Modulhandbuch

Embedded Systems and Microrobotics - Master's Programme

im Sommersemester 2021

erstellt am 12/08/22
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<th>Course Code</th>
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<td>Special Topics in Practical Computer Science II</td>
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Kernmodule

inf900 - Group Project

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<td>Workload</td>
<td>720 h</td>
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<td>Applicability of the module</td>
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<td>Master's Programme Computing Science (Master) &gt; Kernmodule</td>
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<td></td>
<td>Master's Programme Engineering of Socio-Technical Systems (Master) &gt; Systems Engineering</td>
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<tr>
<td>Responsible persons</td>
<td>Lehrenden, Die im Modul (Authorized examiners)</td>
</tr>
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</table>

Skills to be acquired in this module
The students get familiar with different software development aspects in a team. Apart from software engineering knowledge and skills they develop key competences like project management, teamwork, problem solving competence and conflict management.

Additionally, students develop special knowledge, skills and competences from the project group topic.

Professional competence
The students:
- characterise and apply computer science basics (algorithms, data structures, programming, basics of practical, technical and theoretical computer science)
- define and describe essential mathematical, logical and physical basics of computer science
- define and illustrate the core disciplines of computer science (theoretical, practical and technical computer science)

Methodological competence
The students:
- examine problems, use formal methods to phrase and analyze them appropriately
- evaluate problems by the use of technical and scientific literature
- reflect on a scientific topic and write a scientific seminar paper under guidance and present their findings

Social competence
The students:
- integrate criticism into their own actions
- respect team decisions
- communicate with users and experts convincingly

Self-competence
The students:
- take on project management tasks
- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently
- recognise their abilities and extend them purposefully
- reflect their self-perception and actions with regard to professional, methodological and social aspects
- develop and reflect self-developed hypotheses to theories independently
- work in their field independently

Module contents
Cooperative development of a large-scale computer science project. This project general includes the (further) development of a hard or software system.

Reader’s advisory
According to the assigned task

Links
https://www.uni-oldenburg.de/informatik/studium-lehre/infos-zum-studium/projektgruppen-im-masterstudium/

Languages of Instruction
German, English

Duration (semesters)
2 Semester

Module frequency
semi-annual
<table>
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<th><strong>Module capacity</strong></th>
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<td><strong>Reference text</strong></td>
<td>Dieses Modul ist im Rahmen der Projekte FiIF und FoL konzipiert worden</td>
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<tr>
<td><strong>Modullevel / module level</strong></td>
<td>AS (Akzentsetzung / Accentuation)</td>
</tr>
<tr>
<td><strong>Modulart / typ of module</strong></td>
<td>Pflicht o. Wahlpflicht / compulsory or optional</td>
</tr>
<tr>
<td><strong>Lehr-/Lernform / Teaching/Learning method</strong></td>
<td>PG</td>
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</table>
| **Vorkenntnisse / Previous knowledge** | - Programmierkurs  
- Softwaretechnik  
- Soft Skills |
| **Examination** | Im Stud.IP nach Bekanntgabe der einzelnen Gruppen und Themen |
| **Course type** | Project group |
| **SWS** | 8 |
| **Frequency** | SuSe and WiSe |
| **Workload attendance** | 112 h |
**Akzentsetzungsmodul**

inf100 - Human Computer Interaction

<table>
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<th>Human Computer Interaction</th>
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<td>Workload</td>
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**Applicability of the module**
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Praktische Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction

**Responsible persons**
- Boll-Westermann, Susanne (Module responsibility)
- Hein, Andreas (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

**Prerequisites**
With the help of suitable resources, the students can design, prototype, and evaluate a human-machine interface following the user-centered design process (HCD).

**Professional competence** The students:
- can describe and explain the HCD process.
- can classify an unknown method into the HCD process when they are presented with a brief description.
- can select a suitable prototyping approach for a given application.
- can select a suitable prototyping method for a given application.
- can apply selected prototyping methods to create an interactive system.
- can name basic characteristics of human perception and motor skills and explain their importance for the development of interactive systems.
- can suggest and motivate improvement for a given user interface based on the gestalt laws.
- can explain the characteristics of human visual search and utilize it to improve given interfaces.
- can critically compare several variants of an interactive system’s concept based on the “Multiple Resource Theory”.

**Methoden competence** The students:
- can critically compare and select methods for context of use and/or user requirements analysis.
- can apply methods for context of use and/or user requirements analysis to a real-world example.
- can retrospectively discuss and evaluate the use of a method for context of use and/or user requirements analysis.
- can plan, moderate and evaluate an ideation session.
- can formulate a precise research question based on a given problem description.
- can discuss the advantages and disadvantages of an experiment design.
- can select a suitable experiment design for a given research question.
- can define hypotheses and null hypotheses for a given experiment.

**Social competence** The students:
- can work out solutions for a given design problem in group work.
- can present solutions to design problem in the plenum.
- can motivate their methodical approach to a design problem.
- can discuss their designs and results in an appropriate and professional manner with the plenum.
- can accept criticisms by their peer group as valuable contributions to their designs.

**Module contents**
The module covers research methods in the field of human-computer interaction. It discusses the core principles of human-computer interaction and the human-centered design process and its phases, context of use, requirements, and task analysis, prototyping and evaluation. Research methods used in the different phases of the process are introduced and discussed.

Available design options for human-machine interfaces are presented and discussed with regard to human perception capabilities and their limitations. The module discusses methods for user research, including surveys, diaries, case studies, interviews, and focus groups, as well as physiological measurements.

The module goes into further detail on evaluation methods, and introduces the foundations of experimental research in human-computer interaction, including types of research, research hypotheses, experimental design, and statistical analysis.

During the practical project, a concrete human-computer interface will be designed, developed and evaluated.
### Reader's advisory
- Literature in the reserve shelf in the university bibliography. Link list in Stud.IP.

### Links
medien.informatik.uni-oldenburg.de/lehre

### Languages of instruction
German, English

### Duration (semesters)
1 Semester

### Module frequency
once a year

### Module capacity
unlimited

### Reference text
Useful previous knowledge: Interactive Systems

### Modullevel / module level
AS (Akzentsetzung / Accentuation)

### Modulart / typ of module
V+P

### Vorkenntnisse / Previous knowledge
Grundkenntnisse Programmierung

### Examination

<table>
<thead>
<tr>
<th>Final exam of module</th>
<th>Time of examination</th>
<th>Type of examination</th>
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<tbody>
<tr>
<td>The completed practical projects will be presented on a single project day, which will take place at the end of the lecture period. The oral exam takes place within the last two weeks of the lecture period. If necessary, re-examinations will take place at the end of the term. Details on the schedule can be found on the websites of the department and in Stud.IP.</td>
<td>Practical group project which progress has to be presented regularly during the tutorials. Oral exam on the topics of the lecture. Practical project and oral exam count 50% each to the final grade. Both practical project and oral exam have to be passed individually.</td>
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### Course type

<table>
<thead>
<tr>
<th>Course type</th>
<th>Comment</th>
<th>SWS</th>
<th>Frequency</th>
<th>Workload of compulsory attendance</th>
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### Total time of attendance for the module
56 h

### Duration (semesters)
1 Semester

### Module frequency
once a year

### Module capacity
unlimited

### Reference text
Useful previous knowledge: Interactive Systems

### Modullevel / module level
AS (Akzentsetzung / Accentuation)

### Modulart / typ of module
V+P

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Grundkenntnisse Programmierung

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### Total time of attendance for the module
56 h
inf105 - Fault Tolerance in Distributed Systems

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<td>Responsible persons</td>
<td>Lehrenden, Die im Modul (Authorized examiners)</td>
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<td></td>
<td>Theel, Oliver (Module responsibility)</td>
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</table>

Prerequisites

This module provides knowledge of fault-tolerant distributed systems. The terminology, structure, conception, core challenges and related implementation concepts will be covered in detail.

Professional competence
The students:
- Assess what a fault-tolerant distributed system is and develop awareness of its capabilities
- Name and discuss common implementations of fault-tolerant distributed systems

Methodological competence
The students:
- Reflect the implementation challenges of a distributed system
- Are able to adapt and evolve implementation concepts of fault-tolerant distributed systems in new contexts

Social competence
The students:
- Solve problems in small teams
- Present their solutions to the members of the tutorial
- Discuss their different solutions with members of the tutorial

Self-competence
The students:
- Accept criticism
- Question their initially applied methods for problem solving
- Question their initial solutions in the light of newly learned methods

Module contents

1) Fault, Error, Failure
2) Failure semantics, Fault tolerance
3) Byzantine agreement protocols
4) Stable storage
5) Fail-stop processors
6) Atomic commit protocols
7) Classification of replication control schemes
   - pessimistic vs. optimistic
   - semantic vs. syntactic
   - static vs. dynamic
8) Consistency notions
9) Quality criteria
10) Survey of replication control schemes
11) Design of replication control schemes
12) Unifying frameworks
13) Replication in practice

Reader's advisory

A. Schiper et al. (2010): Replication: Theory and Practice

Links

Language of instruction
German
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<td>V+S bzw V+Ü</td>
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inf300 - Hybrid Systems

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Applicability of the module
- Master's Programme Computing Science (Master) > Technische Informatik
- Master's Programme Computing Science (Master) > Theoretische Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons
- Fränzle, Martin Georg (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

Prerequisites

Skills to be acquired in this module

Professional competence
The students:
- characterise formal models of cyber-physical systems: hybrid automata, hybrid state transition systems
- name domain-specific system requirements: safety, stability, robustness
- name analysis methods: symbolic state-space exploration, abstraction and abstraction refinement, generalized Lyapunov-Methods
- use state-of-the-art analysis tools
- select and apply adequate modelling and analysis methods for concrete application scenarios
- apply methods to reduce large state spaces and reduce infinite-state systems by abstraction
- know the de-facto industry standards for system modelling and are able to apply the corresponding modelling frameworks and tools

Methodological competence
The students:
- model heterogeneous dynamical systems with adequate modelling and design tools, in particular Simulink/Stateflow
- transfer modelling and analysis methods to other heterogeneous domains, e.g. socio-technical systems

Social competence
The students:
- work in teams
- solve complex modelling, design, and analysis tasks in teams

Self-competence
The students:
- reflect their actions and respect the scope of methods dedicated to hybrid systems

Module contents
Embedded computer systems continuously interact with their environment, which generally comprises state- and time-continuous components. The coupling of the embedded system to its environment thus induces complex interleavings between discrete computational and decision processes and continuous processes. The resulting processes are neither amenable to the analytic techniques of continuous control nor of discrete mathematics. They instead require a broader, integrated theory: hybrid discrete-continuous systems. The lectures provide an in-depth introduction into a variety of analysis and design methods of these computer-based systems and their recent extensions to cyber-physical systems.

The accompanying hands-on-project enhances the lecture by developing and using design and verification tools.

Reader's advisory

11 / 95

<table>
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<th>Languages of instruction</th>
<th>English, German</th>
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<td>Duration (semesters)</td>
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inf301 - Machine-oriented Systems Engineering

Module label: Machine-oriented Systems Engineering
Module code: inf301
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module
- Master's Programme Computing Science (Master) > Technische Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons
Mikschl, Alfred (Module responsibility)
Lehrenden, Die im Modul (Authorized examiners)

Prerequisites

Skills to be acquired in this module
The module provides practical relevance to the design of digital embedded systems.

Professional competence
The students:
- characterise the structure of microprocessor systems
- name control aspects of time sensitive external components
- program efficient embedded systems

Methodological competence
The students:
- use specifications from electrical components data sheets

Social competence
The students:
- work in a team
- discuss solutions

Module contents
Embedded systems support complex feedback problems, control problems and data processing tasks. They have an important value creation potential for telecommunications, production management, transport and electronics. The functionality of embedded systems is realised by the integration of processors, special hardware and software. The embedded systems design is influenced by the heterogeneity of system architectures, the complexity of systems and technical and economic requirements.

This module gives an initial review of computer architectures. After that embedded systems are introduced by a specific microprocessor. Furthermore, external hardware will be connected to the microprocessor. Besides this, the design of circuit boards will be discussed. The students will design, develop and implement a circuit layout with CAD and programme this embedded system with a Flash-eprom.

Reader's advisory
Lecturers notes, hardware manuals and data sheets, and development tool manuals

Links
Languages of instruction: English, German
Duration (semesters): 1 Semester
Module frequency: semi-annual
Module capacity: unlimited
Modulelevel / module level: AS (Akzentsetzung / Accentuation)
Modulart / typ of module: V+P

Vorkenntnisse / Previous knowledge
Examination: Time of examination
- Final exam of module: At the end of the lecture period
Type of examination: Portfolio (Design, development and implementation of embedded systems, colloquium)
<table>
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<th>Course type</th>
<th>Comment</th>
<th>SWS</th>
<th>Frequency</th>
<th>Workload of compulsory attendance</th>
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<td>WiSe</td>
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<td>Practical training</td>
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**Total time of attendance for the module**

56 h
### inf303 - Fuzzy Control and Artificial Neural Networks in Robotics and Automation

<table>
<thead>
<tr>
<th>Module label</th>
<th>Fuzzy Control and Artificial Neural Networks in Robotics and Automation</th>
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<tbody>
<tr>
<td>Module code</td>
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<td>Credit points</td>
<td>6.0 KP</td>
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<tr>
<td>Workload</td>
<td>180 h</td>
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**Applicability of the module**
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Computing Science (Master) > Technische Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

**Responsible persons**
- Fatikow, Sergej (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

**Prerequisites**

**Skills to be acquired in this module**
Experts in different branches try to approach their application-specific control and information processing problems by using fuzzy logic and artificial neural networks (ANN). The experiences gathered up to now prove robotics and automation technology to be predestined fields of application of both these approaches. The major topics of the course are control problems in robotics and automation technology, principles of fuzzy logic and ANN and their practical applications, comparison of conventional and advanced control methods, combination of fuzzy logic and ANN in control systems. The course gives a comprehensive treatment of these advanced approaches for interested students.

**Professional competence**
The students:
- recognise control problems in robotics and automation technology,
- name principles of fuzzy logic and ANN and their practical applications,
- compare conventional and advanced control methods,
- characterise the combination of fuzzy logic and ANN in control systems

**Methodological competence**
The students:
- will acquire knowledge of the tools, methods and applications in fuzzy logic and ANN
- deepen their knowledge for the practical use of the given methods
- can use common software tools for design and application of fuzzy logic and ANN

**Social competence**
The students:
- gain experience in interdisciplinary work
- are integrated into the recent research work

**Objective of the module / skills:**

**Self-competence**
The students:
- are able to transfer the gained knowledge for later use in their theses or studies for AM&R
- can Design (complex) fuzzy logic controller and ANN systems
- reflect their (control) solutions by using methods learned in this course

**Module contents**
- Control problems in robotics and automation technology
- Basic ideas of fuzzy logic and ANN
- Principles of fuzzy logic
- Fuzzy logic of rule-based systems
- ANN models
- ANN learning rules
- Multilayer perceptron networks and backpropagation
- Associative networks
- Self-organizing feature maps
PID design principles
Design of fuzzy control systems
Fuzzy logic application examples
Design of ANN control systems
ANN application examples
Fuzzy + Neuro: principles and applications

Reader's advisory

Essential:

- Lecture notes (available at the secretariat, A1-3-303) in book form

Recommended:


Secondary Literature:

- Altrock, M. O. R.: Fuzzy Logic, R. Oldenbourg Verlag, 1993
- Kahler, J. und Hubert, F.: Fuzzy-Logik und Fuzzy-Control, Vieweg, 1993
- Kratzer, K.P.: Neuronale Netze, Carl Hanser, 1993
- Lawrence, J.: Neuronale Netze, Sythema Verlag, München, 1992
- Patterson, D.W.: Künstliche neuronale Netze, Prentice Hall, 1996
- Pham, D.T.: Neuro-Fuzzy-Systeme, Addison-Wesley, 1995
- Schulte, U.: Einführung in Fuzzy-Logik, Franzis-Verlag, München, 1993
- Zimmermann H.-J. (Hrsg.): Datenanalyse, VDI-Verlag, 1995

Links

Languages of instruction: English, German

Duration (semesters): 1 Semester

Module frequency: once a year

Module capacity: unlimited

Module level: AS (Akzentsetzung / Accentuation)

Module type: V+Ü

Vorkenntnisse / Previous knowledge: Regelungstechnik

Examination: Time of examination: At the end of the lecture period until the beginning of the next semester

Type of examination: Hands-on-exercises and oral Exam

Final exam of module: At the end of the lecture period until the beginning of the next semester

Course type: Comment | SWS | Frequency | Workload of compulsory attendance

| Lecture | 3 | SuSe | 42
<p>| Exercises | 1 | SuSe | 14 |</p>
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inf305 - Medical Technology

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**Applicability of the module**
- Master's Programme Computing Science (Master) > Nicht Informatik
- Master's Programme Computing Science (Master) > Technische Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

**Responsible persons**
- Hein, Andreas (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

**Prerequisites**

**Skills to be acquired in this module**

**Professional competence**
The students:
- Describe medical diagnosis and therapy methods
- Understand the core concepts of computer-assisted medical interventions
- Are aware of the basic concepts and legal conditions of the development of medical devices
- Define the character of medical devices' software parts and implement them
- Assess the complex interaction of medical products and patients
- Get familiar with the development of medical products within a short period of time

**Methodological competence**
The students:
- Recognise the interdisciplinary challenges and accordingly exchange information with other disciplines

**Social competence**
The students:
- Present solutions for specific questions

**Self-competence**
The students:
- reflect their solutions by using methods learned in this course

**Module contents**
- Medical areas and areas of application
- Basic requirements for medical systems (hygiene, MPG, technical security, materials)
- Medical systems:
  - Functional diagnostics (ECG, EMG, EEG)
  - Imaging systems (CT, MRI, ultrasound, PET, SPECT) - Therapy equipment (Laser, RF, Microtherapy)
  - Signal processing / monitoring (cardiovascular, hemodynamic, respiratory, metabolic, cerebral)
- Medical Informatics (HIS, DICOM, Telemedicine, VR, image processing).

**Reader's advisory**

**essential:**
- Lecture slides

**recommended:**
**secondary literature:**


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inf307 - Robotics

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**Applicability of the module**
- Master's Programme Computing Science (Master) > Nicht Informatik
- Master's Programme Computing Science (Master) > Technische Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master’s Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

**Responsible persons**
- Hein, Andreas (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

**Prerequisites**

**Skills to be acquired in this module**

**Professional competence**
- The students:
  - Name and know the functions and applications of robot systems
  - Characterise the basic concepts to program robot systems
  - Differentiate between the interaction of mechanical, electrical and software components

**Methodological competence**
- The students:
  - Define characteristics and components of robot systems for a specific application
  - Design and implement robot system sub-components
  - Design and parameterise simple control structures
  - Plan the application of robot systems and derive the requirements
  - Model electrical and mechanical systems
  - Develop and realise simple robot systems

**Social competence**
- The students:
  - Solve robot systems problems in team work

**Self-competence**
- The students:
  - Reflect their solutions in reference to robot system methods

**Module contents**
- Integration in production plants / aims / subsystems
- Architectures / classifications (classification of robots)
- Robot components + Computer systems for programming
  - PA-10
  - Lego Mindstorms
- Basics of kinematics
  - Coordinate transformation, homogeneous coordinates, Coordinate transitions
  - Kinematic equation systems, transformation of vectors
- Kinematic
  - Joint types (manipulators) / Wheels, TCP
  - Denavit-Hartenberg-Transformation
  - Forward calculation
  - Backward calculation
- Sensors
  - General properties of sensors, parameter
  - Simple optical position sensors
  - Inductive-, capacitive- und ultrasonic-sensors
  - Distance sensors (laser scanner, triangulation sensors)
  - Force sensors
  - Sensor data preparation
Planing / Regulation
- Overall regulation approach, terms, process- and control functions, PID-controller
- Planning concepts and approaches (On-Line, Off-Line), planning processes, construction and path planning
- Actuators

Reader’s advisory

**essential:**
lecture nodes

**recommended:**

**secondary literature:**

Links

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Vorkenntnisse / Previous knowledge

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**Total time of attendance for the module**

56 h
inf308 - Microrobotics II

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### Applicability of the module
- Master's Programme Computing Science (Master) > Nicht Informatik
- Master's Programme Computing Science (Master) > Technische Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

### Responsible persons
- Fatikow, Sergej (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

### Prerequisites

### Skills to be acquired in this module
After having given an established introduction in the module "Microrobotics and Microsystem Technology" this lecture offers a further specialisation in microrobotics. Within the course, all relevant areas (among others the research topics of the division "Microrobotics and Control Engineering (AMiR)") will be presented and analysed. The student will be provided with an insight into current research projects of AMiR and of other research institutes of microrobotics worldwide; here mainly the requirements of industry to microrobots will be discussed. The lecture will be enhanced by practical courses in the research laboratories of AMiR.

#### Professional competence
The students:
- name and recognise the basic concepts of nanotechnology, in particular, micro- and nanorobotics approaches
- differentiate the development, control and application of micro- and nanorobotics systems
- implement and design application-specific micro- and nanorobotics systems

#### Methodological competence
The students:
- transfer their control engineering and image processing abilities on interdisciplinary problems
- transfer their hands-on experience to develop controls and applications of microrobotic systems on new tasks

#### Social competence
The students:
- work in a team

#### Self-competence
The students:
- reflect their problem-solving behaviour and use hands-on experience to develop, control and application of microrobotics

### Module contents
Smart and versatile microrobots; microactuators (piezo-, ferrofluid- and SMA-actuators) for microrobots; real-time image processing in the micro world (SEM, optical microscopy); micro force sensors and tactile sensors for microrobots; microrobot control systems, e.g. neural networks and fuzzy logic; haptic interface for the control of microrobots; neural speech interface for the control of microrobots; robot-based micro- and nanohandling (SEM, optical microscopy); applications: microassembly, nano-testing, cell handling; Micro Air Vehicles (MAVs); multi-robot systems: team behavior, communication, control issues

### Reader's advisory
- Lecture notes (can be obtained in secretariat, A1-3-303)

### Links

### Languages of instruction
English, German
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inf311 - Low Energy System Design

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**Applicability of the module**
- Master's Programme Computing Science (Master) > Technische Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

**Responsible persons**
- Nebel, Wolfgang (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

**Prerequisites**
- This module introduces the estimation of power dissipation and optimisation.

**Skills to be acquired in this module**

**Professional competence**
- The students:
  - Discuss the fundamental problems of power dissipation
  - Characterise the requirements-driven design process of embedded systems
  - Name power loss analysis and optimization methods
  - Design embedded systems with common design and analysis tools
  - Design power-optimized embedded systems

**Methodological competence**
- The students:
  - Model systems with a hardware description language
  - Analyze and model hardware components
  - Perform multi-dimensional optimization of systems

**Social competence**
- The students:
  - Implement solutions of given problems in teams
  - Discuss their outcomes appropriately

**Self-competence**
- The students:
  - Acknowledge the limits of their ability to cope with pressure during the modeling process of systems

**Module contents**
- According to Moore's Law the number of integratable transistors on a computer chip doubles every two years. In addition, new circuits are getting faster and faster. This leads not only to an increased functionality of a system, but it also increases the electrical power consumption.

This electrical power consumption is problematic from two different points of view: Firstly, the electrical power must be supplied. Secondly, the resulting heat has to dissipate from the system. An increased power consumption always causes lower battery life and higher energy costs. The heat generation reduces the reliability and life of integrated circuits. The cooling (ceramic housings, cooling elements, fans, etc.) increases the system's costs.

Today the development of heat, caused by power dissipation, needs to be considered during the embedded system design process. This knowledge takes the system's reliability and operation costs into account.

This module introduces the estimation of power dissipation and optimisation.

**Reader's advisory**
- Designing CMOS Circuits for Low Power – Dimitros Soudris, Christian Piguet, Costas Goutis
- Low-Power CMOS VLSI Circuit Design – Kaushik Roy, Sharat C. Prasad
- Low-Power Electronics Design – Christian Piguet et al.
- Leakage in Nanometer CMOS Technologies – Siva G. Narendra, Anantha Chandrakasan
- Entwurf von digitalen Schaltungen und Systemen mit HDLs und FPGAs – F. Kesel, R. Bartholomä
- Slides of the module „Eingebettete Systeme I+II“ von Professor Dr.-Ing. Wolfgang Nebel
- Slides and technical readouts of the used hardware and development tools
### Links

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### Vorkenntnisse / Previous knowledge

- inf200 Grundlagen der Technische Informatik,
- inf201 Technische Informatik,
- inf203 Eingebettete Systeme I+,
- inf204 Eingebettete Systeme II

### Examination

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### Course type

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### Total time of attendance for the module

56 h
inf350 - Special Topics in 'Safety-Critical Systems' I

Module label: Special Topics in 'Safety-Critical Systems' I
Module code: inf350
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module: Master's Programme Computing Science (Master) > Technische Informatik
Responsible persons: Lehrenden, Die im Modul (Module responsibility)
Lehrenden, Die im Modul (Authorized examiners)

Prerequisites

Skills to be acquired in this module: This module integrates current developments in the field in adequate study courses.

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

Social competences
The students:
- support team process by their abilities

Self-competences
The students:
- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

Module contents: See assigned course description, e.g. „Sicherheitsanalysetechniken“, „Zielarchitekturen Eingebetteter Systeme für Automotive-Anwendungen“, „Modellbasierter Systementwurf“, ...

Reader's advisory: As announced in course

Links
Language of instruction: German
Duration (semesters): 1 Semester
Module frequency: unregelmäßig
Module capacity: unlimited
Module level / module level: AS (Akzentsetzung / Accentuation)
Modulart / typ of module: je nach Studiengang Pflicht oder Wahlpflicht
Lehr-/Lernform / Teaching/Learning method: 2 Veranst. aus V, Ü, S, P, PR (4SWS)

Vorkenntnisse / Previous knowledge

Examination: Time of examination: Type of examination

Final exam of module: Portfolio or presentation or oral exam
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inf351 - Special Topics in 'Safety-Critical Systems' II

Module label: Special Topics in 'Safety-Critical Systems' II
Module code: inf351
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module:
- Master's Programme Computing Science (Master) > Technische Informatik

Responsible persons:
Lehrenden, Die im Modul (Module responsibility)
Lehrenden, Die im Modul (Authorized examiners)

Prerequisites:
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

Social competences
The students:
- support team process by their abilities

Self-competences
The students:
- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

Module contents:
See assigned course description, e.g. „Sicherheitsanalysetechniken“, „Modellbasierter Systementwurf“, ...

Reader's advisory:
As announced in course

Links:
Language of instruction: German
Duration (semesters): 1 Semester
Module frequency: halbjährlich
Module capacity: unlimited
Modulart / typ of module: je nach Studiengang Pflicht oder Wahlpflicht
Lehr-/Lernform / Teaching/Learning method: 2 Veranst. aus V, S, Ü, P, PR (4SWS)

Vorkenntnisse / Previous knowledge:
Examination
Time of examination
Type of examination
Final exam of module
Portfolio or presentation or oral exam
Course type: Course selection
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inf352 - Current Topics in 'Safety-Critical Systems' I

Module label: Current Topics in 'Safety-Critical Systems' I
Module code: inf352
Credit points: 3.0 KP
Workload: 90 h

Applicability of the module:
- Master's Programme Computing Science (Master) > Technische Informatik

Responsible persons:
- Lehrenden, Die im Modul (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

Prerequisites:
This module integrates current developments in the field in adequate study courses.

Skills to be acquired in this module:

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

Social competences
The students:
- communicate with users and experts convincingly

Self-competences
The students:
- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

Module contents: See assigned course description

Reader's advisory: As announced in course

Links:

Language of instruction: German
Duration (semesters): 1 Semester
Module frequency: unregelmäßig
Module capacity: unlimited

Modulelevel / module level: AS (Akzentsetzung / Accentuation)
Modulart / typ of module: je nach Studiengang Pflicht oder Wahlpflicht
Lehr-/Lernform / Teaching/Learning method: S oder V (2 SWS)

Vorkenntnisse / Previous knowledge:

Examination:
- Time of examination
- Type of examination

Final exam of module:
- At the end of the lecture period
- Presentation or oral exam
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<td>Workload attendance</td>
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inf353 - CurrentTopics in 'Safety-Critical Systems’ II

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<th>Module label</th>
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<td>Workload</td>
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Applicability of the module
- Master's Programme Computing Science (Master) > Technische Informatik

Responsible persons
- Lehrenden, Die im Modul (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

Prerequisites

Skills to be acquired in this module
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

Social competences
The students:
- communicate with users and experts convincingly

self-competences
The students:
- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

Module contents
See assigned course description

Reader's advisory
As announced in course

Links
Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency
unregelmäßig

Module capacity
unlimited

Modullevel / module level
AS (Akzentsetzung / Accentuation)

Modulart / typ of module
je nach Studiengang Pflicht oder Wahlpflicht

Lehr-/Lernform / Teaching/Learning method
S oder V (2SWS)

Vorkenntnisse / Previous knowledge

Examination
Time of examination
Type of examination

Final exam of module
At the end of the lecture period
Presentation or oral exam
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<td>WiSe</td>
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</table>
inf354 - Special Topics in 'Hybrid Systems' I

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<tr>
<th>Module label</th>
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<tbody>
<tr>
<td>Module code</td>
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<tr>
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<td>Workload</td>
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**Applicability of the module**
- Master's Programme Computing Science (Master) > Technische Informatik

**Responsible persons**
- Fränzle, Martin Georg (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

**Prerequisites**
This module integrates current developments in the field in adequate study courses.

**Professional competences**
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

**Methodological competences**
The students:
- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

**Social competences**
The students:
- support team process by their abilities

**self-competences**
The students:
- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

**Module contents**
See assigned course description, e.g. „Modellbasierter Systementwurf“, „Konstruktionsprinzipien ausgewählter Klassen von Fahrzeugfunktionen“

**Reader's advisory**
As announced in course

**Links**

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**Vorkenntnisse / Previous knowledge**

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<td>Frequency</td>
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</table>
**inf355 - Special Topics in 'Hybrid Systems' II**

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<td>Workload</td>
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<td>Applicability of the module</td>
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<tr>
<td>Responsible persons</td>
<td>Fränzle, Martin Georg (Module responsibility)</td>
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</table>

**Prerequisites**

This module integrates current developments in the field in adequate study courses.

**Professional competences**

The students:

- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

**Methodological competences**

The students:

- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

**Social competences**

The students:

- support team process by their abilities

**Self-competences**

The students:

- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

**Module contents**

See assigned course description

**Reader's advisory**

As announced in course

**Links**

Language of instruction: German

Duration (semesters): 1 Semester

Modulart / typ of module: je nach Studiengang Pflicht oder Wahlpflicht

Lehr-/Lernform / Teaching/Learning method: 2 Veranst. aus V, Ü, S, P, PR (4SWS)

Vorkenntnisse / Previous knowledge

Examination: Time of examination

Final exam of module: At the end of the lecture period

Course type: Course selection
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<td>Workload attendance</td>
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inf356 - CurrentTopics in 'Hybrid Systems' I

Module label: CurrentTopics in 'Hybrid Systems' I
Module code: inf356
Credit points: 3.0 KP
Workload: 90 h
Applicability of the module: Master's Programme Computing Science (Master) > Technische Informatik

Responsible persons:
- Fränzle, Martin Georg (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

Prerequisites
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

Social competences
The students:
- communicate with users and experts convincingly

Self-competences
The students:
- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

Module contents: See assigned course description
Reader's advisory: As announced in course

Links

Languages of instruction: German, English
Duration (semesters): 1 Semester
Module frequency: unregelmäßig
Module capacity: unlimited
Module level/module level: AS (Akzentsetzung/Accentuation)
Modulart/typ of module: je nach Studiengang Pflicht oder Wahlpflicht
Lehr-/Lernform/Teaching/Learning method: S oder V (2SWS)
Vorkenntnisse/Previous knowledge

Examination
- Time of examination
- Type of examination
Final exam of module
- At the end of the lecture period
- Presentation or oral exam
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inf357 - Current Topics in 'Hybrid System' II

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<td>Workload</td>
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<td>Applicability of the module</td>
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<td>Responsible persons</td>
<td>Fränzle, Martin Georg (Authorized examiners)</td>
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<td>Lehrenden, Die im Modul (Authorized examiners)</td>
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### Prerequisites

This module integrates current developments in the field in adequate study courses.

#### Professional competences

The students:

- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

#### Methodological competences

The students:

- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

#### Social competences

The students:

- communicate with users and experts convincingly

#### Self-competences

The students:

- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

### Module contents

See assigned course description

### Reader's advisory

As announced in course

### Language of instruction

German

### Duration (semesters)

1 Semester

### Module frequency

unregelmäßig

### Module capacity

unlimited

### Module level / module level

AS (Akzentsetzung / Accentuation)

### Modulart / typ of module

je nach Studiengang Pflicht oder Wahlpflicht

### Lehr-/Lernform / Teaching/Learning method

S oder V (2SWS)

### Vorkenntnisse / Previous knowledge

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inf358 - Special Topics in 'Hardware/Software Systems' I

**Module label**
Special Topics in 'Hardware/Software Systems' I

**Module code**
inf358

**Credit points**
6.0 KP

**Workload**
180 h

**Applicability of the module**
- Master's Programme Computing Science (Master) > Technische Informatik

**Responsible persons**
Nebel, Wolfgang (Module responsibility)
Lehrenden, Die im Modul (Authorized examiners)

**Prerequisites**
This module integrates current developments in the field in adequate study courses.

**Professional competences**
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

**Methodological competences**
The students:
- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

**Social competences**
The students:
- support team process by their abilities

**Self-competences**
The students:
- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

**Module contents**
See assigned course description, e.g. „Spezifikation und Modellierung Eingebetteter Systeme“

**Reader's advisory**
As announced in course

**Links**

**Language of instruction**
German

**Duration (semesters)**
1 Semester

**Module frequency**
ahljährlich

**Module capacity**
unlimited

**Modullevel / module level**
AS (Akzentsetzung / Accentuation)

**Modulart / typ of module**
je nach Studiengang Pflicht oder Wahlpflicht

**Lehr-/Lernform / Teaching/Learning method**
2 Veranst. aus V, Ü, S, P, PR (4SWS)

**Vorkenntnisse / Previous knowledge**

**Examination**

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</table>
inf359 - Special Topics in 'Hardware/Software Systems' II

Module label: Special Topics in 'Hardware/Software Systems' II
Module code: inf359
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module:
- Master's Programme Computing Science (Master) > Technische Informatik

Responsible persons:
Nebel, Wolfgang (Module responsibility)
Lehrenden, Die im Modul (Authorized examiners)

Prerequisites:
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

Social competences
The students:
- support team process by their abilities

Self-competences
The students:
- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

Module contents:
See assigned course description, e.g. „Spezifikation und Modellierung Eingebetteter Systeme“

Reader's advisory:
As announced in course

Links:

Language of instruction: German
Duration (semesters): 1 Semester
Module frequency: unregelmäßig
Module capacity: unlimited

Module level / module level: AS (Akzentsetzung / Accentuation)
Moduleart / typ of module: je nach Studiengang Pflicht oder Wahlpflicht
Lehr-/Lernform / Teaching/Learning method: 2 Veranst. aus V, Ü, S, P, PR (4SWS)

Vorkenntnisse / Previous knowledge:

Examination:
Time of examination
Type of examination: Exercices or presentation or oral exam

Final exam of module: The exam period will be announced during the course
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inf360 - CurrentTopics in 'Hardware/Software Systems' I

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<td>Applicability of the module</td>
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<td>Responsible persons</td>
<td>Nebel, Wolfgang (Module responsibility)</td>
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<td>Skills to be acquired in this module</td>
<td>This module integrates current developments in the field in adequate study courses.</td>
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<td>Professional competences</td>
<td>The students:</td>
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<tr>
<td></td>
<td>• Recognise and evaluate applied techniques and methods of their subject and are aware of their limits</td>
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<td>• Identify, structure and solve problems/tasks, also in new or developing subject areas</td>
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<td></td>
<td>• Apply state of the art and innovative methods to solve problems, if necessary from other disciplines</td>
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<td></td>
<td>• Are aware of the current limits and contribute to the development of computer science research and technology</td>
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<td>• Discuss and evaluate recent computer science developments</td>
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<tr>
<td>Methodological competences</td>
<td>The students:</td>
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<tr>
<td></td>
<td>• Examine tasks with technical and research literature, write an academic article and present their solutions academically</td>
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<td>• Evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research</td>
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<td>• Schedule time processes and resources</td>
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<tr>
<td>Social competences</td>
<td>The students:</td>
</tr>
<tr>
<td></td>
<td>• Communicate with users and experts convincingly</td>
</tr>
<tr>
<td>Self-competences</td>
<td>The students:</td>
</tr>
<tr>
<td></td>
<td>• Pursue the overall and special computer science development critically</td>
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<tr>
<td></td>
<td>• Develop and reflect self-developed hypotheses to theories independently</td>
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Module contents                     See assigned course description, e.g. „Energieeffizienz in der IKT“, „Smart Resource Integration“, ...

Reader's advisory                   As announced in course

Links

Language of instruction             German
Duration (semesters)                1 Semester
Module frequency                   unregelmäßig
Module capacity                    unlimited

Modullevel / module level           AS (Akzentsetzung / Accentuation)
Modulart / typ of module           je nach Studiengang Pflicht oder Wahlpflicht
Lehr-/Lernform / Teaching/Learning method | S oder V (2SWS)

Vorkenntnisse / Previous knowledge

Examination                        Time of examination Type of examination
Final exam of module                At the end of the lecture period Presentation or oral exam
<table>
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<td>Frequency</td>
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<td>Workload attendance</td>
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inf361 - Current Topics in 'Hardware/Software Systems' II

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<tr>
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Prerequisites

This module integrates current developments in the field in adequate study courses.

Professional competences

The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences

The students:
- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

Social competences

The students:
- communicate with users and experts convincingly

Self-competences

The students:
- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

Module contents

See assigned course description, e.g. „Energieeffizienz in der IKT“, „Smart Resource Integration“, ...

Reader's advisory

As announced in course

Links

Language of instruction: German
Duration (semesters): 1 Semester
Module frequency: unregelmäßig
Module capacity: unlimited
Modulelevel / module level: AS (Akzentsetzung / Accentuation)
Modulart / typ of module: je nach Studiengang Pflicht oder Wahlpflicht
Lehr-/Lernform / Teaching/Learning method: S oder V (2 SWS)

Vorkenntnisse / Previous knowledge

Examination

Time of examination: At the end of the lecture period
Type of examination: As announced in the according course

Final exam of module

At the end of the lecture period
As announced in the according course
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**inf366 - Special Topics in 'Microrobotics and Control Engineering' I**

<table>
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**Prerequisites**

This module integrates current developments in the field in adequate study courses.

**Professional competences**

The students:

- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

**Methodological competences**

The students:

- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

**Social competences**

The students:

- support team process by their abilities

**Self-competences**

The students:

- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

**Module contents**

See assigned course description, e.g. „Nanomontage und Nanohandhabung“

**Reader's advisory**

As announced in course

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**Vorkenntnisse / Previous knowledge**

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inf367 - Special Topics in 'Microrobotics and Control Engineering' II

Module label
Special Topics in 'Microrobotics and Control Engineering' II

Module code
inf367

Credit points
6.0 KP

Workload
180 h

Applicability of the module
- Master's Programme Computing Science (Master) > Technische Informatik

Responsible persons
Fatikow, Sergej (Module responsibility)
Lehrenden, Die im Modul (Authorized examiners)

Prerequisites
This module integrates current developments in the field in adequate study courses.

Skills to be acquired in this module

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

Social competences
The students:
- support team process by their abilities

Self-competences
The students:
- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

Module contents
See assigned course description

Reader's advisory
As announced in course

Language of instruction
German

Duration (semesters)
1 Semester

Module frequency
unregelmäßig

Module capacity
unlimited

Modul level / module level
AS (Akzentsetzung / Accentuation)

Modulart / typ of module
ej nach Studiengang Pflicht oder Wahlpflicht

Lehr-/Lernform / Teaching/Learning method
2 Veranst. aus V, Ü, S, P, PR (4SWS)

Vorkenntnisse / Previous knowledge

Examination
Time of examination
Type of examination

Final exam of module
The exam period will be announced during the course
Portfolio or presentation or oral exam
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### inf368 - Current Topics in 'Microrobotics and Control Engineering' I

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**Skills to be acquired in this module**

**Professional competences**

The students:

- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

**Methodological competences**

The students:

- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

**Social competences**

The students:

- communicate with users and experts convincingly

**Self-competences**

The students:

- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

**Module contents**

See assigned course description

**Reader's advisory**

As announced in course

**Links**

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**Vorkenntnisse / Previous knowledge**

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inf369 - Current Topics in 'Microrobotics and Control Engineering' II

Module label: Current Topics in 'Microrobotics and Control Engineering' II
Module code: inf369
Credit points: 3.0 KP
Workload: 90 h
Applicability of the module: Master's Programme Computing Science (Master) > Technische Informatik
Responsible persons:
- Fatikow, Sergej (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

Prerequisites
This module integrates current developments in the field in adequate study courses.

Professional competences
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences
The students:
- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

Social competences
The students:
- communicate with users and experts convincingly

Self-competences
The students:
- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

Module contents: See assigned course description
Reader's advisory: As announced in course

Language of instruction: German
Duration (semesters): 1 Semester
Module frequency: unregelmäßig
Module capacity: unlimited
Module level / module level: AS (Akzentsetzung / Accentuation)
Modular / typ of module: je nach Studiengang Pflicht oder Wahlpflicht
Lehr-/Lernform / Teaching/Learning method: S oder V (2 SWS)

Vorkenntnisse / Previous knowledge

Examination:
- Time of examination
- Type of examination
Final exam of module:
- At the end of the lecture period
- Presentation or oral exam
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inf374 - Special Topics in 'Automotive' I

**Module label**          Special Topics in 'Automotive' I
**Module code**            inf374
**Credit points**          6.0 KP
**Workload**           180 h
**Applicability of the module**
  - Master's Programme Computing Science (Master) > Technische Informatik
**Responsible persons**
  Lehrenden, Die im Modul (Module responsibility)
  Lehrenden, Die im Modul (Authorized examiners)

**Prerequisites**
This module integrates current developments in the field in adequate study courses.

**Professional competences**
The students:

- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

**Methodological competences**
The students:

- evaluate and apply tools, technology and methods sophisticatedly
- combine new and original approaches and methods creatively
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

**Social competences**
The students:

- support team process by their abilities

**Self-competences**
The students:

- pursue the overall and special computer science development critically
- implement innovative professional activities effectively and independently

**Module contents**
See assigned course description, e.g. „Zielarchitekturen Eingebetteter Systeme für Automotive-Anwendungen“

**Reader's advisory**
As announced in course

**Links**

**Language of instruction**          German
**Duration (semesters)**           1 Semester
**Module frequency**            halbjährlich
**Module capacity**             unlimited
**Modullevel / module level**        AS (Akzentsetzung / Accentuation)
**Modulart / typ of module**
  je nach Studiengang Pflicht oder Wahlpflicht
**Lehr-/Lernform / Teaching/Learning method**
  2 Veranst. aus V, S, Ü, P, PR (4SWS)

**Vorkenntnisse / Previous knowledge**

**Examination**

**Final exam of module**
Type of examination
Portfolio or presentation or oral exam

**Course type**
Course selection
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inf375 - Special Topics in 'Automotive' II

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<td>• Support team process by their abilities</td>
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<td>• pursue the overall and special computer science development critically</td>
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<td>• implement innovative professional activities effectively and independently</td>
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Module contents

| Reader's advisory | As announced in course |

Language of instruction

| Duration (semesters) | 1 Semester |

| Module frequency | unregelmäßig |

| Module capacity | unlimited |

| Modullevel / module level | AS (Akzentsetzung / Accentuation) |

| Modulart / typ of module | je nach Studiengang Pflicht oder Wahlpflicht |

| Lehr-/Lernform / Teaching/Learning method | 2 Veranst. aus V, S, Ü, P, PR (4SWS) |

| Vorkenntnisse / Previous knowledge | |

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inf376 - Current Topics in 'Automotive' I

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### Prerequisites

This module integrates current developments in the field in adequate study courses.

#### Professional competences

The students:

- Define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- Recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- Identify, structure and solve problems/tasks, also in new or developing subject areas
- Apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- Are aware of the current limits and contribute to the development of computer science research and technology
- Discuss and evaluate recent computer science developments

#### Methodological competences

The students:

- Examine tasks with technical and research literature, write an academic article and present their solutions academically
- Evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- Schedule time processes and resources

#### Social competences

The students:

- Communicate with users and experts convincingly

#### Self-competences

The students:

- Pursue the overall and special computer science development critically
- Develop and reflect self-developed hypotheses to theories independently

### Module contents

See assigned course description

### Reader's advisory

As announced in course

### Links

Language of instruction: German

Duration (semesters): 1 Semester

Module frequency: unregelmäßig

Module capacity: unlimited

Modullevel / module level: AS (Akzentsetzung / Accentuation)

Modulart / typ of module: je nach Studiengang Pflicht oder Wahlpflicht

Lehr-/Lernform / Teaching/Learning method: S oder V (2 SWS)

### Vorkenntnisse / Previous knowledge

Examination: Time of examination

Type of examination: Presentation or oral exam

Final exam of module: At the end of the lecture period
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inf377 - Current Topics in 'Automotive' II

Module label: Current Topics in 'Automotive' II
Module code: inf377
Credit points: 3.0 KP
Workload: 90 h

Applicability of the module:
- Master's Programme Computing Science (Master) > Technische Informatik

Responsible persons:
Lehrenden, Die im Modul (Module responsibility)
Lehrenden, Die im Modul (Authorized examiners)

Prerequisites:

Skills to be acquired in this module:
This module integrates current developments in the field in adequate study courses.

Professional competences:
The students:
- define and contrast a computer science part, in which they are specialised, in detail or evaluate computer science in general
- recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- identify, structure and solve problems/tasks, also in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- are aware of the current limits and contribute to the development of computer science research and technology
- discuss and evaluate recent computer science developments

Methodological competences:
The students:
- examine tasks with technical and research literature, write an academic article and present their solutions academically
- evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research
- schedule time processes and resources

Social competences:
The students:
- communicate with users and experts convincingly

Self-competences:
The students:
- pursue the overall and special computer science development critically
- develop and reflect self-developed hypotheses to theories independently

Module contents:
See assigned course description

Reader's advisory:
As announced in course

Links:

Language of instruction: German
Duration (semesters): 1 Semester
Module frequency: unregelmäßig
Module capacity: unlimited
Module level / module level: AS (Akzentsetzung / Accentuation)
Modulart / typ of module: je nach Studiengang Pflicht oder Wahlpflicht
Lehr-/Lernform / Teaching/Learning method: S oder V (2 SWS)

Vorkenntnisse / Previous knowledge:

Examination:
Time of examination: At the end of the lecture period
Type of examination: Presentation or oral exam
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inf450 - Correctness of Graph Programs

Module label: Correctness of Graph Programs

Module code: inf450

Credit points: 6.0 KP

Workload: 180 h

Applicability of the module:
- Master's Programme Computing Science (Master) > Theoretische Informatik

Responsible persons:
- Lehrende, Die im Modul (Authorized examiners)
- Lehrende, Die im Modul (Module responsibility)

Prerequisites:
The objectives of this module are modelling of systems, system changes and system properties. Introduction to graph programs. Introduction into system correctness. Methods for proving system correctness.

Professional competence
The students:
- Describe the basics of graph programs and graph properties
- Describe verification procedures of system correctness

Methodological competence
The students:
- Model systems, system changes and system properties
- Apply the formalism of graph programs

Social competence
The students:
- Solve problems in a team
- Present and discuss their proposed solutions

Self-competence
The students:
- Reflect upon their actions with regard to term rewriting systems and the methods of those

Module contents
The module is an introduction to the modelling of systems, system changes and system properties by means of graphs, graph programs and graph conditions and presents a method for proving correctness of systems with respect to a pre- and a postcondition.

The basic structures used in this lecture are graphs; they are used in practically all domains of computing science for the representation of complex structures. Graph programs are constructed from the core constructs of nondeterministic rule application, sequential composition and iteration and they can effect programmatic changes of a graph structure. One well-known method for determining the correctness of programs with respect to a pre- and a postcondition is based on the construction of a weakest precondition of the postcondition with respect to the program and the attempt to decide whether the given precondition implies the computed weakest precondition.

Reader's advisory

Links
Language of instruction: German
Duration (semesters): 1 Semester
Module frequency: im 2-Jahres-Zyklus
Module capacity: unlimited
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| Vorkenntnisse / Previous knowledge | - inf400 Theoretische Informatik I  
- inf401 Theoretische Informatik II |
| Examination | Time of examination | Type of examination |
| Final exam of module | Will be announced during the course presentation or oral exam |
| Course type | Comment | SWS | Frequency | Workload of compulsory attendance |
| Lecture | 3 | WiSe | 42 |
| Exercises | 1 | WiSe | 14 |
| Total time of attendance for the module | | | 56 h |
inf453 - Combination of Specification Techniques

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**Responsible persons**
Olderog, Ernst-Rüdiger (Module responsibility)
Lehrenden, Die im Modul (Authorized examiners)

**Prerequisites**
inf400/inf401 Theoretische Informatik I and II

**Skills to be acquired in this module**
Introduction to the specification languages Z for data, CSP for processes, and their combination CSP-OZ for reactive systems with data and process parts.

**Professional competence**
The students:
- specify data and processes with Z, CSP and CSP-OZ formally
- check data refinement relations formally
- verify CSP-OZ specifications with FDR model checker

**Methodological competence**
The students:
- are able to integrate complementary specification methods

**Social competence**
The students:
- work together in small groups to solve problems
- present solutions to problems to groups of other students

**Self-competence**
The students:
- learn persistence in pursuing difficult tasks
- learn precision in specifying problems

**Module contents**
The course addresses a research trend in formal methods, the combination and integration of different specification methods. It focuses on a concrete combination CSP-OZ of the specification techniques CSP (Communicating Sequential Processes) for processes and Z and Object-Z for data, respectively. Reactive systems are described by CSP-OZ.

As a preparation, the specification languages Z and CSP are described, followed by the combination CSP-OZ with its process-oriented semantics. The concepts of refinement and inheritance and the possibility of automatic verification of a sublanguage of CSP-OZ with the FDR model checker for CSP will be discussed. Finally, the course explains possibilities of extending CSP-OZ for the specification of time-critical systems.

**Topics:**
- specification of complex data and operations in Z, type definition and pattern calculations of Z, data refinement
- specifications of communicating processes in CSP, operational semantics of CSP, three abstract semantic models

for CSP: Trace semantics, failures semantics, failures-divergences semantics, process refinement in the above semantics, FDR model checker for CSP

- combined specification method CSP-OZ, transformational semantics as CSP-process, theorems of refinements,

object-oriented concepts of class and inheritance in CSP-OZ

**Reader's advisory**
Essential:

**Recommended:**


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<td>Modulelevel / module level</td>
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<td>Modulart / typ of module</td>
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**Lehr-/Lernform / Teaching/Learning method**

| Vorkenntnisse / Previous knowledge | - inf400 Theoretische Informatik I                  |
|                                   | - inf401 Theoretische Informatik II                 |

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**Total time of attendance for the module** 56 h
inf454 - Communicating and Mobile Systems

Module label: Communicating and Mobile Systems
Module code: inf454
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module:
- Master's Programme Computing Science (Master) > Theoretische Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons:
Olderog, Ernst-Rüdiger (Module responsibility)
Lehrenden, Die im Modul (Authorized examiners)

Prerequisites:

Skills to be acquired in this module:
Introduction to Milner's Calculus of Communicating Systems (CCS) and the \( \pi \)-calculus.

Professional competence
The students:
- Know the theory of the operational semantics of CCS and the \( \pi \)-calculus
- Perform equivalence proofs using simulations and bisimulations
- Specify communicating and mobile systems with CCS and the \( \pi \)-calculus

Methodological competence
The students:
- Learn about different views on mobility
- Recognize equivalences as formal means for system correctness

Social competence
The students:
- Work together in small groups to solve problems
- Present their solutions to groups of other students

Self-competence
The students:
- Learn persistence in pursuing difficult tasks
- Learn precision in specifying problems

Module contents
Communication is one of the basic concepts of computer science. It occurs between computers in a network as well as between components of a computer. The focus of the course is on Robin Milner's \( \pi \)-calculus. It enables a new modelling of communication, taking the location of the communication into account.

The \( \pi \)-calculus can describe the change of data in a computer as well as the sending of messages or even programs along networks like the internet. It is also possible to describe reconfigurable networks. This will be shown using the examples of mobile phones, schedulers, automatic vending machines, data structures, communication protocols, and objects in object-oriented programming. All these applications are backed by the theory of the \( \pi \)-calculus, which is based on operational semantics and a concept of behavioural equivalence. The theory will be explained in a step-by-step manner.

Topics:
- different views on mobility
- transition systems with simulations and bisimulations
- Milner's Calculus of Communicating Systems (CCS) and Milner's \( \pi \)-calculus for mobile systems, both with operational semantics, structural congruence, strong equivalence and observational equivalence, relationship between reactions and transitions, solvability of recursive equations
- formal specification of examples of communicating and mobile systems using CCS and the \( \pi \)-calculus
- proof of strong equivalence and observational equivalence of given processes
- specification of dynamic data structures in the \( \pi \)-calculus

Reader's advisory

| Links                                      | http://csd.informatik.uni-oldenburg.de/ |
| Languages of instruction                  | German, English                         |
| Duration (semesters)                      | 1 Semester                              |
| Module frequency                          | irregular                               |
| Module capacity                           | unlimited                               |
| Modullevel / module level                 | AS (Akzentsetzung / Accentuation)       |
| Modular / type of module                  | V+Ü                                     |
| Lehr-/Lernform / Teaching/Learning method | V+Ü                                     |
| Vorkenntnisse / Previous knowledge        | Theoretische Informatik II              |
| Examination                               | Time of examination                     |
| Final exam of module                      | At the end of the lecture period        |
| Course type                               | Comment                                 |
| Lecture                                   | 3                                       |
| Exercises                                 | 1                                       |
| Total time of attendance for the module   | 56 h                                    |
### inf456 - Real-Time Systems

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| **Applicability of the module** | Master's Programme Computing Science (Master) > Theoretische Informatik  
 Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction  
 Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering |
| **Responsible persons** | Lehrenden, Die im Modul (Authorized examiners)         
 Olderog, Ernst-Rüdiger (Module responsibility) |

#### Prerequisites

Introduction to formal methods of the specification and verification of time sensitive systems and their combinations.

**Professional competence**

- Learn about different models of time and real-time properties
- Specify and verify real-time systems
- Model real-time systems using Timed Automata and PLC-Automata
- Apply the model checker UPPAAL for the verification of real-time properties
- Specify real-time systems using the Duration Calculus
- Learn about decidability and undecidability results for real-time systems

**Methodological competence**

- Recognize logic and automata as adequate forms for describing real-time systems

**Social competence**

- Work together in small groups to solve problems
- Present their solutions to groups of other students

**Self-competence**

- Learn persistence in pursuing difficult tasks
- Learn precision in specifying problems

### Module contents

Examples of time-critical systems are railway control systems, robots, or even gas burners. It is essential for these systems to comply with certain timing conditions. For example, the control of a railway crossing must close the gates not later than 4 seconds after the sensors have reported an approaching train. If the gates are open, they should stay that way for at least 15 seconds to allow for a safe crossing of vehicles.

Different specification methods have been developed to describe such timing conditions.

The Duration Calculus developed by Zhou Chaochen in 1991 is one attractive method. It is a logic combined with a calculus, in which the duration of states can be described. The course will introduce the Duration Calculus and will explain its application by means of examples. As further specification method Timed Automata introduced by Alur & Dill in 1994 will be presented. After the specification of real-time system requirements the verification of programs implementing these requirements will follow. The specification methods of the Duration Calculus and Timed Automata are used to describe the real-time behaviour of these programs. The correctness is then proven on the basis of these behavioral descriptions.

**Topics:**

- discrete and continuous model of time
- logics and automata models for the specification of real-time systems (predicate logic, Duration Calculus, Timed CTL, Timed Automata, PLC-Automata)
- decidability and undecidability results for real-time systems
- model checker UPPAAL for Timed Automata
- formal specification of real-time systems using Duration Calculus as well as Timed Automata and PLC-Automata
- verification of concrete Timed Automata using the model checker UPPAAL,
- transformation of Duration Calculus for discrete time into regular languages
- implementability of real-time systems on PLC-like hardware

Reader's advisory

essential:


recommended:


Links

Languages of instruction German, English
Duration (semesters) 1 Semester
Module frequency irregular
Module capacity unlimited
Modullevel / module level AS (Akzentsetzung / Accentuation)
Modulart / typ of module V+Ü

Vorkenntnisse / Previous knowledge Theoretische Informatik I + II
Examination Time of examination Type of examination
Final exam of module At the end of the lecture period Exercises and written or oral exam
Course type Comment SWS Frequency Workload of compulsory attendance
Lecture 3 SuSe or WiSe 42
Exercises 1 SuSe or WiSe 14

Total time of attendance for the module 56 h
inf458 - Term Rewriting Systems

Module label: Term Rewriting Systems
Module code: inf458
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module:
- Master's Programme Computing Science (Master) > Theoretische Informatik

Responsible persons:
Lehrende, Die im Modul (Authorized examiners)
Lehrende, Die im Modul (Module responsibility)

Prerequisites:

Skills to be acquired in this module:
The objectives of this module are an introduction to (term) rewriting systems, termination and confluence, the undecidable sets of termination and confluence problems, verification procedures of termination and confluence

Professional competence:
The students:
- describe the basics of term rewriting systems
- characterise the undecidability of termination and confluence problems
- describe verification procedures of termination and confluence

Methodological competence:
The students:
- apply verification procedures of termination and confluence
- apply Huet’s completion procedure

Social competence:
The students:
- solve problems in a team
- present and discuss their results

Self-competence:
The students:
- reflect their actions with regard to term rewriting systems and the methods of those

Module contents:
The module is an introduction to term rewriting systems and provides verification procedures for termination and confluence. Term rewriting systems, termination and confluence are introduced, the undecidability of termination and confluence problems and the decidability for a set of special term rewriting systems are shown. For this purpose reduction and simplification orders, critical pairs, orthogonality and Huet's completion procedure are introduced, examined and combined.

Reader's advisory:

Links:

Language of instruction: German
Duration (semesters): 1 Semester
Module frequency: im 2-Jahres-Zyklus
Module capacity: unlimited
Reference text: Blockveranstaltung
Module level / module level: AC (Aufbaucurriculum / Composition)
Modulart / typ of module: je nach Studiengang Pflicht oder Wahlpflicht
Lehr-/Lernform / Teaching/Learning method:

74 / 95
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Total time of attendance for the module 56 h
inf513 - Simulation-based Smart Grid Engineering and Assessment

Module label
Simulation-based Smart Grid Engineering and Assessment

Module code
inf513

Credit points
6.0 KP

Workload
180 h

Applicability of the module
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik

Responsible persons
Lehnhoff, Sebastian (Module responsibility)

Prerequisites
Programming with JAVA

Skills to be acquired in this module
Successfully completing this lecture will enable the students to mathematically model simple controllable electrical generators and consumers and to simulate them together with appropriate control algorithms within smart grid scenarios. To achieve this goal, students will start with deriving computational models from physical models and evaluate them. In order to manage the integration of control algorithms, students are taught the principles of cosimulation using the "mosaik" smart grid co-simulation framework as an example.

Students will be able to understand and apply distributed, agent-based control schemes to decentralized energy generators and/or consumers. As a result, students are able to analyze the requirements for successful application to real power balancing regarding capacity utilization, robustness, and flexibility. In addition, students learn the foundations of planning and conducting simulation based experiments as well as the interpretation of the results. Special attention will be paid on establishing a balance between the results' precision and robustness and the necessary effort (design of experiments) in order to gain as much insight into interdependencies with as few experiments as possible.

Professional competence
The students:

- derive and evaluate computational models from physical models
- use the "mosaik" smart grid co-simulation framework
- analyze the requirements for successful applications to real power balancing regarding capacity utilization, robustness, and flexibility
- name the foundations of planning and conducting simulation based experiments as well as the interpretation of the results
- are aware of the balance between the results' precision and robustness and the necessary effort (design of experiments) in order to gain as much insight into interdependencies with as few experiments.

Methodological competence
The students:

- model simple controllable electrical generators and consumers
- simulate simple controllable electrical generators and consumers with appropriate control algorithms within smart grid scenarios
- apply distributed agent-based control schemes to decentralized energy generators and/or consumers
- evaluate simulation results
- search information and look into methods to implement models
- propose hypothesis and check their validity with design of experiments methods

Social competence
The students:

- apply the pair programming development technique
- discuss design decisions
- identify work packages and are responsible for it

Self-competence
The students:

- reflect on their own use of power as a limited resource
- accept and use criticism to develop their own behaviour

Module contents
In this practical course students:
- model controllable, modulating electrical energy generators and consumers,
- put their hands on mosaik (installation, description and configuration of scenarios, conduction of simulations),
- learn the principles of agent-based heuristics for optimization problems in future smart grid scenarios,
- learn about the challenges of implementing agent-based mechanisms (multi-criticality, convergency, quality) on the training,
- learn the foundations for choice and design of simulation based experiments.

Reader's advisory

Suggested reading:

Smart Grids:


Multiagentensysteme:


Co-Simulation


Versuchsplanung:

- Klein, B.: "Versuchsplanung - DoE", Oldenbourg, 2011

Links

http://mosaik.offis.de

Language of instruction

German

Duration (semesters)

1 Semester

Module frequency

jährlich

Module capacity

unlimited

Reference text

Elective module in the master specialization area (energy computer science).

Associated with the modules:

- Energieinformationssysteme
- Smart Grid Management

Modullevel / module level

AS (Akzentsetzung / Accentuation)

Modulart / typ of module

je nach Studiengang Pflicht oder Wahlpflicht

Lehr-/Lernform / Teaching/Learning method

- Programmierung mit Java
- Programmierung mit Python

Vorkenntnisse / Previous knowledge

Examination

Time of examination

Type of examination

Final exam of module

At the end of the semester

Oral exam

Course type

Practical training

SWS

4

Frequency

SuSe

Workload attendance

56 h
inf533 - Probabilistic Modelling I

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Applicability of the module
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons
- Boll-Westermann, Susanne (Module responsibility)
- Fatikow, Sergej (Module responsibility)
- Marx Gomez, Jorge (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

Prerequisites

Skills to be acquired in this module
Probabilistic Bayesian models are generated with special tools (e.g. BUGS, JAGS, STAN) or domain specific programming languages (, WebPPL, PyMC3, …etc.). If they mimic cognitive processes of humans (e.g. pilots, drivers) or animals they could be used as cooperative assistance systems in technical or financial systems like cars, robots, or recommenders.

Professional competence
The students:
- learn to map problem to model classes to come up with practical solutions

Methodological competence
The students:
- acquire basic skills in the design, implementation, and identification of probabilistic models with Bayesian methods
- acquire knowledge about alternative non-Bayesian machine learning methods

Social competence
The students:
- learn to present and discuss probabilistic theories, methods, and models.

Self-competence
The students:
- reflect and evaluate chances and limitations of probabilistic approaches
- learn to deliberate on machine-learning alternatives

Module contents
Theories, methods, and examples of Bayesian models with practical applications

Reader's advisory
Recent eBooks, eTutorials

Links
http://www.uni-oldenburg.de/en/computingscience/lcs/probabilistic-programming/

Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency
jährlich

Module capacity
unlimited

Reference text
Associated with the module:
- inf534 Probabilistic Modelling II

Modullevel / module level
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inf534 - Probabilistic Modelling II

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**Applicability of the module**
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodul der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction

**Responsible persons**
- Boll-Westermann, Susanne (Module responsibility)
- Marx Gomez, Jorge (Module responsibility)
- Fatikow, Sergej (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

**Prerequisites**
Probabilistic models are generated with special tools (e.g. BUGS, JAGS, STAN) or domain specific programming languages (WebPPL, PyMC3, …, etc.). If they mimic cognitive processes of humans (e.g. pilots, drivers) or animals they could be used as cooperative assistance systems in technical or financial systems like cars, robots, or recommenders. In this part of the seminar we read, present, and discuss recent research papers.

**Professional competence:**
The students:
- learn to connect problem- with model classes to come up with practical solutions

**Methodological competence**
The students:
- acquire advanced skills in the design, implementation, and identification of probabilistic models with Bayesian methods
- acquire knowledge about alternative machine learning methods

**Social competence**
The students:
- learn to present and discuss probabilistic theories, methods, and models

**Self-competence**
The students:
- reflect and evaluate chances and limitations of probabilistic approaches
- learn to deliberate on machine-learning alternatives

**Module contents**
Theories, methods, and examples of Bayesian models with practical applications

**Reader's advisory**
Recent publications

**Links**
http://www.uni-oldenburg.de/en/computingscience/lcs/probabilistic-programming/

**Language of instruction**
German

**Duration (semesters)**
1 Semester

**Module frequency**
halbjährlich

**Module capacity**
unlimited

**Reference text**
Associated with the module:
- inf533 Probabilistische Modellierung I

**Module level / module level**
AS (Akzentsetzung / Accentuation)
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<td>- Grundkenntnisse Progammierung</td>
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**inf950 - Interdisciplinary Module I**

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<td>Workload</td>
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</tr>
<tr>
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<td>Lehrenden, Die im Modul (Authorized examiners)</td>
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</table>

**Prerequisites**

**Skills to be acquired in this module**

**Ziele des Moduls/Kompetenzen:**
Die Absolventinnen und Absolventen kennen die Grundlagen und anwendungsrelevanten Hintergründe der ausgewählten Disziplin.

**Fachkompetenzen**
Die Studierenden:

- benennen die Grundlagen und Methoden des gewählten Gebietes
- wenden die Fachsprache des Anwendungsgebietes kompetent an

**Methodenkompetenzen**
Die Studierenden:

- charakterisieren Nutzungskontext und Anforderungen von IT im gewählten Gebiet
- wenden die disziplinären Methoden und Techniken des Anwendungsgebietes an und kontrastieren diese mit den aus der Informatik bekannten Methoden und Techniken
- untersuchen Probleme eines Anwendungsgebietes mit den disziplin-typischen Methoden

**Sozialkompetenzen**
Die Studierenden:

- können die Verschiedenheit von Fachkulturen einschätzen und respektieren andere Fachgebiete und deren Arbeitsweise
- bereiten sich auf Anwendungsszenarien für IT-Systeme vor

**Selbstkompetenzen**
Die Studierenden:

- reflektieren ihr Selbstbild und Handeln vor dem Hintergrund einer anderen Fachdisziplin

**Module contents**
Das Modul wird mit Fachmodulen aus anderen Disziplinen oder Modulen des Departments für Informatik instanziert, die als Nicht Informatik-Modul gekennzeichnet sind. Die Veranstaltungsformen und Prüfungsmodalitäten orientieren sich an dem jeweils gewählten Modul.

**Reader’s advisory**

**Languages of instruction**

**Duration (semesters)**
1 Semester

**Module frequency**

**Module capacity**
unlimited

**Modulart / typ of module**
AS (Akzentsetzung / Accentuation)

**Lehr-/Lernform / Teaching/Learning method**
je nach Studiengang Pflicht oder Wahlpflicht

**Vorkenntnisse / Previous knowledge**

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**Course type**
Course selection

**SWS**
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inf514 - Simulation-based Smart Grid Engineering and Assessment

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<td>Lehnhoff, Sebastian (Module responsibility) Lehrenden, Die im Modul (Authorized examiners)</td>
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Skills to be acquired in this module

Das Modul hat zum Ziel in der Energieinformatik benötigte mathematische und methodische Grundlagen zur Durchführung großer Simulationsstudien zu vermitteln.

**Fachkompetenzen**

Die Studierenden

- kennen Methoden zur Analyse von BlackBox-Zielfunktionen
- erkennen die Zusammenhang zwischen Genauigkeit und Zuverlässigkeit erwarteter Ergebnisse und dem dazu notwendigen Aufwand
- kennen Verfahren, um mit möglichst wenigen Versuchen (Einzelexperimenten) Wirkzusammenhänge zwischen Einflussfaktoren und beobachteten Zielgrößen sicher zu bestimmen
- bewerten die Aussagekraft von durch Simulation erzielten Ergebnissen
- charakterisieren (verteilt) Algorithmen anhand ihrer Eigenschaften
- transferieren Beweistechniken auf verteilt Problemstellungen

**Methodenkompetenzen**

Die Studierenden

- wählen geeignete statistische Methoden zur Auswertung von Simulationsergebnissen
- wenden Methoden der statistischen Versuchsplanung an
- erzeugen Signifikanztests an zur Bewertung und zum Vergleich von Algorithmen
- erzeugen beliebig verteilte Daten zur Simulation
- stellen Ergebnisse der Algorithmenbewertung statistisch valide dar

**Sozialkompetenzen**

Die Studierende

- diskutieren die getroffene Algorithmenauswahl
- präsentieren und diskutieren Ergebnisse mit anderen Studierenden

**Selbstkompetenz**

Die Studierenden

- reflektieren den eigenen Umgang mit der begrenzten Ressource Energie
- erheben Probleme und Unsicherheiten statistischer Methoden
- erkennen die Grenzen simulativer Studien und die Verantwortung bei der richtigen Wahl statistischer Methoden
- nehmen Kritik an und verstehen sie als Vorschlag für die Weiterentwicklung des eigenen Handelns

Module contents

In dieser Veranstaltung werden

- mathematische Grundlagen (Algebra, Statistik, mehrdimensionale Analysis, Regressions-
Korrelationsanalyse der Energieinformatik vermittelt
Grundlagen zu Bewertungssystemen (Metriken, Kriterien) vermittelt
verschiedene Methoden zur statistischen Auswertung praktisch vermittelt

Reader's advisory
Wird in der Veranstaltung bekannt gegeben

Links

Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency
im Wintersemester

Module capacity
unlimited

Modullevel / module level
MM (Mastermodul / Master module)

Modulart / typ of module
Wahlpflicht / Elective

Lehr-/Lernform / Teaching/Learning method
V + Ü

Vorkenntnisse / Previous knowledge
Programmiergrundlagen in Java oder Python

Examination
Time of examination  
Type of examination
Final exam of module
Am Ende der Veranstaltungszeit  
mündliche Prüfung

Course type  
Comment  
SWS  
Frequency  
Workload of compulsory attendance

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<th>Frequency</th>
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<td>Exercises</td>
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Total time of attendance for the module 56 h
inf515 - Intelligent Energy Systems

Module label: Intelligent Energy Systems
Module code: inf515
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module:
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik

Responsible persons:
Bremer, Jörg (Module responsibility)
Lehnhoff, Sebastian (Module responsibility)
Lehrende, Die im Modul (Authorized examiners)

Prerequisites

Skills to be acquired in this module

Das Modul befasst sich mit der Integration (verteilter) künstlicher Intelligenz in die zukünftige Steuerung des Energienetzes.
Das Modul vermittelt moderne Techniken der künstlichen Intelligenz und des maschinellen Lernens als Beitrag beispielsweise in der semi-automatischen Betriebsführung von Stromnetzen, bei der von Einsicht getriebenen Vermarktung von dezentralen Energieanlagen oder bei der Prognose von Last- und Erzeugungszeitreihen

Fachkompetenzen
Die Studierenden
- kennen Methoden zur Modellierung der Flexibilität von Energieanlagen mittels maschinellem Lernen
- können Flexibilitätsmodelle implementieren
- kennen verschiedene Ansätze der Agenten-basierten Modellierung und Koordination im elektrischen Netz
- kennen Techniken des Adversarial Resilience Learning
- bewerten verschiedene Verfahren des Deep und Reinforcement Learning hinsichtlich ihrer Eigenschaften und Eignung in der verteilten Lastplanung
- charakterisieren Methoden maschinellen Lernens anhand ihrer Eigenschaften

Methodenkompetenz
Die Studierenden
- erzeugen systematisch zulässige Lösungen mittels Einsatz von Dekodertechnik
- wenden maschinelles Lernen in verteilten Algorithmen praktisch an

Sozialkompetenz
Die Studierenden
- wenden die Entwicklungsmethode des Pairprogrammings an
- diskutieren die getroffenen Design Entscheidungen
- präsentieren ihre Arbeitsergebnisse anderen Studierenden

Selbstkompetenz
Die Studierenden
- reflektieren den eigenen Umgang mit der begrenzten Ressource Energie
- nehmen Kritik an und verstehen sie als Vorschlag für die Weiterentwicklung des eigenen Handelns
- erkennen die gesellschaftspolitische Verantwortung beim Einsatz von Methoden der künstlichen Intelligenz

Module contents
In dieser Veranstaltung werden
- mathematische Grundlagen Supportvektor-basierter Modellierungstechniken vermittelt
- geometrische Untervektorraummodellierungen vermittelt und von den Studierenden angewendet
- Grundlagen verteilter Algorithmen in Energienetzen vermittelt
- das Design intelligenter Agenten mittels Reinforcement Learning und Q-Learning vermittelt und praktisch angewendet
- Grundlagen des Adversarial Resilience Learning vermittelt
Reader's advisory

- Mehr wird in der Veranstaltung bekannt gegeben

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inf516 - Agent-based Methods in Energy Systems

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Applicability of the module
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik

Responsible persons
- Nieße, Astrid (Module responsibility)
- Lehrenden, Die im Modul (Authorized examiners)

Prerequisites

Skills to be acquired in this module

Module contents

Reader's advisory

Links

Languages of instruction
- German, English

Duration (semesters)
- 1 Semester

Module frequency
- unlimited

Modulelevel / module level
- MM (Mastermodul / Master module)

Modulart / typ of module
- Wahlpflicht / Elective

Vorkenntnisse / Previous knowledge

Examination

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Course type

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<td>SuSe or WiSe</td>
<td>28</td>
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Total time of attendance for the module
- 56 h
Abschlussmodul
mam - Master´s Thesis Module

Module label Master´s Thesis Module
Module code mam
Credit points 30.0 KP
Workload 900 h

Applicability of the module

Responsible persons
Sonnenschein, Michael (Module responsibility)
der Informatik, Lehrende (Authorized examiners)

Prerequisites

Skills to be acquired in this module
The students prove that they are able to process and solve complex computer science tasks based on gained scientific knowledge and applied research methods. The students successfully implement a task especially by using their acquired professional and methodological knowledge and their professional and social competences.
The accompanying seminar is used to discuss the master's thesis methodically and content-related. During the seminar the exchange of research and practical experience fosters the students' ability to discuss and evaluate their thesis with other students and experts.
The master's thesis is finished by a colloquium.

Professional competence
The students:

- Recognise and evaluate applied techniques and methods of their subject and are aware of their limits
- Design solutions for complex, possibly vaguely defined or unusual computer science tasks/problems and evaluate these with reference to state of the art computer science and technology
- Identify, structure and solve problems/tasks, also in new or developing subject areas
- Apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- Relate knowledge from different disciplines and apply this new knowledge in complex situations
- Develop complex computer systems, processes and datamodels
- Are aware of the current limits and contribute to the development of computer science research and technology
- Discuss and evaluate recent computer science developments

Methodological competence
The students:

- Identify and develop one or more solutions
- Evaluate and apply tools, technology and methods sophisticatedly
- Examine tasks with technical and research literature, write an academic article and present their solutions academically
- Schedule processes and resources
- Apply project management techniques
- Combine new and original approaches and methods creatively
- Evaluate problems/tasks, including new or developing subject areas of their discipline and apply computer science methods for solutions and research

Social competence
The students:

- Communicate with users and experts convincingly
- Take reasonable decisions

Self-competence
The students:

- Pursue the overall and special computer science development critically
- Implement innovative professional activities effectively and independently
- Recognise their abilities and extend them purposefully
- Reflect their self-perception and actions with regard to professional, methodological and social aspects
- Develop and reflect self-developed hypotheses to theories independently
- Work in their field independently
<table>
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<th>The content of this module is an independent topic research. The research findings will be presented and discussed in a master’s thesis colloquium.</th>
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<td><strong>Reader's advisory</strong></td>
<td>Wird entsprechend des konkreten Themas spezifiziert.</td>
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<td><a href="https://www.uni-oldenburg.de/informatik/studium-lehre/infos-zum-studium/abschlussarbeiten/">https://www.uni-oldenburg.de/informatik/studium-lehre/infos-zum-studium/abschlussarbeiten/</a></td>
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## Frühere Module

### inf191 - Special Topics in Practical Computer Science II

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**Applicability of the module**
- Master's Programme Computing Science (Master) > Praktische Informatik

**Responsible persons**

**Prerequisites**

**Skills to be acquired in this module**

Das Modul hat zum Ziel aktuelle Entwicklungen im Vertiefungsgebiet "Zuverlässige Systeme" II in den jeweils angemessenen Lehrveranstaltungsformen in das Studium zu integrieren.

**Fachkompetenzen**
- differenzieren und kontrastieren einen Teilbereich der Informatik, auf den sie sich spezialisiert haben, im Detail genauer oder reflektieren die Informatik im Allgemeinen
- erkennen und beurteilen die in ihrem Spezialgebiet anzuwendenden Techniken und Methoden und deren Grenzen
- identifizieren, strukturieren und lösen Probleme auch in neuen oder erst im Entstehen begriffenen Bereichen ihrer Disziplin
- wenden dem Stand der Wissenschaft entsprechende und innovative Methoden bei der Untersuchung und Lösung von Problemen an, gegebenenfalls unter Rückgriff auf andere Disziplinen
- erkennen die Grenzen des heutigen Wissenstands und der heutigen Technik und tragen zur weiteren wissenschaftlichen und technologischen Entwicklung der Informatik bei
- diskutieren aktuelle Entwicklungen der Informatik und beurteilen deren Bedeutung

**Methodenkompetenzen**
- evaluieren Werkzeuge, Technologien und Methoden und wenden diese differenziert an
- entwickeln kreativ neue und originäre Vorgehensweisen und Methoden
- reflektieren Probleme auch in neuen oder erst im Entstehen begriffenen Bereichen ihrer Disziplin und wenden Informatik-Methoden zur Untersuchung und Lösung an

**Sozialkompetenzen**
- integrieren ihre Fähigkeiten in Teamsprozesse

**Selbstkompetenzen**
- verfolgen die weitere Entwicklung in der Informatik allgemein und in ihrem Spezialgebiet kritisch
- führen innovative Tätigkeiten in ihrem Berufsfeld erfolgreich und eigenverantwortlich aus

**Module contents**

je nach Vertiefungsgebiet und zugeordneter Lehrveranstaltung

**Reader's advisory**

je nach Vertiefungsgebiet und zugeordneter Lehrveranstaltung

**Links**

**Language of instruction**
- German

**Duration (semesters)**
- 1 Semester

**Module frequency**
- unregelmäßig

**Module capacity**
- unlimited

**Modullevel / module level**

**Modulart / typ of module**
- Lehr-/Lernform / Teaching/Learning method
  - 2 Veranstaltungen aus V, Ü, S, P, PR

**Vorkenntnisse / Previous knowledge**

**Examination**
- Time of examination
- Type of examination

**Final exam of module**
- Am Ende der Vorlesungszeit nach Absprache mit dem Lehrenden
  - Fachpraktische Übungen oder Referat oder mündliche Prüfung

**Course type**
- **Comment**
- **SWS**
- **Frequency**
- **Workload of compulsory attendance**

<table>
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**Total time of attendance for the module**

56 h
**inf189 - Special Topics in Practical Computer Science I**

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**Prerequisites**

**Skills to be acquired in this module**

Das Modul hat zum Ziel aktuelle Entwicklungen im Vertiefungsgebiet XYZ in den jeweils angemessenen Lehrveranstaltungsformen in das Studium zu integrieren.

**Fachkompetenzen**

Die Studierenden: - differenzieren und kontrastieren einen Teilbereich der Informatik, auf den sie sich spezialisiert haben, im Detail genauer oder reflektieren die Informatik im Allgemeinen - erkennen und beurteilen die in ihrem Spezialgebiet anzuwendenden Techniken und Methoden und deren Grenzen - identifizieren, strukturieren und lösen Probleme auch in neuen oder erst im Entstehen begriffenen Bereichen ihrer Disziplin - wenden den Stand der Wissenschaft entsprechende und innovative Methoden bei der Untersuchung und Lösung von Problemen an, gegebenenfalls unter Rückgriff auf andere Disziplinen - erkennen die Grenzen des heutigen Wissenstands und der heutigen Technik und tragen zur weiteren wissenschaftlichen und technologischen Entwicklung der Informatik bei - diskutieren aktuelle Entwicklungen der Informatik und beurteilen deren Bedeutung

**Methodenkompetenzen**

Die Studierenden: - untersuchen Probleme anhand technischer und wissenschaftlicher Literatur verfassen nach wissenschaftlichen Gesichtspunkten einen Artikel und präsentieren ihre Ergebnisse in einem wissenschaftlichen Vortrag - reflektieren Probleme auch in neuen oder erst im Entstehen begriffenen Bereichen ihrer Disziplin und wenden Informatik-Methoden zur Untersuchung und Lösung an - planen zeitliche Abläufe und andere Ressourcen Sozialkompetenzen

Die Studierenden: - kommunizieren überzeugend mündlich und schriftlich mit Anwendern und Fachleuten Selbstkompetenzen

Die Studierenden: - verfolgen die weitere Entwicklung in der Informatik allgemein und in ihrem Spezialgebiet kritisch entwickeln und reflektieren eigene Theorien zu selbständig aufgestellten Hypothesen

**Module contents**

In diesem Modul werden aktuelle Themen aus dem Gebiet Rechnernetze und Telekommunikation angeboten. Einzelheiten zu Zielen und Inhalten entnehmen Sie bitte der zugeordneten Veranstaltung oder wenden Sie sich direkt an den Lehrenden

**Reader's advisory**

je nach Vertiefungsgebiet und zugeordneter Lehrveranstaltung

**Links**

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**Modulelevel / module level**

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**Vorkenntnisse / Previous knowledge**

Examination

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**Course type**

Seminar

**SWS**

2

**Frequency**

Workload attendance

28 h
**inf581 - Special Topics in 'Digitalized Energy Systems'**

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**Total time of attendance for the module** 56 h