TECHNISCHE HOCHSCHULE DEGGENDORF

Electives
Artificial Intelligence and Data Science
Winter Semester

Faculty Computer
Science Date: 16.09.2024

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TECHNISCHE HOCHSCHULE DEGGENDORF

Table of Contents

AIN-B-18 Key Competencies 3

Module code	AIN-B-18
Module coordination	Prof. Dr. Javier Valdes
Course number and name	AIN-B-18 Technology Ethics and Sustainability AIN-B-18 Academic Writing
Lecturer	Prof. Dr. Javier Valdes
Semester	3
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Undergraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	project work, written ex. 60 min.
Duration of Examination	60 min.
Weight	5/210
Language of Instruction	English

Module Objective

The content of the module is divided into two subjects "Technology ethics and sustainability" (subject A) and "Scientific work" (subject B).

Subject A

With the formulation of the Sustainable Development Goals (SDGs) by the United Nations in 2015, there is a comprehensive orientation framework for how humanity should develop in the future and how people's actions and behavior should be evaluated with regard to these development goals. This also applies in particular to technical developments, as it must be constantly checked whether the new technologies meet both ethical and sustainable requirements. In the course of the lectures, the need for sustainable development is linked to the digital transformation of our society and econom. Ethical aspects of technological development are also addressed, with a focus on Artificial Intelligence and associated possible risks: systemic, human, algorithmical and data bias. In addition to an introduction to ethical principles, the ACM Code of Ethics and Professional Conduct (The Code) is discussed.

Professional competences:

o Students understand the role of Artificial Intelligence in sustainable development.
o Students are familiar with the global development goals (SDGs) and are able to evaluate their own behavior and both existing technologies and potential inventions within the framework.
o Students are familiar with ethical principles and requirements in the context of technical innovations and development and can apply these in their studies and later professional activities
o Students are familiar with possible sources of bias in Artificial Intelligence applications and can identify, evaluate and respond to them in their later professional activities

Subject B
"Being able to write academically or technically is a key skill that is crucial for progressing in your studies and career. As a rule, students do not bring these academic writing skills with them from school, but acquire them parallel to their acculturation in the subject."
This quote from the brochure of the Center for University Didactics (DIZ, 2016) shows the content orientation of the module. The content is intended to prepare students for their studies and academic work at an early stage. The course covers everything from the requirements for academic work to the process flow, research methods and quality criteria for academic work.
Students learn how to find suitable scientific literature, how to manage it and how to use it for scientific work (e.g. reading, understanding, citing). In exercises, students practise scientific writing, research data management and scientific data visualization.

Professional competences

o Students are familiar with the requirements and quality criteria of academic work.
o Students develop the process flow of scientific work and the structuring of scientific work.
o Students will be able to work independently in academic work, in particular: research methods, literature reviews, and academic writing.
o Students know the rules for writing student essays and quality criteria for academic work in a student context and are able to apply them.

Applicability in this and other Programs

Applicability of this module in other degree programmes is guaranteed.

The module lays the foundations for the degree program and is linked in particular with the following advanced modules:

CY-B and KI-B: Key qualification 5
CY-B and KI-B: Bachelor module
Degree programs: BA Artificial Intelligence and BA Cyber Security

Entrance Requirements

None

Learning Content

Subject A
o Concepts and definitions of sustainability and sustainable development
o Sustainability models
o Digital transformation and ethical and sustainable aspects
o Artificial intelligence and sustainability
o Ethical foundations
o Bias in artificial intelligence
o Evaluating Artificial Intelligence Applications
o Ethical aspects for computer scientists and programmers
o ACM Code of Ethics and Professional Conduct
o The European Approach to the governance of Artificial Intelligence

Subject B
o Science and research
o Scientific work: Requirements, process and quality criteria
o Literature search, assessment and evaluation
o State of research and theory
o Scientific methods
o Academic writing
o Basics of scientific data visualization
o Preparing a scientific paper

Teaching Methods

Seminar-based teaching with group and team work
Project work
Blended learning

Remarks

For Key Competencies 3, students can choose either courses offered by the faculty or German.

Recommended Literature

Standars and Norms:

VCIO based description of systems for AI trustworthiness characterisation. VDE SPEC 90012. (2023).

Artificial Intelligence Risk Management Framework. AI RMF 1.0. (2023).

Research Articles:

Blondeel, Mathieu, et al. "The geopolitics of energy system transformation: A review." *Geography Compass* 15.7 (2021): e12580.

Cowls, Josh, et al. "The AI gambit: leveraging artificial intelligence to combat climate changeopportunities, challenges, and recommendations." *Ai & Society* (2021): 1-25.

Grober, Ulrich. "Deep roots-a conceptual history of'sustainable development'(Nachhaltigkeit)." Wissenschaftszentrum Berlin für Sozialforschung (WZB). (2007)

Siau, Keng, and Weiyu Wang. "Artificial intelligence (AI) ethics: ethics of AI and ethical AI." *Journal of Database Management (JDM)* 31.2 (2020): 74-87.

Zajko, Mike. "Conservative AI and social inequality: conceptualizing alternatives to bias through social theory." *Ai & Society* (2021): 1047-1056.

Additionally, online resources in the form of podcast, videos, blogs and specialized websites for academic writing will be provide during the course

MMC-02 Advanced Robotics

Module code	MMC-02
Module coordination	Prof. Dr. Stefan Scherbarth
Course number and name	MMC1002 Advanced Robotics
Lecturer	Prof. Dr. Stefan Scherbarth
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

The contents of the module **Autonomous Systems** enable the students to apply advanced knowledge in robotics based on the basics of robotics. Networking with autonomous systems supports the application-oriented teaching of the methodology and professional competence of robotics.

After completing the Cooperative and Autonomous Systems module, students will be able to

- Develop application-oriented solutions from the acquired methods for autonomous systems with regard to localization, navigation, route planning, obstacle recognition and tracking.
- Analyze and apply robotic methods in a targeted manner

- Using the generated methods in simulation models

Within the module **Autonomous Systems** the following competences are to be taught:

Professional competence:

Professional competencies are acquired in the sub-module Cooperative and autonomous systems:

- Understanding and applying methods of autonomous systems
- Modelling of environmental conditions and vehicle relations
- Apply the methods for the localization of vehicles in space
- Application of methods for obstacle recognition and route planning
- Analysis of control loops for autonomous systems
- Understanding and Applying Denavit-Hartenberg Relationships
- Understanding and applying forward and inverse kinematics
- Application of robot simulations and programming of robots
- Understand and apply the functions for joint collaboration between robots and humans.
- Understanding and applying methods of machine learning, in particular artificial intelligence
- Understanding different approaches to building assembly lines

Methodological competence:

Methodological competencies are acquired in the submodule Cooperative and Autonomous Systems:

- Application of robot programming
- Verification (evaluation) of robot movements
- Application of localization, navigation, route planning, and obstacle detection of autonomous systems
- Application of calculated robot relations in suitable simulation systems

Personal competence:

- Solution of complex robotics topics and their application as autonomous systems

Social competence:

- The students are able to look at autonomous systems and to deepen and use the competences acquired in the module in a prepared way.

Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of autonomous system to provide irrespectively of the mobility platform for different application scenarios. Interfaces to mechatronics, control engineering, electrical engineering and computer science result.

Entrance Requirements

Bachelor's degree in mechatronics, mechanical engineering, electrical engineering, industrial engineering, technical physics or computer science

Learning Content

Within the framework of the lecture " **Advanced Robotics** " knowledge about essential topics of autonomous robot systems will be imparted. The focus is on assistance, service and mobile robots. In this context, guidelines for collaborative robots and mobile robots will be discussed. In addition, robot system architectures and path planning are the topics of the lecture.

The subject " **Autonomous Systems** " deals with in-depth contents of mobile and collaborative robotics. 3D obstacle / object recognition, localization and map generation, as well as navigation and route planning play a decisive role. Cognitive systems, machine learning and artificial intelligence are also addressed.

Teaching Methods

Advanced Robotics and Autonomous Systems

Seminaristic teaching with joint exercises to deepen the theory learned through application

Remarks

The theoretical knowledge acquired by the students can be independently analysed and applied in the topics of the corresponding case study in the MCS-3 module. This intensifies the transfer of knowledge into practice and the targeted deepening of the acquired technical and methodological competencies by recognizing contexts and evaluating them.

Recommended Literature

- Siciliano B., Khatib O.: Handbook of Robotics. Springer.
- Corke P.: Robotics, Vision and Control. Springer.
- Craig J. J.: Introduction to Robotics. Pearson Education.
- Spong M. W.: Robot Modeling and Control. Wiley.
- Siegert H. J., Bocionek S.: Robotik: Programmierung intelligenter Roboter. Springer.
- Brillowski Klaus: Einführung in die Robotik - Auslegung und Steuerung serieller Roboter. Shaker-Verlag.

MMC-03 Autonomous Systems

Module code	MMC-03
Module coordination	Prof. Dr. Igor Doric
Course number and name	MMC 1003 Autonomous systems
Lecturer	Prof. Dr. Igor Doric
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

The contents of the module **Autonomous Systems** enable students to apply advanced knowledge in robotics focusing on the basics of robotics. Networking with autonomous systems supports the application-oriented teaching of the methodology and professional competence of robotics.

After completing the Autonomous Systems module, students will be able to

- Develop application-oriented solutions from the acquired methods for autonomous systems with regard to localization, navigation, route planning, obstacle recognition and tracking;
- Analyze and apply robotic methods in a targeted manner;
- Using the generated methods in simulation models.

Within the module **Autonomous Systems** , the following competences are to be taught:

Professional competence:

- Understanding and applying methods of autonomous systems
- Modelling of environmental conditions and vehicle relations
- Applying the methods for the localization of vehicles in space
- Application of methods for obstacle recognition and route planning
- Analysis of control loops for autonomous systems
- Understanding and applying Denavit-Hartenberg Relationships
- Understanding and applying forward and inverse kinematics
- Application of robot simulations and programming of robots
- Understanding and applying the functions for joint collaboration between robots and humans
- Understanding and applying methods of machine learning, in particular artificial intelligence
- Understanding different approaches to building assembly lines

Methodological competence:

- Application of robot programming
- Verification (evaluation) of robot movements
- Application of localization, navigation, route planning, and obstacle detection of autonomous systems
- Application of calculated robot relations in suitable simulation systems

Personal competence:

- Solution of complex robotics topics and their application as autonomous systems

Social competence:

- Students are able to look at autonomous systems and to deepen and use the competences acquired in the module in a prepared way.

Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of autonomous system to provide irrespectively of the mobility platform for different application scenarios. Interfaces to mechatronics, control engineering, electrical engineering and computer science result.

Entrance Requirements

Bachelor's degree in mechatronics, mechanical engineering, electrical engineering, industrial engineering, technical physics or computer science

Learning Content

Within the framework of the module **Autonomous Systems** , students deal with indepth contents of mobile and collaborative robotics. 3D obstacle / object recognition, localization and map generation, as well as navigation and route planning play a decisive role. Cognitive systems, machine learning and artificial intelligence are also addressed.

Teaching Methods

Seminaristic teaching with joint exercises to deepen the theory learned through application

Recommended Literature

- Siciliano B., Khatib O.: Handbook of Robotics. Springer.
- Corke P.: Robotics, Vision and Control. Springer.
- Craig J. J.: Introduction to Robotics. Pearson Education.
- Spong M. W.: Robot Modeling and Control. Wiley.
- Siegert H. J., Bocionek S.: Robotik: Programmierung intelligenter Roboter. Springer.
- Brillowski Klaus: Einführung in die Robotik - Auslegung und Steuerung serieller Roboter. Shaker-Verlag.

MMC-04 Case Study Cooperative and autonomous systems

Module code	MMC-04
Module coordination	Prof. Dr. Igor Doric
Course number and name	MMC 1004 Case Study Cooperative and autonomous systems
Lecturer	Prof. Dr. Igor Doric
Semester	1
Duration of the module	1 semester
Module frequency	
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Portfolio
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

The module "Case Study Cooperative and autonomous Systems" enables students to apply the knowledge acquired in module MCS-2 in the field of cooperative and autonomous systems, to deepen it independently and to work on and analyse subject-relevant application examples in a team.

Professional competence:

- Understanding and applying methods of autonomous systems
- Modelling of environmental conditions and vehicle relations
- Apply the methods for the localization of vehicles in space

- Application of methods for obstacle recognition and route planning
- Analysis of control loops for autonomous systems
- Understanding and Applying Denavit-Hartenberg Relationships
- Understanding and applying forward and inverse kinematics
- Application of robot simulations and programming of robots
- Understand and apply the functions for joint collaboration between robots and humans.
- Understanding and applying methods of machine learning, in particular artificial intelligence
- Understanding different approaches to building assembly lines

Methodological competence:

- Application of robot programming
- Verification (evaluation) of robot movements
- Application of localization, navigation, route planning, and obstacle detection of autonomous systems
- Application of calculated robot relations in suitable simulation systems

Personal competence:

The Case Study Cooperative and Autonomous Systems teaches students how to solve complex robotic problems and how to use them as autonomous systems in groups with distributed tasks. The students learn how to analyze, apply and evaluate a task in relation to autonomous systems.

Social competence:

The students are able to view autonomous systems on the basis of case studies and to deepen and use their competences acquired from the module in group work.

Applicability in this and other Programs

Interfaces to mechatronics, control engineering, electrical engineering and computer science result.

Entrance Requirements

Bachelor's degree in mechatronics, mechanical engineering, electrical engineering, industrial engineering, technical physics or computer science

Learning Content

On the basis of a selected application example, the students are supposed to carry out independ literature research, if necessary independent small subtasks,etc. and work on the topic themselves by means of literature research.

Sample Autonomous Systems

- Characteristics of the required control loops of networked systems
- Sensors / actuators for vehicle control
- Localization and Mapping
- Route planning, tracking and obstacle detection
- ...

The case studies are examined as so-called examination papers, i.e. no classical examination.

Teaching Methods

Guided processing of seminar topics in study groups. Accompanying events / presentations depending on the selected topic area.

Remarks

The students learn to analyze and apply theoretical knowledge about the topics of the case study independently. This intensifies the transfer of knowledge into practice and the targeted deepening of the acquired technical and methodological competencies by recognizing contexts and evaluating them.

Recommended Literature

- Siciliano B., Khatib O.: Handbook of Robotics. Springer.
- Corke P.: Robotics, Vision and Control. Springer.
- Craig J. J.: Introduction to Robotics. Pearson Education.
- Spong M. W.: Robot Modeling and Control. Wiley.
- Siegert H. J., Bocionek S.: Robotik: Programmierung intelligenter Roboter. Springer.
- Brillowski Klaus: Einführung in die Robotik - Auslegung und Steuerung serieller Roboter. Shaker-Verlag.

MMC-01 Cyber Physical Systems

Module code	MMC-01
Module coordination	Prof. Dr. Jochen Hiller
Course number and name	MMC 1001 Cyber Physical Systems
Lecturer	Prof. Dr. Jochen Hiller
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	6
ECTS	5
Workload	Time of attendance: 90 hours self-study: 60 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

Structures and Functions of Cyber-Physical Systems

New business models of cyber-physical systems

Intelligent, self-regulating, sensor-supported and networked production systems will make "intelligent factories" possible in the near future. At the other end of the spectrum, the industrial Internet of Things (IIOT) has become relevant in the social sphere.

The main objective of the module is the basic understanding, analysis and recognition of the different functionalities of the system components within a cyberphysical system structure.

The development of IT technology has influenced the global business landscape. Customers change from traditional roles, in relation to the company and in interactions with each other in connection with the social networks. Supply chains are being reinvented, setting new standards in terms of time and space. Risk, opportunity, innovation and capital must all be redefined. Simultaneous management within an organisation and coexistence with external ecosystem partners requires new instruments and new attitudes. Business models are being reinvented in a fascinating way. Strategic agility has, to some extent, been forced upon us by the economic situation.

Upon completion of this module, the student has achieved the following learning objectives:

Professional competence:

- Embedded systems and applications;
- Wireless technologies in industry and household;
- Intelligent systems for sensor and actuator applications;
- Concept of IT-controlled business models;
- Factors that determine customer value;
- Barriers and enabling factors for modern business models;

Methodological competence:

- Understanding, analyzing and synthesizing information about Internet technologies of embedded computer systems;
- Communication with suppliers of intelligent system components, such as intelligent sensors and actuators;
- Discussion of important cyber-technical issues, such as the robustness and feasibility of communication interfaces.
- Understanding of different business concepts of cyber-physical systems;
- Identification and analysis of the different forms of technical business solutions;
- Synthesis of customer values;

Personal competence:

- Create simple descriptions of the structure and functions of cyber-phyiscal systems.
- Acquisition and transfer of system terminology
- Construction of simple business models of a cyber-physical system.
- Capturing and communicating customer needs

Social competence:

- Work in small groups to discuss and present the overview.
- Presentation and discussion of realized business models for different business concepts.

Applicability in this and other Programs

Structures and Functions of Cyber Physical Systems:
The module provides a basis for embedded system and IT-related modules in all study programs of the Faculty of Applied Natural Sciences and Industrial Engineering;.
New Business Models for Cyber Physical Systems:
Can be used in any other study program in the field of New Economics.

Entrance Requirements

Bachelor's degree in mechatronics, mechanical engineering, electrical engineering or bachelor's degree in industrial engineering, technical physics or computer engineering.

Learning Content

Structures and Functions of Cyber-Physical Systems:

- Design of Embedded Computer Systems
- CPS Applications
- Internet of Things
- Ubiquitous Computing
- Industry 4.0 - Digital Manufacturing
- Sensors and Actuators
- RFID
- IPv4 and IPv6
- International Standard OPC-UA
- Safety

New Business Models of Cyber-Physical Systems:

- Customer Value from the Customer Process
- More Customers and More for the Customer
- Innovation and Personalization
- Silent Commerce
- Examples of New Business Models
- Analyzing
- Economics Calculations

Teaching Methods

Lectures / tutorials / home work / group activities

Whiteboard, visualizer online learning portal (iLearn)

Recommended Literature

Structures and Functions of Cyber-Physical Systems:

- Dietmar P. F. Möller: Guide to Computing Fundamentals in Cyber-Physical Systems; Concepts, Design Methods, and Applications; Springer-Verlag;
- Eva Geisberger/Manfred Broy: Living in a networked world; acatech STUDY 2015;
- Acatech: Cyber-Physical Systems; acatech POSITION PAPER 2011

New Business Models of Cyber-Physical Systems:

- Henning Kagermann: IT Driven Business Models; Global Case Studies in Transformation; Wiley 2011
- Gassmann, Frankenberger: The St. Gallen Business Model Navigator; University of St. Gallen

MET-09 SELECTED TOPICS IN MIRCRO- AND NANOELECTRONICS

Module code	MET-09
Module coordination	Prof. Dr. Günther Benstetter
	Elektronische und nachrichtentechnische Systeme (ENS)
Course number and name	MET 2102 Selected Topics in Micro- and Nanoelectronics
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

The modul Selected Topics in Micro- and Nanoelectronics pushes students to deal with current issues of micro and nanolectronics. They learn the necessary steps to understand the technology and functionality of selected micro- and nanoelectronic systems and to design and assess test and characterization methods for highly integrated systems.

The students achieve the following learning objectives:

Professional Skills

Knowledge:

General understanding of functioning and technology of selected micro- and nanoelectronic devices and systems

Sound knowledge of selected physical analytical methods to characterize micro and nanostructures

Understanding of reliability testing fundamentals

Skills:

Ability to implement and assess physical and electrical analysis techniques to characterize micro- and nanoelectronic devices

Ability to independently implement and assess reliability investigations on integrated circuits

Competences:

Competence to classify semiconductor technologies and to identify individual process steps of complex systems

Competence to assess quality and reliability of highly integrated devices and systems

Methodological Skills

Based on their learned professional skills in the field of micro-and nanoelectronics characterization, the students are able to transfer their approaches to systematically analyse and evaluate complex systems.

Soft Skills

The students are able analyse complex technologies in both ways either individually or as member of international teams.

Applicability in this and other Programs

For this degree program:

Compulsory subject within Master-Program Electrical Engineering and Information Technology, focus Electronic and Telecommunication Systems (ENS)

For other degree program:

Master of Applied Computer Science

Elective for Master Applied Research in Engineering Sciences

Entrance Requirements

Formally none

Recommended: physics, materials sciences and electronic devices

In terms of content: basic knowledge of electronic components and integrated circuits

Learning Content

Micro- and nanochip manufacturing and technology

Analysis of highly integrated devices

Quality assurance of micro- and nanoelectronic systems

Trends in nanoelectronics and new technologies

Teaching Methods

Lecture and practical trainings in teams

Blackboard, PC presentations & simulations, visualizer/ beamer

Remarks

Independent work with analytical tools such as scanning electron microscope, scanning probe microscope or wafer probe station

Recommended Literature

M. Lanza: Conductive Atomic Force Microscopy: Applications in Nanomaterials. John Wiley & Sons 2017.

R. Waser: Nanoelectronics and information technology. John Wiley & Sons 2012.

S. Wolf: Microchip manufacturing. Lattice press, Sunset Beach, California 2004.

B. Streetman: Solid State Electronic Devices, 7th edition. Prentice Hall 2014.

S. Sze: Semiconductor Devices, 3rd edition. John Wiley & Sons 2006.

MET-16 AUTOMOTIVE AND INDUSTRIAL DRIVE SYSTEMS

Module code	MET-16
Module coordination	Prof. Dr. Nikolaus Müller
	Automatisierungstechnik (AT)
Course number and name	MET 2108 Automotive and Industrial Drive Systems
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

The module Automotive and Industrial Drive Systems introduces diverse electrical drive systems, teaches the typical methods of control and shows the special requirements in an automotive or industrial environment, respectively. The subject offers an overview over electrical drive systems for industrial applications and in vehicles and introduces further sustainable drive concepts.

The students achieve the following learning objectives:

Professional Skills

Special subject Automobile Electrical Drive Systems

Students can list components of an electrical power train

They know how to calculate the pulse patterns of a space-vector modulation

They can describe the electrochemical processes in batteries and can explain their behavior

They can oppose advantages and disadvantages of an electrical power train to a conventional combustion engine driven car

They can name hybrid vehicle concepts and alternative combustion engines

They can analyze alternative fuels for their applicability in cars

They can assess different power train concepts for their application

Special subject Industrial Electrical Drive Systems

Students understand the structure of a multi-axle motion control system

They master the mathematical methods of a field-oriented description of three-phase electrical machines

They can describe the dynamic behavior of three-phase synchronous and asynchronous machines

They can name different design approaches for speed control systems of electrical drives

They can design speed control systems for electrical drives

Soft Skills

Students work out contents within groups

Applicability in this and other Programs

For this degree program:

Compulsory subject within Master-Program Electrical Engineering and Information Technology, focus automation engineering (AT)

For other degree program:

Elective for Master Applied Research in Engineering Sciences

Entrance Requirements

Formally: none

Learning Content

Special subject Automobile Electrical Drive Systems

1. Electrical Power Train

   1.1. Motors

1.2. Inverter Control with Space Vector Modulation

1.3. Batteries

1.4. Charging Concepts

2. Fual-assisted Electric Cars

2.1. Fuel-Cells

2.2. Hybrid Vehicles

3. Sustainable Combustion Engine Concepts

3.1. Alternative Fuels

3.2. Alternative Combustion Engines

Special subject Industrial Electrical Drive Systems

1. Industiral drives

1.1. General properties

1.2. Energy efficiency classes

1.3. Motion control

1.4. Charging Concepts

2. Dynamic models of electric machines

2.1. Modelling of the dynamic behaviour of electric machines

2.2. Clark / Park transformation

2.3. Dynamic model synchronous machine

2.4. Dynamic model asynchronous machine

3. Closed loop control of electric devices

3.1. General control system design

3.2. Speed control for DC machines

3.3. Control system design for 3~ machines

3.4. Direct torque control

Teaching Methods

Semenaristic lessons, group work

Recommended Literature

R. Jurgen: Electric and Hybrid-Electric Vehicles. SAE international 2011.

J. Beretta: Automotive Electricity. Wiley 2010.

M. Ehsani / Y. Gao / S. Longo/ K. Ebrahimi: Modern Electric, Hybrid Electric and Fuel Cell Vehicle, 3. edition. CRC-Press 2019.

A. Emadi: Advanced Electric Drive Vehicles. CRC-Press 2015.

J. Erjavec: Hybrid Electric & Fuel Cell Vehicles, 2. edition. Delmar 2013.

I. Husain: Electric and Hybrid Vehicles, 2. edition. CRC-Press 2011.

A. Khajepour / S. Fallah / A. Goodarzi: Electric and Hybrid Vehicles. Wiley 2014.

B. Bose: Modern Power Electronics and AC Drives. Prentice Hall 2002.

G. Henneberger: Electrical Machines I. Lecture notes. Technical University Aachen 2002.

R. Dorf / R. Bishop: Modern Control Systems, 13. edition. Pearson Prentice Hall 2017.

Different journals

Application notes

AIX-B-4 Quantum Computing

Module code	AIX-B-4
Module coordination	Prof. Dr. Patrick Glauner
Course number and name	FWP-4 Quantum Computing
Original study program	X-Katalog FWP AI
Lecturers	Prof. Dr. Patrick Glauner Prof. Dr. Horst Kunhardt
Duration of the module	1 semester
Module frequency	annually, winter semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Examination form of the chosen module (specialized exam for M-AID students)
Language of Instruction	English

Module Objective
This class provides students with an introduction to Quantum Computing (QC), which looks promising to solve certain computational problems substantially faster than classical computers. QC began in the early 1980s and in recent years, investment into QC research has increased in both the public and private sectors. Students will acquire knowledge in QC and its applications in various domains such as machine learning and cryptography. They will also be able to elaborate it further in the future, for example in projects or further studies. Overall, QC is a cutting-edge field, with many high-pay opportunities for graduates.

Applicability in this and other Programs
Miscellaneous

Entrance Requirements
- Programming
- Algorithms and data structures
- Mathematics, in particular linear algebra

Learning Content
- Introduction: history, comparison to traditional computing, applications, business potentials
- Foundations: complex numbers, complex vector spaces

- Systems: deterministic systems, probabilistic systems, quantum systems, assembling systems

- Quantum theory: states, superposition, observables, measuring, dynamics, assembling quantum systems, entanglement
- Architecture: bits and qubits, classical gates, reversible gates, quantum gates, no-cloning theorem
- Selected algorithms: Deutsch's, Deutsch-Jozsa, Simon's, Grover's, Shor?s
- Theoretical computer science: limits of quantum computing, complexityclasses
- Quantum computers and programming: goals and challenges, decoherence, physical realizations, quantum annealing, adiabatic quantum computing
- Applications: quantum machine learning, quantum cryptography, quantum information theory

Teaching Methods

- Lectures
- Seminars
- Discussion of research papers and recent news
- Coursework and case studies, including laboratory problems

Recommended Literature

- P. Glauner and P. Plugmann (Eds.), "Innovative Technologies for Market Leadership: Investing in the Future", Springer, 2020.
- N. S. Yanofsky and M. A. Mannucci, "Quantum Computing for Computer Scientists", Cambridge University Press, 2008.

HPC-M-06 Optimization Methods

Module code	HPC-M-06
Module coordination	Prof. Dr. Peter Faber
Course number and name	HPC-M-06 Optimization Methods
Original study program	Master High Performance Computing / Quantum Computing
Lecturers	Prof. Dr. Peter Faber
Duration of the module	1 semester
Module frequency	annually, winter semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Written student research project
Language of Instruction	English

Module Objective

The students gain an understanding of the construction of modern optimizing compilers and their run-time systems. They understand how certain optimization techniques work, why specific programming patterns may improve performance and others may prohibit optimizations. They are able to apply their knowledge and use appropriate techniques at the appropriate place. Ideally, the students can work on an optimization pass for themselves.

Applicability in this and other Programs

Software design and programming lectures

Entrance Requirements

None

Learning Content

Optimization methods for modern computer architectures are discussed. In particular, theoretical and practical aspects of parallel programming systems for modern high-performance computing systems are highlighted. This includes insights into the inner workings of optimizing compilers and their run-time systems. Optimization methods employed by these compilers are presented and discussed, as well as performance analysis and respective tools.

Teaching Methods

- Lectures, presentations
- lab sessions

- exercises

Recommended Literature

- Klemm, Michael; Cownie, Jim; High Performance Parallel Runtimes -- Design and Implementation. De Gruyter, Oldenbourg. 2021
- Aho; Lam, Monica Sin-Ling; Sethi, Ravi; Ullman, Jeffrey David. Compilers: Principles, Techniques, and Tools (2 ed.). Boston, Massachusetts, USA. Addison-Wesley. 2006
- Further literature as specified during the course

MET-12 SIGNALS AND SYSTEMS IN COMMUNICATION TECHNOLOGY

Module code	MET-12
Module coordination	Prof. Dr. Matthias Wuschek
	Elektronische und nachrichtentechnische Systeme (ENS)
Course number and name	MET 2105 Signals and Systems in Communication Technology
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

In the module Signals and Systems in Communications Technology the students first deal with important basics of the description of signals in time and frequency domain and get to know the most important characteristics of signals. Furthermore, they become familiar with the essential laws of Fourier Transformation and their significance in signal theory. They then apply this knowledge when it comes to the transmission behavior of LTI systems in time and frequency domain. The last part of the module introduces the basics of analyzing random signals in time and frequency domain, as well as how to describe and determine the transmission behavior of LTI systems in the case of random signals.

The students achieve the following learning objectives:

Professional Skills

The students know and understand important characteristics of signals in time and frequency domain.

The students know the most important laws of Fourier Transformation.

The students know the basic signal transmission behavior of LTI systems in time and frequency domain.

The students know important characteristics of random signals in time and frequency domain (statistical parameters, density and distribution functions, auto and cross correlation function, power spectrum).

The students are familiar with the basic signal transmission behavior of LTI systems in the case of random signals.

Methodological Skills

Students can determine the most important parameters of signals. The students can determine the spectrum of important elementary signals by means of the Fourier Transformation. Students can calculate the transmission behavior of elementary LTI systems in time and frequency domain. The students are able to calculate important characteristics of random signals as well as the transmission behavior of elementary LTI systems with random signals in time and frequency domain. The students have the ability to independently research and develop existing basic knowledge.

Soft Skills

Students are able to reasonably justify and critically evaluate the basic properties of deterministic and random signals as well as of LTI systems in time and frequency domain.

Applicability in this and other Programs

For this degree program:

Compulsory subject within Master-Program Electrical Engineering and Information Technology, focus Electronic and Telecommunication Systems (ENS)

For other degree program:

Master of Applied Computer Science

Elective for Master Applied Research in Engineering Sciences

Entrance Requirements

Formally: none

In terms of content: In the Bachelor Degree Course ET taught knowledge of subject basics ET, mathematics and fundamentals of communications engineering.

Learning Content

2.19. Integration theorem (frequency domain)

2.20. Convolution theorem (time domain)

2.21. Convolution theorem (frequency domain)

3. Basic transmission characteristics of communication systems

3.1. Theoretical classification of communication systems

3.2. Signal transmission behavior of LTI systems in time domain

3.3. Signal transmission behavior of LTI systems in frequency domain

3.4. Low-pass systems

3.5. High-pass systems

3.6. Band-pass Systems

3.7. Runtime systems

4. Random signals

4.1. Introduction

4.2. Momentary value properties of random signals

4.3. Characteristics of random signals in time and frequency domain

4.4. Transmission of random signals via LTI systems

Teaching Methods

Teaching in form of seminars, exercises

Remarks

Support by the e-learning platform

Recommended Literature

J.Prokais / M. Salehi: Communication Systems Engineering, ISBN 0-3130-95007-6

S. Haykin: Communication Systems, ISBN 0-471-17869-1

A. Oppenheim: Signals and Systems, ISBN 0-13-651175-9

Z. Gajic: Linear Dynamic Systems and Signals, ISBN 0-201-61854-0

T. Chon: Statistical Signal Processing, ISBN 1-85233-385-5

MET-11 SPECIAL DEVICES AND CIRCUITS

Module code	MET-11
Module coordination	Prof. Dr. Werner Bogner
	Elektronische und nachrichtentechnische Systeme (ENS)
Course number and name	MET 2104 Special Devices and Circuits
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Master
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

In the module Special Devices and Circuits the students first deal with the special physical fundamentals of semiconductor technology by the example of special devices with negative differential resistance for high-frequency oscillators. They will also learn about the properties of modern MOS devices and their specific requirements in integrated technology design. Students will learn the necessary steps and peculiarities in IC design as well as the design of basic circuits for highly integrated analog MOS circuits.

The students achieve the following learning objectives:

Professional Skills

The students know and understand the physical fundamentals of modern semiconductor devices.

They know various semiconductor devices with negative differential resistance and can analyze their properties. Students have the ability to apply such devices as high-frequency oscillators.

The students know the structure and understand special properties of integrated MOS circuits. They are able to apply characterization procedures and evaluate the results.

Methodological Skills

The students are able to differentiate the different properties of MOS transistor models by means of simulations. They can apply various basic circuits and circuit components of integrated analog standard CMOS technology and merge them into more complex circuits and evaluate these by means of simulation. The students have the ability to independently research and develop existing basic knowledge.

Soft Skills

The students are able to substantiate and critically evaluate properties of various electronic components and analogue MOS circuits.

Applicability in this and other Programs

For this degree program:

Compulsory subject within Master-Program Electrical Engineering and Information Technology, focus Electronic and Telecommunication Systems (ENS)

For other degree program:

Master of Applied Computer Science

Elective for Master Applied Research in Engineering Sciences

Entrance Requirements

Formally: none

In terms of content: Knowledge acquired in Bachelor degree in the subjects electronic components, circuit technology 1, rf-electronics

Learning Content

1. Introduction
2. Negative Conductance Microwave Devices
    - 2.1. Esaki or tunnel diode
    - 2.2. IMPATT - diode
    - 2.3. Transferred Electron Devices
3. MOSFET
    - 3.1. The ideal MOS-structure

3.2. Basic MOSFET behavior

3.3. Second order effects

3.4. Electrical behavior of short channel MOSFET

3.5. Comparison MOSFET - BJT

4. CMOS Technology and Layout Considerations

4.1. Physical structure of MOS-transistor

4.2. Passive Components

4.3. CMOS Considerations

4.4. Layout Considerations

5. Active Device Modeling

5.1. (C)MOS Simple Large-Signal Model (LEVEL 1)

5.2. (C)MOS Small-Signal Model

5.3. Computer Simulation Models

6. Analog CMOS Subcircuits

6.1. MOS Diode / Active Resistor

6.2. Current Sinks and Sources

6.3. Current Mirrors

6.4. Current and Voltage References

6.5. VT Referenced Source or Bootstrap Reference

6.6. Bandgap Reference

7. CMOS Amplifiers

7.1. Inverters

7.2. Differential Amplifier

7.3. Design of CMOS Operational Amplifier

7.4. Output Amplifier

Teaching Methods

Seminar based teaching, simulation examples, exercises

Remarks

Support by the e-learning platform

Recommended Literature

Streetman / Banerjee: Solid State Electronic Devices, 6th edition. Prentice Hall 2006.

Muller / Kamins: Device Electronics for Integrated Circuits, John Wiley&Sons 2003.

Brennan / Brown: Theory of Modern Electronic Semiconductor Devices, John Wiley&Sons 2008.

Sze: Semiconductor Devices, 3rd edition. John Wiley & Sons 2012.

Allen / Holberg: CMOS Analog Circuit Design, 3rd edition. Oxford University Press 2011.

Comer / Comer: Fundamentals of Electronic Circuit Design, John Wiley&Sons 2003.

Razavi: Design of Analog CMOS Integrated Circuits, 2nd edition. McGraw-Hill Education 2016.

MET-17 ADVANCED AUTOMATION

Module code	MET-17
Module coordination	Prof. Dr. Werner Bogner
	Automatisierungstechnik (AT)
Course number and name	MET 2109 Advanced Automation
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

In the subject Advanced Automation students obtain an overview on how programmable logic controllers (PLCs) work, as well as basic hardware and software requirements.
They learn the standardized (IEC61131-3) and manufacturer-specific (TIA Portal) programming options. They learn how to use visualization software for the user interface.
The students acquire the basic competence to understand automated processes in the automotive industry, power plants, chemical industry, building technology and transportation. Thusthe students are able to shape the digital transformation of the industry.

The students achieve the following learning objectives:

Professional Skills

The students are familiar with the concepts and components of a modern automation system including the structure and functionality of industrial communication systems, also with regard to safety and security.
They are able to analyze, classify and solve simple tasks in automation technology.
The students know the requirements of hardware and software for a Programmable

Logic Controller (PLC). They know the structure and the way a PLC operates. They are able create PLC programs. By using visualization software they can demonstrate the processes.

Methodological Skills

The application-oriented knowledge allows the students to compare advantages and disadvantages of the individual industrial bus systems, to examine in contrast the advantages and disadvantages of the individual programming languages to find optimal solutions.

Soft Skills

The students work on problems in a focused and independent way.
They can communicate their solutions both verbally and in writing in appropriate technical language.
They learn from mistakes, can assess and improve their own abilities.
They are able to work actively as a team.

Applicability in this and other Programs

For this degree program:

Compulsory subject within Master-Program Electrical Engineering and Information Technology, key focus automation (AT)

For other degree program:

Master Program: Applied Computer Science

Elective for Master Applied Research in Engineering Sciences

Entrance Requirements

Formally: none

In terms of content: Basic knowledge of automation

Learning Content

1. Function of SPS
   - 1.1. Hardware requirements
   - 1.2. Current embodiments
   - 1.3. Environmental conditions
   - 1.4. Real-time requirements
2. Programming languages

3. Presentation of automation technology with regard to industrial communication
    3.1. ISO / OSI model in industrial communication
    3.2. Automation pyramid
    3.3. Vertical communication
    3.4. Structure and functionality of common comunication systems

Teaching Methods

Seminars with practical experience

Recommended Literature

R. Laubner / P. Göhner: Prozessautomatisierung I. Springer Verlag 1999.
G. Wellenreuther / D. Zastrow: Steuerungstechnik mit SPS, Springer/Vieweg 2015.
G. Wellenreuther: Automatisieren mit SPS - Übersichten und Übungsaufgaben, Springer/
Vieweg 2015.
K. John / M. Tiegelkamp: SPS-Programmierung mit IEC, Springer Verlag 2009.
G. Schnell: Bussysteme in der Automatisierungstechnik, 4. Auflage. Vieweg Verlag 2000.
W. Kriesel / O. Madelung: AS-Interface ? Das Aktuator-Sensor-Interface für die Automation. Hanser Verlag 1999.
M. Popp: Profibus-DP/DPV1, 2. Auflage. Hüthig Verlag 2000.
M. Popp: Das PROFINET IO-Buch: Grundlagen und Tipps für Anwender, 2. Auflage. VDE
Verlag 2010.
Ausbildungsunterlagen der Fa. Siemens: www.siemens.com/global/de/home/unternehmen/nachhaltigkeit/ausbildung/sce.html

MET-10 MODERN RF AND RADIO SYSTEMS

Module code	MET-10
Module coordination	Prof. Dr. Matthias Wuschek
	Elektronische und nachrichtentechnische Systeme (ENS)
Course number and name	ET 2103 Modern RF and Radio Systems
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

In the module Modern RF and Radio Systems the students first deal with important basics of Radar technology. You will also learn the characteristics and applications of the three basic types of Radar systems (Pulse, CW, FMCW). They then apply this knowledge when it comes to the practical dimensioning of the most important parameters of Radar systems. In addition, they become acquainted with special methods for target tracking and are introduced in methods of Radar signal theory. Finally, they get to know the mode of operation as well as advantages and disadvantages of Phased Array Antennas. The last part of the module introduces the basics of ground-based air navigation systems.

The students achieve the following learning objectives:

Professional Skills

The students know and understand basic processes of Radar technology.

The students know and understand the basic principles of target tracking, Radar signal processing and Phased Array Antennas.

The students are familiar with the functionality of important ground-based radio navigation systems in aviation.

Methodological Skills

Students can select or specify the most suitable Radar systems for specific technical tasks. Students can dimension the most important parameters of Radar systems. The students have the ability to independently research and develop existing basic knowledge.

Soft Skills

Students are able to reasonably justify and critically evaluate the basic characteristics of Radar and aeronautical navigation systems.

Applicability in this and other Programs

For this degree program:

Compulsory subject within Master-Program Electrical Engineering and Information Technology, focus Electronic and Telecommunication Systems (ENS)

For other degree program:

Master of Applied Computer Science

Elective for Master Applied Research in Engineering Sciences

Entrance Requirements

Formally: none

In terms of content: In the Bachelor Degree Course ET taught knowledge of subject basics ET, mathematics and fundamentals of communications engineering.

Learning Content

1. Introduction into the course
2. Radar Technology
    - 2.1. Introduction
    - 2.2. Basics
    - 2.3. Pulse Radar
    - 2.4. CW-Radar
    - 2.5. FMCW-Radar

2.6. Pulse Doppler Radar

2.7. Tracking Radar

2.8. Radar Signal processing

2.9. Phased Array Antennas

3. Ground-based air navigation systems

3.1. Overview

3.2. Instrument landing system (ILS)

3.3. Non directional Beacon (NDB)

3.4. VHF Omnidirectional Radio Range (VOR)

3.5. Distance Measuring Equipment (DME)

Teaching Methods

Teaching in the form of seminars, exercises

Remarks

Support by the e-learning platform

Recommended Literature

W. Mansfeld: Funkortungs- und Funknavigationsanlagen, Hüthig Verlag

M. I. Skolnik: Introduction to Radar Systems, MHHE Verlag

B. Huder: Einführung in die Radartechnik, Teubner Verlag

J. Göbel: Radartechnik: Grundlagen und Anwendungen, VDE-Verlag

MAI-1 Special Mathematical Methods

Module code	MAI-1
Module coordination	Prof. Dr. Thorsten Matje
Course number and name	MAI-1 Special Mathematical Methods
Original study program	Master Applied Computer Science
Lecturers	Prof. Dr. Thorsten Matje
Duration of the module	1 semester
Module frequency	annually, winter semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Language of Instruction	English

Module Objective

The students basically deal with methods of probability calculation. They learn the necessary steps to work out independent solutions for corresponding problems in the field of engineering, whereby in particular they are enabled to critically question the selection of the corresponding methods and calculation procedures.

The students achieve the following learning objectives:

Students get to know typical models, methods and tasks from engineering practice, which can be processed with probability theory and statistics, together with corresponding solution methods and strategies. A stochastic way of thinking is anchored.

Professional Skills

The students have knowledge of algebra, analysis and probability theory. In addition, they know the concepts of discrete and continuous random variables. Students are able to work conceptually and methodically. They know the most important discrete and continuous probability distributions and have applied them in practical exercises. In particular, they know the basic assumptions and models behind the individual distributions. They are therefore able to select a suitable probability distribution on the basis of a problem description and to systematically work out the solution on the basis of this distribution. They have the knowledge to interpret data statistically. In summary, the students can apply their acquired knowledge to engineering tasks in a practice-oriented way.

Methodological Skills

Depending on the task, the students are able to identify and successfully apply appropriate calculation methods from a range of calculation methods. They are able to use scientific calculators and probability tables and, if necessary, computer algebra software. The students have the ability to carry out independent research on the basis of extensive exercises and to develop their existing knowledge independently.

Soft Skills

The students are aware of their responsibility as future engineers. They are in a position to discursively question problems among themselves, to justify the solutions argumentatively and to critically evaluate the results of their calculations.

Applicability in this and other Programs

Compulsory subject in Electrical Engineering and Information Technology (Master)
For any other degree programs:
Elective for Master Applied Research in Engineering Sciences
Elective for Master Artificial Intelligence and Data Science

Entrance Requirements

Formally: None

Learning Content

1. Set Theory and Probability
    1.1. Set Operations and Venn Diagrams
    1.2. Applying Set Theory to Probability
    1.3. Relative Frequency, 4-Field-Tableau
    1.4. Probability Axioms
    1.5. Conditional Probability, Law of Total Probability, Bayes Theorem
    1.6. Independent Events
    1.7. Sequential Experiments and Tree Diagrams
    1.8. Counting Methods (Combinatorics)
    1.9. Reliability Problems
2. Discrete Random Variables
    2.1. Discrete Random Variable
    2.2. Probability Mass Funktion (PMF)
    2.3. Cumulative Distribution Function (CDF)
    2.4. Averages
    2.5. Functions of a Discrete Random Variable
    2.6. Derived Random Variables
    2.7. Variance and Standard Deviation
    2.8. Important Discrete Probability Mass Functions
3. Continuous Random Variables
    3.1. Motivation and Overview
    3.2. Probability Density Function (PDF)
    3.3. Expected Value and Variance in the Continuous Case
    3.4. Functions of a Continuous Random Variable
    3.5. Special Continuous Probability Distributions

Teaching Methods

Lectures and seminaristic lessons in alternation, solving problems during the lecture and independent extended training of the computing competence on the basis of weekly exercise sheets, detailed solutions to the exercise sheets are each given with a time delay of one week and are to be compared with the own solutions, if questions arise these are clarified in the lecture.

Remarks

The active participation of the students during the lecture and in the processing of the exercise sheets is particularly important through a discursive style. Challenge and encourage is the motto, so that they are catapulted from an initial passive attitude into a mode of activity.

Recommended Literature

- H. Schwarzlander: Probability – Concepts and Theory for Engineers. Wiley 2011.
- J. A. Gubner: Probability and Random Processes for Electrical and Computer Engineers. Cambridge University Press 2006.
- W. W. Hines / D. C. Montgomery / D. M. Goldsman, C. M. Borror: Probability and Statistics in Engineering, 4th ed. Wiley 2003.
- A. Papoulis / S. U. Pillai: Probability, Random Variables, and Stochastic Processes, 4th ed. McGraw-Hill 2002.
- R. D. Yates / D. J. Goodman: Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers. Wiley 1998.

LSI-A1 Biomedical Data Analysis

Module code	LSI-A1
Module coordination	Prof. Dr. Melanie Kappelmann-Fenzl
Course number and name	LSI-A1 Biomedical Data Analysis
Original study program	Master Life Science Informatics
Lecturers	Prof. Dr. Philipp Torkler
Duration of the module	1 semester
Module frequency	Annually, winter semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours Virtual learning: 45 hours Total: 150 hours
Type of Examination	Written student research project
Duration of Examination	90 min.
Language of Instruction	English

Module Objective

This interdisciplinary module combines knowledge from the fields of informatics, statistics and molecular biology.
The *Biomedical Data Analysis* module shows the students the practical application of computer-aided biomedical data analysis and enables them to carry it out independently. This module is an interdisciplinary tutorial in which the students perform the NGS data analysis workflow by themselves under professional instruction.
After completing the Biomedical Data Analysis module, students will have obtained the following learning competencies:

Professional competence

After successfully completing the module, students will:

- have learned how to manage NGS data.
- be familiar with file formats and their usage in the different analysis approaches.
- know about common data analysis workflows and be able to interpret and
- visualize the achieved results.

Methodological competence

After successfully completing the module, students will:

- be able to perform quality control on sequencing data.
- be able to perform mapping procedures and understand the differences between various mapping algorithms.
- be able to create genome indices and know the relevance of a reference genome.
- be able to perform NGS data analysis in terms of RNA-Seq data.

Social competence

- Interdisciplinary and interpersonal collaboration when working together in small groups on performing biomedical data analysis.
- Working together with fellow-students in small groups on designing and developing NGS data analysis workflows.
- Team building by interactive working groups.

Applicability in this and other Programs

Master seminar, master thesis

Entrance Requirements

Advantageous: Module LSI-01: Introduction to Informatics and Biomedicine,
Basic knowledge in R, Basic knowledge in Statistics

Learning Content

1 NGS Data- File Formats
2 NGS-Open Sources
3 Reference Genome
4 Mapping
5 Data Analysis- Genomics
    5.1 Variant Calling
6 Data Analysis- Epigenetics
    6.1 ChIP-Seq
    6.2 Methyl-Seq
7 A practical approach: Data Analysis- Transcriptomics
    7.1 Count Table Generation
    7.2 Differential Expression Analysis
    7.3 Differential Exon Usage

Teaching Methods

Tutorial, practical exercises, application examples
The module consists of an interactive theoretical part with blended learning components. Within the tutorial the students use example NGS datasets to perform the biomedical data analysis workflow. In the practical part of the tutorial the students should learn to find solutions to problems independently by discussions and research work.

Remarks

The iLearn teaching and learning platform provides students with additional literature references and learning material to prepare for the lectures.

Recommended Literature

Detailed lecture notes are available online for preparation and follow-up work
- The Biostars Handbook: Bioinformatics Data Analysis Guide; 2019; https://www.biostarhandbook.com/

AIX-M-1 Mobile and Wireless Networks

Module code	AIX-M-1
Module coordination	Prof. Dr. Andreas Kassler
Course number and name	FWP-1 Mobile and Wireless Networks
Lecturer	Prof. Dr. Andreas Kassler
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	undergraduate / postgraduate (additional seminar part for postgraduate)
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 90 hours self-study: 60 hours Total: 150 hours
Type of Examination	Portfolio
Weight	
Language of Instruction	English

Module Objective

Upon completion of the course, students should be able to:

- explain the principles and limitations of wireless communication,

- explain important technical aspects of current wireless communication systems,

- compare and contrast different wireless communication systems based on an understanding of shared challenges (such as mobility management),

- explain the principles of medium access control and why they have been designed in a certain way,

- summarise key functions and principles behind different architectures for mobile and wireless communication systems,

- critically evaluate different properties of a mobile communication system, taking into account design considerations, capacity, and limitations in relation to the technology in question.

Applicability in this and other Programs

The course can be used in Bachelor of Applied Informatics, Bachelor of Internet of Things, CyberSecurity and Bachelor Elektromobilität, autonomes Fahren und mobile Robotik.

It can also be used in Master of Applied Computer Science, Master of Electrical Engineering. In case it is used at MAster Level, Students must complete an additional Seminar part, where they will present a research paper of their choice that is related to the course content and lead a discussion about it.

Entrance Requirements

Students should have basic understanding of computer networks.

Learning Content

The course treats the principles of mobile and wireless, including the function and operation of modern mobile and wireless communication systems and networks related to architecture, protocol, and algorithms. Current wireless systems, such as cellular systems and mobile Internet, including the WLAN standard IEEE 802.11, are used as examples to explain these principles.
The course includes components and exercises that treat these topics in-depth.

The course covers the following:

- Radio signals

- Coding, modulation, and multiplexing

- Medium access

- The basic principles of cellular systems and networks - WLAN (e.g. WiFi) and WPAN (e.g. Bluetooth)

Teaching Methods

- Interactive Lectures

- Interactive Exercise Sessions

- In addition for Master students: They need to read a scientific paper of their choice that suits the course content, present the paper in a workshop and lead a discussion around it

Remarks

Lectures with exercise sessions, where students demonstrate how they solve problems related to class topics.

Recommended Literature

Schiller, Jochen (2003). Mobile Communications (2nd edition). Addison Wesley

Stallings, William and Beard, Cory (2016). Wireless Communications Networks and Systems

FWP-1 Mobile and Wireless Networks

Type of Examination

Portfolio

AIX-M-10 Imaging Physics

Module code	AIX-M-10
Module coordination	Prof. Dr. Simon Zabler
Course number and name	FWP-10 Imaging Physics
Lecturer	Prof. Dr. Simon Zabler
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Language of Instruction	English

Module Objective

MET-15 SPECIAL TOPICS OF CONTACTLESS SENSOR SYSTEMS

Module code	MET-15
Module coordination	Prof. Dr. Martin Jogwich
	Automatisierungstechnik (AT)
Course number and name	MET 2107 Special Topics of Contactless Sensor Systems
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	Postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/90
Language of Instruction	English

Module Objective

The students achieve the following learning objectives:

Professional Skills

Students gain a thorough knowledge and a deep understanding of modern contactless sensors and sensor systems, especially of optical sensors

Methodological Skills

They learn to evaluate different tasks of industrial projects, when contactless measurements can help solving the problem.

The students develop a deep understanding of finding strategies for solving these problems, especially by applying analog and digital image processing techniques.

Soft Skills

The students learn to apply these strategies successfully in special case studies with problems, which they have solve e.g. during their master thesis and their projects in industry jobs.

Applicability in this and other Programs

For this degree program:

Compulsory subject within Master-Program Electrical Engineering and Information Technology, focus automation engineering (AT)

For any other degree program:

Elective for Master Applied Research in Engineering Sciences

Entrance Requirements

Formally: none

In terms of content: Deep knowledge of basic mathematics and its scientific and technical application, in particular trigonometry, coordinate systems, vector analysis, matrix calculus, differential and integral calculus, geometric transformations, fitting and interpolation techniques.
Deep knowledge of basic physics and its scientific and technical application in particular generation, transfer and measurement of electromagnetic radiation, in particular from the visible part of the spectrum.

Learning Content

Basics of sensor principles using geometrical optics (e.g. triangulation, image acquisition and image preprocessing)

Basics of sensor principles using electromagnetic radiation transfer (e.g. time of flight measurement, thicknesss measurement, photometry, fluorescence, interferometry, light barriers and light scanners)

Basics of sensor principles using electromagnetic radiation detection (e.g. photomultiplier, photo sensors, CCD and CMOS sensors)

Case studies of sensor application: Machine vision applications using image acquisition, image preprocessing and image processing

Teaching Methods

Lectures, practical exercise (software workshops), laboratory work

Recommended Literature

C. Demant et al: Industrial Image Processing bzw. Industrielle Bildverarbeitung, Springer.

R. Gonzalez / R. Woods: Digital Image Processing, Prentice Hall.

J. Haus: Optical Sensors, Wiley-VCH.

S. Hesse / G. Schnell: Sensoren für die Prozess- und Fabrikautomation, Vieweg.

A. Hornberg (editor): Handbook of Machine Vision, Wiley-VCH.

B. Jähne: Digital Image Processing bzw. Digitale Bildverarbeitung, Springer.

R. Jain / R. Kasturi, B.G / Schunck: Machine Vision, McGraw-Hill Book Company.

J. Niebuhr / G. Lindner: Physikalische Messtechnik mit Sensoren, Oldenbourg.

M. Petrou / P. Bosdigoianni: Image Processing, John Wiley & Sons.

E. Schiessle: Industriesensorik, Vogel Verlag.

C. Solomon / T. Breckon: Fundamentals of Digital Image Processing.

C. Steger / M. Ulrich / Chr. Wiedemann: Machine Vision Algorithms and Applications, Wiley-VCH.

WI-06 Advanced Software Engineering

Modul Nr.	WI-06
Modulverantwortliche/r	Prof. Dr. Andreas Wölfl
Kursnummer und Kursname	WI-1106 Advanced Software Engineering
Lehrende	Prof. Dr. Andreas Wölfl
Semester	1
Dauer des Moduls	1 Semester
Häufigkeit des Moduls	jährlich
Art der Lehrveranstaltungen	Pflichtfach
Niveau	Postgraduate
SWS	4
ECTS	5
Workload	Präsenzzeit: 30 Stunden Selbststudium: 90 Stunden Virtueller Anteil: 30 Stunden Gesamt: 150 Stunden
Prüfungsarten	Portfolio
Gewichtung der Note	5/90
Unterrichts-/Lehrsprache	Deutsch

Qualifikationsziele des Moduls

Vermittlung der Grundlagen modellgetriebener Softwareentwicklung. Modelle dienen zur Beschreibung von Programmen auf einer hohen Abstraktionsebene. Vermittlung von methodischen Kompetenzen, sowie Design- und Realisierungskomptenzen im Bereich modellgetriebener Softwareentwicklung und im Bereich der Entwicklung von domänenspezifischen Sprachen.

Im Einzelnen haben die Studierenden nach Abschluss des Moduls folgende Lernergebnisse erreicht:

Fachkompetenz

- Die Studierenden können die Grundlagen der modellgetriebenen Softwareentwicklung anwenden.

- Sie sind in der Lage aus Anforderungen initiale Entwicklungsmodelle abzuleiten.
- Sie können Codegeneratoren entwickeln, die diese Modelle in Zielsprachen überführen.

Methodenkompetenz

- Sie sind in der Lage aus Anforderungen auf systematsche Weise einen objektorientierten Entwurf (Analyse und Design) mittels geeigneter Modellierungssprachen durchzuführen.
- Sie können ausgehend von Anforderungen eigene textuelle DSLs realisieren.

Persönliche Kompetenz

- Durch zielorientiertes Arbeiten entwickeln die Studierenden ein hohes Maß an Zielstrebigkeit.
- Durch agile Methoden wird die Selbstmotivation der Studierenden gefördert.
- Durch die Task-orientierte Arbeitsweise wird das problemlösende Denken der Studierenden geschärft.

Sozialkompetenz

- Durch die aktive Teilnahme an Teammeetings wird die Teamfähigkeit gestärkt.

Verwendbarkeit in diesem und in anderen Studiengängen

Dieses Modul ist in allen Informatikstudiengängen verwendbar

Zugangs- bzw. empfohlene Voraussetzungen

Bachelor in einem Informatikstudiengang, darüberhinaus sehr gute Programmierkenntnisse und sehr gute Kenntnisse im Software Engineering (empfohlene Voraussetzung)

Inhalt

Inhalte:

- Modellierung mit Klassendiagrammen
- Metamodelle
- Definition von Constraints
- Modelleditoren
- Modelltransformationen
- Interne vs. Externe DSLs
- Grundlagen Compilerbau
- Language Implementation Patterns

- Typsysteme
- Linking & Scoping
- Code Generation

Lehr- und Lernmethoden

Seminaristischer Unterricht

Besonderes

Die Vorlesung wird teilweise virtuell angeboten.

Empfohlene Literaturliste

D. Steinberg et al.: EMF- Eclipse Modeling Framework, Addison Wesley 2009
T. Stahl, M. Völter: Modellgetriebene Softwareentwicklung, dpunkt.verlag, 2005
J. Warmer, A. Kleppke: The Object Constraint Language, Addison Wesley, 2003
R. Gronback: Eclipse Modeling Project - A Domain-Specific Language Toolkit, Addison Wesley 2009
D. S. Frankel: Model Driven Architecture, OMG Press, 2003
M. Völter: DSL Engineering, 2013
T. Parr: Language Implementation Patterns, The Pragmatic Bookshelf, 2010
L. Bettinit: Implementing Domain-Specific Languages with Xtext and Xtend, Pack Publishing, 2016

Weitere Bücher und Originalliteratur werden in der Vorlesung bekannt gegeben.

WI-1106 Advanced Software Engineering

Prüfungsarten

Portfolio

MSS-03 Model-Based Function Engineering

Module code	MSS-03
Module coordination	Prof. Dr. Roland Platz
Course number and name	MSS1103 Model-Based Function Engineering
Lecturer	Prof. Dr. Roland Platz
Semester	1
Duration of the module	1 semester
Module frequency	each semester
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

Virtual conceptual models support and evaluate the design process in all stages in the product life cycle: from the first idea to serial production. This course introduces the modeling of the main design stages definition and specification, concept, optimization via verification, design, realization, and test via validation. The course discusses conceptual approaches to evaluate uncertainty and reliability of the product design. Computational tools like the modeling language Object-Process CASE Tool (OPCAT) and numerical computing environment Matlab, Matlab-Simulink and Matlab-Simscape support the modelling process.

Professional competence:

- In depth knowledge of system engineering processes for mechatronic and cyber-physical Systems.
- Knowledge and practical experience systems performance evaluation, e.g. reliability, remaining life testing.

Methodological competence:

- Hands-on experience in mathematical modeling and numerical simulation of mechatronic systems.
- Conducting model-based design of embedded systems.

Personal competence:

- Moderating and solving complex tasks in teams during assignments during class.
- Analysing, synthesing, evaluating, discussing, and presenting results of tasks with and in front of fellow students during class.

Social competence:

- Communicating and exchanging ideas on a factual ground with students with diverse backgrounds.
- Taking ownership of responsibility when presenting results and findings to fellow students during class.

Applicability in this and other Programs

The students learn about systematic design approach for mechatronic and cyber-physical systems.

Entrance Requirements

- Basic principles of physics (axioms of technical mechanics) and mathematics (differential equations, statistics)
- Fundamentals of mechanical engineering (mechanics, electronics, design concepts)
- Fundamentals of metrology (conversions of physical units)
- Basics for mathematical modeling for numerical simulation

Learning Content

Introduction Mechatronic Systems

VDI 2206 Mechatronic and Cyber-Physical Systems

Product Development Process (PDP) and Product Life Cycle (PLC)

Systems Engineering

System Modeling Language, Software Tools SysML and OPCAT

Generic Life Cycle Stages, Technology Readiness Level TRL, Basic Linear Control Concepts

Model-Based Design of Embedded Systems

Modeling Physical Systems using Matlab/Simulink/Simscape

HIL-Simulation and Test

Design of Experiments (DoE)

Reliability Evaluation Tools in Early Development Stage
- Failure Mode and Effects Analysis (FMEA) / Fault, Error, Failure
- Faults, Fault Tree Analysis (FTA)

Bayesian Statistics, Maximum Likelihood Estimation, Markov Chains, Stochastics

Durability/Life Tests

Dealing with Uncertainty, Functional Safety

Teaching Methods

Class in lecture format with:

- slides and handwritten derivations,
- quizzes,
- group assignments and discussions,
- time for questions.

Remarks

- Online class with three in-person classes during the semester.
- Interactive class with group assigments and live discussions.

Recommended Literature

Bertsche, Bernd; Göhner, Peter; Jensen, Uwe; Schinköthe, Wolfgang; Wunderlich, Hans-Joachim (2009): Zuverlässigkeit mechatronischer Systeme. Berlin, Heidelberg: Springer Berlin Heidelberg, checked on 4/18/2021.

Dori, Dov; Renick, Aharon; Wengrowicz, Niva (2016): When quantitative meets qualitative: enhancing OPM conceptual systems modeling with MATLAB computational capabilities. In Res Eng Design 27 (2), pp. 141164. DOI: 10.1007/s00163-015-0209-9.

Gausemeier, Jürgen; Dumitrescu, Roman; Steffen, Daniel; Czaja, Anja; Wiederkehr, Olga; Tschirner, Christian (2015): Systems Engineering. in industrial practice. With assistance of Heinz Nixdorf Institute, University of Paderborn, Faculty of Product Engineering, Fraunhofer Institute for Production Technology IPT Project Group Mechatronic Systems Design, UNITY AG.

Lavi, Rea; Dori, Yehudit Judy; Wengrowicz, Niva; Dori, Dov (2020): Model-Based Systems Thinking: Assessing Engineering Student Teams. In IEEE Trans. Educ. 63 (1), pp. 3947. DOI: 10.1109/TE.2019.2948807.

Schwer, L. E. (2006): Guide for Verification and Validation in Computational Solid Mechanics. Reprinted by permission of The American Society of Mechanical Engineers.

U.S. Nuclear Regulatory Commission (1981): Fault Tree Handbook,

Walden, David D. (2015): INCOSE Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities, checked on 3/29/2021Jensen, Jeff C. (2010): Elements of Model-Based Design (Technical Report No. UCB/EECS-2010-19). Available online at http://www.eecs.berkeley.edu/Pubs/TechRpts/2010/EECS-2010-19.html, checked on 5/23/2021.

2004: VDI 2206 Design methodology for mechatronic systems.

2021: VDI 2206 - Development of mechatronic and cyber-physical systems.

VHB Scientific Writing

Abstract:
You have to write your Bachelor's thesis and have never done anything like this before? Are you about to write your admission paper for the final exams to become a teacher and need basic skills in writing a scientific paper? Or are you working on your first research project of your own in your PhD and want to refresh your knowledge on how to describe it in a structured way?

"Scientific Writing" in English is a crucial qualification course for students of all disciplines and all skill levels (Bachelor's, Master's, PhD). Specifically for students of natural sciences who are often required to draft texts in English (ranging from letters & e-mails about papers, to abstracts, to posters, to scientific publication and third party applications), this course shall not only help them encounter the "fear of blank page" but also help them overcome the language barrier.

The online seminar "Scientific Writing" aims at targeting students of natural sciences and health sciences who wish to improve their academic writing skills in English. The course helps attaining skills in literature search, drafting various parts of scientific publication & publishing and presenting the results of the scientific publication in English. The objective of the seminar is to provide a brief theoretical introduction on each topic of the course. Exercises with clearly defined tasks give students the opportunity to test what they have learned and applied directly during the flow of the seminar. Thus for example the student has the opportunity to draft one's own scientific publication step-by-step. Immediate feedback from the tutor can help the students with their queries if they are stuck. The learning objectives are specified at the end of each class. The lectures shall be held independent of other events and shall be open to audiences of all types.

To receive a graded ECTS certificate, it is necessary to complete the online units of the course and pass an exam. In the first unit you will find more detailed information about the requirements.

The online cases include the following topics:

PREPARATION OF THE ARTICLE
1. Introduction
2. Literature search
3. Literature management
4. Planning of the writing process

THE WRITING PROCESS
5. Language and Expression
6. Methods
7. Introduction and Aims
8. Results
9. Discussion and Conclusion
10. Title and Abstract
11. Visuals

12. Bibliography and Citation

PUBLISHING AND PRESENTING
13. Submission to the journal
14. Oral presentation
15. Poster presentation
16. Peer-reviewing

"Scientific Writing" in English is a crucial qualification course for students of all disciplines and all skill levels (Bachelor's, Master's, PhD). Specifically for students of natural sciences who are often required to draft texts in English (ranging from letters & e-mails about papers, to abstracts, to posters, to scientific publication and third party applications), this course shall not only help them encounter the "fear of blank page", but also help them overcome the language barrier. The online seminar "Scientific Writing" aims at targeting students of natural sciences and health sciences who wish to improve their academic writing skills in English. The course navigates from dealing with basic linguistic features to complex expertise of academic writing. Initially the course deals with the first steps of scientific writing, the phase of preparation of the article. The course explains how to search and manage the scientific literature as well as how to plan the writing process. In a second phase, the course guides through the writing process itself. After dealing with important aspects of English language and expression in scientific writing, the course offers learning units that help in acquiring expertise in drafting various parts of a scientific publication. Additionally, these learning units offer a step-by-step opportunity to compose one’s own scientific publication. In a third phase, the course explains how to publish and present a scientific publication. In this part of the course students can acquire knowledge not only regarding the procedure of submitting an article to a journal, but also concerning the oral and poster presentation of the scientific publication. The objective of the seminar is to provide a brief theoretical introduction on each topic of the course. Exercises with clearly defined tasks give students the opportunity to test what they have learned and applied directly during the flow of the seminar. Immediate feedback from the tutor can help the students with their queries if they are stuck. The learning objectives are specified at the end of each class. The lectures shall be held independent of other events and shall be open to audiences of all types.