essential structures and functions of cyber-physical systems (short: CPS) and establishes the link to mechatronic systems.

- definition and structure of embedded systems
- correlation/differentiation CPS – IoT
- ubiquitous and pervasive computing
- cyber-physical concept map
- CPS in automatization and production
- basic technologies of networked systems
  - sensor technology, actuator technology
  - smart systems and their linkage
  - close range communication systems RFID and PLC
  - internet communication systems IPv4 and IPv6
  - OPC-UA Unified Architecture
  - simulation software for production planning and control

MCS1102 – Business Models for CPS (2 SWS, 2 CP)

"A business model defines how optimal and profitable a product reaches the customer through the whole value chain". (Henning Kagermann)

Following this definition and influenced through CPS, basic business models are reflected and their effect on the customers will be examined.

Business models which are directly related to the application of cyber-physical systems will be presented and discussed. Examples are the following:

- new supplier/costumer relationships using WEB2.0
- individualization of products
- system networking to support maintenance, service, etc. of technical systems
- automation approaches regarding production control
Module MCS-2 – Cooperative and autonomous systems

MCS1103 – Advanced Robotics (4 SWS, 4 CP)

In the course of the lecture "Advanced Robotics", solid knowledge regarding significant topics of autonomous robot systems will be acquired. Paramount are assistance-, service- and mobile robots. Within this context, guidelines and standards will be presented – in particular safety aspects of collaborative robots. Further elements of this lecture encompass robot system architectures, localization and mapping as well as navigation and path planning.

MCS1104 – Autonomous Systems (4 SWS, 4 CP)

The lecture "Autonomous Systems" deepens the understanding of mobile and collaborative robotics.

Thereby, 3D obstacle/object recognition and real-time image processing play key roles. Cognitive systems, machine learning and artificial intelligence are also covered in the lecture.

MCS1105 – Case Study Cooperative and Autonomous Systems (4 SWS, 6 CP)

By means of a selected application example, students are expected to develop and work on a topic by literature research and – where appropriate – elaborate on smaller independent sub-tasks. Within the introductory part of the lecture, the overall topic will be explained and the sub-tasks defined.

Example autonomous driving:

- characteristics of the necessary networked systems
- aspects of functional safety for autonomous vehicles
- sensor and actuator technology of the vehicle control system
- autonomous driving and mobility concepts
- (legal/operational framework)
- ...

Case studies are so-called "Prüfungsstudienarbeiten" (student research projects). Therefore, there will be no classic exam at the end of the semester.

Module MCS-3 – Advanced Simulation Systems

MCS1106 – Advanced Modelling and Simulation (4 SWS, 4 SP)
Basic knowledge of modelling and simulation will be broadened by these and possibly further topics:

- approaches in theoretical modelling of extensive mechanical/electrical/thermal/ ... systems, for example, energy approach by Lagrange, further approaches of network analysis, finite elements, ...
- techniques for experimental system analysis/modelling: parameter identification, parameter estimation
- presentation and discussion of different procedures of the numeric simulation
- Comparison of causal and non-causal simulation systems

MCS1107 – Case Study Mechatronic System Simulation (4 SWS, 6 CP)

By means of a selected application example, students need to work independently on a connected modelling and simulation task or on a specific sub-topic in the field of modelling/simulation. Contributions by experts from the industry can deepen the understanding of specific topics.

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Modules semester 2

Module MCS-4 Human Machine Interfaces

MCS2101 – Virtual Reality / Augmented Reality (4 SWS, 4 CP)

The lecture "Virtual Reality/Augmented Reality" is to equip the students with basic knowledge about the essential topics of the digital enhancement options – the “extended reality” – from technical reasonable solutions in the field of the system engineering development. Paramount are software applications to realize the HMI (Human Machine Interface) with different sensual perceptions and the technical concept to implement the corresponding content with the control unit, like for example a HMD – (Head Mounted Display). Within this framework, the different digital expansions and definitions will be explained. Furthermore, the conventional planning and implementation of VR/AR-projects will be discussed.

MCS2102 – Mobile and adaptive HMI (2 SWS, 2 CP)

This topic can comprise different aspects:

a) mobile and adjustable presentation of process information
   • acquisition and processing of process dates to create a process description (in contrast to sheer process control/monitoring) → sensors and other data sources
   • organization of a BDE-system
   • interfaces to mobile devices

b) environmental or contextual presentation of process data
   • methods to position determination (indoor/outdoor positioning)
   • indent systems, .g. barcodes, data matrix, RFID
   • design of the data display (active web page?)

   c) registration of user interactions through feelings/ language / …
      • methods of gesture recognition
      • basics of language recognition
      • human-machine-interaction scenarios, e.g. for collaborative robotic systems

MCS2103 – Case Study VR/AR in System Engineering (4 SWS, 6 CP)

Within a project team including different roles and work packages, the selected example is to be examined by the students. In a first review, each topic will be researched and explained. In the process, possible solutions will be pointed out.
The overall work process, according to the value chain, will be realized through research – synthesis – design – prototype and evaluation.

Thematic areas of system engineering developments of VR and AR encompass:

- manufacturing systems
- education system
- health system
- entertainment
- art

Case studies are so-called “Prüfungsstudienarbeiten” (student research projects). Therefore, there will be no classic exam at the end of the semester.

Module MCS-5 – Additive Manufacturing

MCS2104 – Technologies of Additive Manufacturing (4 SWS, 4 SP)

Additive Manufacturing in accordance with 3D-print based on a concatenation of innovative technical sub-disciplines. These are illustrated along the entire manufacturing process and discussed in an appropriately professional manner.

- acquisition and processing of 3D data
- production-ready design (selection of forms and structures, support structures, bionic approaches)
- laser technology
- materials (plastics, metals, binder, classification, characteristics)
- production process
- detailed procedure of selected additive production processes

MCS2105 – AM production processes (4 SWS, 4 CP)

Additive respectively with 3D-print manufactured products do not only replace conventional products. The special characteristics of the production process enable new and process specific product features. Thereof again specific business models or process subsequences can be revealed, which are only applicable in additive manufacturing. The following components outline these specific processes:

- Additive Manufacturing Production Process: Introduction, Classification and Definition
- Characteristics of AM Technology
- Technology Overview and Application Examples
- Economic Significance of Additive Manufacturing Technology
- Economic Calculation of the Additive Manufacturing Process
• Motivation for Additive Manufacturing beyond Economic Benefits
• Metal Additive Manufacturing Getting Started
• Design for Metal Additive Manufacturing
• Future Perspective of Additive Manufacturing

MCS2106 – Case Study Cyber-physical production systems using AM (4 SWS, 6 CP)
Topics which can be covered in the course of the case study:
  • development supporting use
  • decentralised spare part production
  • food-printing
  • medical technological application
  • bioprint technology
  • reverse engineering
  • tooling

Contributions from experts from the industry can deepen the understanding of specific topics.

Case studies are so-called “Prüfungsstudienarbeiten” (student research projects). Therefore, there will be no classic exam at the end of the semester.

Module MCS-6 – FWP

MCS2107 – Auswahl aus einem Fächerkatalog („selection from a subject catalog“) (4 SWS, 4 CP)
The following options are available:

• Project: integration of optical surface analytics in a CNC machine (only SS 2019)

No programming skills are necessary to take part. The course starts at beginner level but will proceed rather rapidly. Additionally, some project work has to be done. Altogether, the whole course will be structured around a recommended course text book, which helps you to further deepen your understanding on an independent level.
• Integrated Production Systems (vhb)

Participants of this course are provided an overview of the tasks of a production manager in an international company:
  o Motivation, philosophy and objectives
  o Methods and tools
  o Experience from industrial practice
  o Overview regarding the current situation of production systems of global acting companies

Should you require any further information, please consult the website www.vhb.org

• Programming in C++ (vhb)

This course teaches the fundamentals of the programming language C/C++. The course is divided into two parts. Part 1 is suitable for beginners and participants with basic C/C++ knowledge. Part 2 primarily deals with dynamic objects and C++ special concepts and thus rather caters to advanced users. The two parts of the course can be worked upon independently from each other, or even in one semester.
For the acceptance as FWP-course, part 1 and part 2 are necessary.
Should you require any further information, please consult the website www.vhb.org
Modules semester 3

Module 7 – Functional Safety

MCS3101 – Principles of Functional Safety (4 SWS, 4 CP)
- Introduction / Motivation
- Standards, laws and directives in the EU
- Introduction Functional Safety
- Application of (Functional) Safety in the field of machine safety (examples)
- Statistics in Safety and Reliability
- Introduction of parameter and variables in statistics
- Derivation of characteristic values for units and systems
- Probability distributions in safety and reliability engineering and their relations
- Reliability datasets
- Analyzation of technical system reliability
- Software and tools in reliability and safety engineering

MCS3102 – Design of Safe Systems (2 SWS, 2 CP)
- Which design procedures have an influence on the reliability (e.g., voting/multi-channel systems/monitoring mechanisms like for example watchdogs? Do preferable design procedures for reliable systems exist?
- Application of risk minimization in the product development (use of standards like DIN EN 12100 and subsequent EN ISO 13849-1)
- tools for risk management or rather risk minimization

Module MCS-8 – Master module

MCS3103 – Master thesis (22 CP)
Elaboration of the Master thesis

MCS3104 – Master seminar (2 CP)
Master thesis seminar