Modules for Embedded Systems and Microrobotics

Kernmodule

inf900 - Group Project

<table>
<thead>
<tr>
<th>Module label</th>
<th>Group Project</th>
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<tbody>
<tr>
<td>Module code</td>
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<tr>
<td>Credit points</td>
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<tr>
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<td>Master Informatik &gt; Kernmodule</td>
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<tr>
<td>Contact person</td>
<td>Module responsibility</td>
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<td></td>
<td>○ Die im Modul Lehrenden</td>
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<tr>
<td>Authorized examiners</td>
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Entry requirements

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

1 / 83
<table>
<thead>
<tr>
<th>Languages of instruction</th>
<th>German, English</th>
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<tbody>
<tr>
<td>Duration (semesters)</td>
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<td>- Programmierkurs</td>
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<td>- Softwaretechnik</td>
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<td>- Soft Skills</td>
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<td>Active involvement, presentation, final report, project assessment</td>
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<table>
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<td>Workload attendance</td>
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Akzentsetzungsmodule

inf100 - Human Computer Interaction

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<th>Human Computer Interaction</th>
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<td></td>
<td>Susanne Boll-Westermann</td>
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<td>Entry requirements</td>
<td>Professional competence</td>
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<tr>
<td></td>
<td>The students:</td>
</tr>
<tr>
<td></td>
<td>Name the human-computer interaction core principles</td>
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<tr>
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<td>Characterise the basic elements of the human-centered design of interactive systems</td>
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<td>Methodological competence</td>
<td>The students:</td>
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<tr>
<td></td>
<td>Comprehend context of use and user requirements of human-machine interfaces</td>
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<tr>
<td></td>
<td>Design, develop and evaluate human-machine interfaces</td>
</tr>
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<td></td>
<td>Conduct experiments with their prototypes</td>
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<td>Social competence</td>
<td>The students:</td>
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<tr>
<td></td>
<td>Implement human-computer interfaces in practical hands-on projects in teams</td>
</tr>
<tr>
<td></td>
<td>Evaluate human-machine interfaces with potential users</td>
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<tr>
<td></td>
<td>Develop and present solutions for Human-Computer Interaction related problems</td>
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<td></td>
<td>Integrate technical and factual comments into own results</td>
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<tr>
<td>Module contents</td>
<td>The module introduces the field of human-computer interfaces and their historical context. Moreover, it shows motivating examples of human-computer interaction. The module covers the core principles of human-computer interaction. In detail, the module deals with the design concepts of interactive systems: context of use, requirements and task analysis, human perception capabilities, design process, usability, prototyping and evaluation. During the practical project a concrete human-computer interface will be designed, developed and evaluated according to this concepts.</td>
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<td>medien.informatik.uni-oldenburg.de/lehre</td>
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<td>Lern- Lehrform / Type of program</td>
<td>V + P</td>
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<th>Type of examination</th>
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<tr>
<td>Final exam of module</td>
<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. Find out more about the schedule 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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<th>Comment</th>
<th>SWS</th>
<th>Frequency</th>
<th>Workload attendance</th>
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<tr>
<td>Lecture</td>
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<tr>
<td>Practical</td>
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<td>SuSe</td>
<td>28 h</td>
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| Total time of attendance for the module | 56 h |


inf105 - Fault Tolerance in Distributed Systems

Module label: Fault Tolerance in Distributed Systems
Module code: inf105
Credit points: 6.0 KP
Workload: 180 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Praktische Informatik

Contact person:
Module responsibility: Oliver Theel
Authorized examiners:
- Die im Modul Lehrenden
- Die Modulverantwortlichen
Module counseling:
- Die im Modul Lehrenden

Entry requirements:

Skills to be acquired in this module:
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

Links

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

Reference text: connectet with:
Betriebssysteme 1 und 2
Betriebssysteme-Praktikum
Verteilte Betriebssysteme

Modullevel: AS (Akzentsetzung / Accentuation)
Modulart: Wahlpflicht / Elective

Vorkenntnisse / Previous knowledge: V+S or V+Ü

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<th>Type of examination</th>
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<tr>
<td>Final exam of module</td>
<td>End of lecture period</td>
<td>written exam or oral exam or practical work</td>
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<td>Seminar or exercise</td>
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<td>WiSe</td>
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Total time of attendance for the module: 56 h
inf300 - Hybrid Systems

Module label Hybrid Systems
Module code inf300
Credit points 6.0 KP
Workload 180 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Engineering of Socio-Technical Systems > Embedded Brain Computer Interaction
- Master Informatik > Technische Informatik
- Master Informatik > Theoretische Informatik

Contact person
Module responsibility
- Martin Georg Fränzle
- Die im Modul Lehrenden

Authorized examiners
- Martin Georg Fränzle
- Die im Modul Lehrenden

Entry requirements

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


Links

- Languages of instruction: English, German
- Duration (semesters): 1 Semester
- Module frequency: once a year
- Module capacity: unlimited
- Module level: AS (Akzentsetzung / Accentuation)
- Modulart: Pflicht o. Wahlpflicht / compulsory or optional
- Lern-/Lehrform / Type of program: V+Ü

Previous knowledge

- Examination: Final exam of module at the end of the lecture period
- Type of examination: Semester project including written work and final presentation

Course type

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<tr>
<td>Lecture</td>
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Total time of attendance for the module: 56 h
inf301 - Machine-oriented Systems Engineering

Module label: Machine-oriented Systems Engineering

Module code: inf301

Credit points: 6.0 KP

Workload: 180 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Engineering of Socio-Technical Systems > Embedded Brain Computer Interaction
- Master Engineering of Socio-Technical Systems > Human-Computer Interaction
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Informatik > Technische Informatik

Contact person:

Module responsibility:
- Alfred Mikschl
- Werner Damm
- Die im Modul Lehrenden

Authorized examiners:
- Alfred Mikschl
- Die im Modul Lehrenden

Entry requirements:

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: German, English

Duration (semesters): 1 Semester

Module frequency: semi-annual

Module capacity: unlimited

Modullevel: AS (Akzentsetzung / Accentuation)

Modulart: Pflicht o. Wahlpflicht / compulsory or optional

Lern-Lehrform / Type of program: V+P

Vorkenntnisse / Previous knowledge: „Eingebettete Systeme I and II“ and successful completion of the module „Praktikum Technische Informatik“
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<td>Final exam of module</td>
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<td>Portfolio (Design, development and implementation of embedded systems, colloquium)</td>
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<td>WiSe</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

Module label: Fuzzy Control and Artificial Neural Networks in Robotics and Automation

Module code: inf303

Credit points: 6.0 KP

Workload: 180 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodulle
- Master Engineering of Socio-Technical Systems > Embedded Brain Computer Interaction
- Master Engineering of Socio-Technical Systems > Human-Computer Interaction
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Engineering Physics > Schwerpunkt: Renewable Energies
- Master Informatik > Angewandte Informatik
- Master Informatik > Technische Informatik

Contact person:
Module responsibility:
- Sergej Fatikow
- Die im Modul Lehrenden

Authorized examiners:
- Sergej Fatikow
- Die im Modul Lehrenden

Entry requirements:
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 AMIR
- 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:

• Kahler, J.: Fuzzy Control für Ingenieure, Vieweg, Braunschweig Wiesbaden, 1995
• Zell, A.: Simulation Neuronaler Netze, Addison-Wesley / Oldenbourg Verlag, Bonn, 1996

Secondary Literature:

• Altrock, M. O. R.: Fuzzy Logic, R. Oldenbourg Verlag, 1993
• Kahler, J. und Hubert, F.: Fuzzy-Logik und Fuzzy-Control, Vieweg, 1993
• Kretzer, K.P.: Neuronale Netze, Carl Hanser, 1993
• Lawrence, J.: Neuronale Netze, Syshema Verlag, München, 1992
• Omidvar, O. and van der Smagt, P. (eds.): Neural Networks for Robotics, Academic Press, 1997
• Patterson, D.W.: Künstliche neuronale Netze, Prentice Hall, 1996
• Pham, D.T.: Fuzzy Logic: Technology, Oldenbourg, 1993
• nd Liu, X.: Neural Networks for Identification, Prediction and Control, Springer, 1997
• Rigoll, G.: Neuronale Netze, Expert Verlag, Renningen-Malsheim, 1994
• Schulte, U.: Einführung in Fuzzy-Logik, Franzis-Verlag, München, 1993
• von Altrock, C.: Fuzzy Logic: Technologie, Oldenbourg, 1993
• Zahariarion, S., Ladewig-Reibling, P. und Thoer, St.: Neuronale Netze für Ingenieure, Vieweg, Wiesbaden, 1998
• Zimmermann H.-J. (Hrsg.): Datenerfassung, VDI-Verlag, 1995
• Zimmermann, H.-J. (Hrsg.): Neuro + Fuzzy: Technologien und Anwendungen, VDI-Verlag, 1995

Links

Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency
once a year

Module capacity
unlimited

Modullevel
AS (Akzentsetzung / Accentuation)

Modulart
Pflicht o. Wahlpflicht / compulsory or optional

Lern-Lehrform / Type of program
V+Ü

Vorkenntnisse / Previous knowledge
Control engineering

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

Course type
Comment
SWS
Frequency
Workload attendance

12 / 83
<table>
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<th>Course type</th>
<th>Comment</th>
<th>SWS</th>
<th>Frequency</th>
<th>Workload attendance</th>
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**Total time of attendance for the module**  
56 h
# inf305 - Medical Technology

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</table>
| Used in course of study | | Master eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule  
|               | Master Engineering of Socio-Technical Systems > Embedded Brain Computer Interaction  
|               | Master Engineering of Socio-Technical Systems > Human-Computer Interaction  
|               | Master Engineering of Socio-Technical Systems > Systems Engineering  
|               | Master Informatik > Nicht Informatik  
|               | Master Informatik > Technische Informatik |
| Contact person | Module responsibility  
|               | Andreas Hein  
|               | Die im Modul Lehrenden  
| Authorized examiners | Die im Modul Lehrenden  
|               | Andreas Hein |
| Entry requirements | 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:
• Dugas, M.; Schmidt, K.: Medizinische Informatik und Bioinformatik. Springer Verlag, 2003

secondary literature:


Links

Languages of instruction  German, English
Duration (semesters)  1 Semester
Module frequency  once a year
Module capacity  unlimited
Module level  AS (Akzentsetzung / Accentuation)
Module type  Pflicht o. Wahlplicht / compulsory or optional
Lern-Lehrform / Type of program  V+Ü
Vorkenntnisse / Previous knowledge  
- Signal and Image Processing
- Control Engineering

Examination  Time of examination  Type of examination

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<thead>
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<th>At the end of the lecture period</th>
<th>Portfolio: Hands-on exercises, report, and written or oral exam</th>
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Course type  Comment  SWS  Frequency  Workload attendance

| Lecture  3.00  WiSe  42 h |
| Exercizes  1.00  WiSe  14 h |

Total time of attendance for the module  56 h
inf307 - Robotics

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<tr>
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<td>Module code</td>
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<tr>
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<td>6.0 KP</td>
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<tr>
<td>Workload</td>
<td>180 h</td>
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</table>

**Used in course of study**
- Master Engineering of Socio-Technical Systems > Embedded Brain Computer Interaction
- Master Engineering of Socio-Technical Systems > Human-Computer Interaction
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Informatik > Nicht Informatik
- Master Informatik > Technische Informatik

**Contact person**

**Module responsibility**
- Andreas Hein
- Die im Modul Lehrenden

**Authorized examiners**
- Die im Modul Lehrenden
- Andreas Hein

**Entry requirements**

**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:**
- Juckenack, D.: Handbuch der Sensortechnik: Messen mechanischer Größen. Verlag moderne Industrie,
  Landsberg/Lech, 1989.
- Jiang, X.; Bunke, H.: Dreidimensionales Computersehen (Gewinnung und Analyse von Tiefenbildern), Springer
  Verlag, 1997.

**secondary literature:**

Links

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Vorkenntnisse / Previous knowledge

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<td>At the end of the lecture periode</td>
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</table>

Course type                  | Comment | SWS | Frequency | Workload attendance |
---                          |---------|-----|-----------|---------------------|
Lecture                     | 3.00    | SuSe| 42 h      |
Exercises                   | 1.00    | SuSe| 14 h      |

Total time of attendance for the module 56 h
-inf308 - Microrobotics II-

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<td></td>
<td>Master Engineering of Socio-Technical Systems &gt; Human-Computer Interaction</td>
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<td>Master Engineering of Socio-Technical Systems &gt; Systems Engineering</td>
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**Contact person**

- Module responsibility
  - Sergej Fatikow
  - Die im Modul Lehrenden

- Authorized examiners
  - Sergej Fatikow
  - Die im Modul Lehrenden

**Entry requirements**

**Skills to be acquired in this module**

After having given an established introduction in the module “Microrobotics and Microsystems 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 secretariate, A1-3-303)
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<td>Languages of instruction</td>
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inf311 - Low Energy System Design

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<td>Contact person</td>
<td>Wolfgang Nebel</td>
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<tr>
<td></td>
<td>Die im Modul Lehrenden</td>
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Authorized examiners

- Die im Modul Lehrenden
- Wolfgang Nebel

Entry requirements

Skills to be acquired in this module

This module introduces the estimation of power dissipation and optimisation.

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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<th>Languages of instruction</th>
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<td>- inf200 Grundlagen der Technische Informatik, - inf201 Technische Informatik, - inf203 Eingebettete Systeme I, - inf204 Eingebettete Systeme II</td>
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<td>hands-on exercises and oral exam</td>
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Total time of attendance for the module 56 h
inf350 - Special Topics in 'Safety-Critical Systems' I

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<td>- Andreas Hein</td>
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<td>- Werner Damm</td>
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<td>- Andreas Hein</td>
</tr>
<tr>
<td></td>
<td>- Werner Damm</td>
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</table>

**Entry requirements**

**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“, „Modellbasiertes 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: AS (Akzentsetzung / Accentuation)

Modulart: je nach Studiengang Pflicht oder Wahlpflicht

Lern-Lehrform / Type of program: 2 courses out of V, S, Ü, P, PR
## Previous knowledge

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inf351 - Special Topics in 'Safety-Critical Systems' II

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| Used in course of study             | Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungmodule  
                                         Master Informatik > Technische Informatik |
| Contact person                      | Module responsibility                           |
|                                    | Andreas Hein                                     |
|                                    | Werner Damm                                      |
|                                    | Die im Modul Lehrenden                            |
| Authorized examiners                | Andreas Hein                                     |
|                                    | Werner Damm                                      |
|                                    | Die im Modul Lehrenden                            |

| Entry requirements                  | 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, e.g. „Sicherheitsanalysetechniken“, „Modellbasierter Systementwurf“, ... |
| Reader's advisory                  | As announced in course                        |

<p>| Links                               |                                              |
| Language of instruction             | German                                       |
| Duration (semesters)                | 1 Semester                                   |
| Module frequency                    | halbjährlich                                 |
| Module capacity                     | unlimited                                    |
| Modulelevel                         | AS (Akzentsetzung / Accentuation)            |
| Modulart                            | je nach Studiengang Pflicht oder Wahlpflicht |</p>
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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

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Technische Informatik

Contact person
Module responsibility
- Andreas Hein
- Werner Damm
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Werner Damm
- Die im Modul Lehrenden

Entry requirements

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

Modullevel
AS (Akzentsetzung / Accentuation)

Modulart
je nach Studiengang Pflicht oder Wahlpflicht
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</table>
CurrentTopics in 'Safety-Critical Systems' II

Module label
CurrentTopics in 'Safety-Critical Systems' II

Module code
inf353

Credit points
3.0 KP

Workload
90 h

Used in course of study
- Master Eingebettete Systeme und Mikrobotik > Akzentsetzungsmodulle
- Master Informatik > Technische Informatik

Contact person
Module responsibility
- Andreas Hein
- Werner Damm
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Werner Damm
- Die im Modul Lehrenden

Entry requirements
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
AS (Akzentsetzung / Accentuation)

Modulart
je nach Studiengang Pflicht oder Wahlpflicht
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inf354 - Special Topics in 'Hybrid Systems' I

Module label: Special Topics in 'Hybrid Systems' I
Module code: inf354
Credit points: 6.0 KP
Workload: 180 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Informatik > Technische Informatik

Contact person:
Module responsibility:
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Authorized examiners:
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Entry requirements:
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:

Language of instruction:
German

Duration (semesters):
1 Semester

Module frequency:
halbjährlich

Module capacity:
unlimited

Module level:
AS (Akzentsetzung / Accentuation)

Modulart:
je nach Studiengang Pflicht oder Wahlpflicht
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<td>SuSe or WiSe</td>
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## inf355 - Special Topics in 'Hybrid Systems' II

### Module label
Special Topics in 'Hybrid Systems' II

### Module code
inf355

### Credit points
6.0 KP

### Workload
180 h

### Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Technische Informatik

### Contact person

**Module responsibility**
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

**Authorized examiners**
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

### Entry requirements

#### 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

### Reader's advisory
As announced in course

### Links

**Language of instruction**
German

**Duration (semesters)**
1 Semester

**Module frequency**
unregelmäßig

**Module capacity**
unlimited

**Modullevel**
AS (Akzentsetzung / Accentuation)

**Modulart**
je nach Studiengang Pflicht oder Wahlpflicht
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</table>
inf356 - Current Topics in 'Hybrid Systems' I

Module label
Current Topics in 'Hybrid Systems' I

Module code
inf356

Credit points
3.0 KP

Workload
90 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Technische Informatik

Contact person
Module responsibility
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Entry requirements

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
AS (Akzentsetzung / Accentuation)

Modulart
je nach Studiengang Pflicht oder Wahlpflicht
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inf357 - Aktuelle Themen aus dem Gebiet "Hybride Systeme" II

Module label: Aktuelle Themen aus dem Gebiet "Hybride Systeme" II
Module code: inf357
Credit points: 3.0 KP
Workload: 90 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Technische Informatik

Contact person:
Module responsibility:
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Authorized examiners:
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Entry requirements:
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: AS (Akzentsetzung / Accentuation)
Modulart: je nach Studiengang Pflicht oder Wahlpflicht
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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

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Informatik > Technische Informatik

Contact person
Module responsibility
- Andreas Hein
- Wolfgang Nebel
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Wolfgang Nebel
- Die im Modul Lehrenden

Entry requirements

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. „Spezifikation und Modellierung Eingebetteter Systeme“

Reader's advisory
As announced in course

Links

Language of instruction
German

Duration (semesters)
1 Semester

Module frequency
halbjährlich

Module capacity
unlimited

Modullevel
AS (Akzentsetzung / Accentuation)

Modulart
je nach Studiengang Pflicht oder Wahlpflicht
Lern-/Lehrform / Type of program | 2 courses out of V, S, Ü, P, PR
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Vorkenntnisse / Previous knowledge

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Course type | Course selection
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SWS | 2.00
Frequency | SuSe or WiSe
Workload attendance | 28 h
inf359 - Spezielle Themen aus dem Gebiet “Hardware-/Software-Systeme” II

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<td></td>
<td>- Andreas Hein</td>
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<td></td>
<td>- Wolfgang Nebel</td>
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<td>- Die im Modul Lehrenden</td>
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<tr>
<td>Authorized examiners</td>
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<td>- Wolfgang Nebel</td>
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<td>- Die im Modul Lehrenden</td>
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<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>- apply state of the art and innovative methods to solve problems, if necessary from other disciplines</td>
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<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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<td>The students:</td>
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<td>- evaluate and apply tools, technology and methods sophisticatedly</td>
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<td>- combine new and original approaches and methods creatively</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>The students:</td>
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<td></td>
<td>- support team process by their abilities</td>
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<td>Self-competences</td>
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<td>The students:</td>
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<tr>
<td></td>
<td>- pursue the overall and special computer science development critically</td>
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<td></td>
<td>- implement innovative professional activities effectively and independently</td>
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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

Modullevel
AS (Akzentsetzung / Accentuation)

Modulart
je nach Studiengang Pflicht oder Wahlpflicht
<table>
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<td>Type of examination</td>
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inf360 - CurrentTopics in 'Hardware/Software Systems' I

**Module label**          CurrentTopics in 'Hardware/Software Systems' I
**Module code**           inf360
**Credit points**         3.0 KP
**Workload**              90 h

**Used in course of study**
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungs module
- Master Informatik > Technische Informatik

**Contact person**
- Module responsibility
  - Andreas Hein
  - Wolfgang Nebel
  - Die im Modul Lehrenden
- Authorized examiners
  - Andreas Hein
  - Wolfgang Nebel
  - Die im Modul Lehrenden

**Entry requirements**

**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, 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**
AS (Akzentsetzung)

**Modulart**
Wahlpflicht
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inf361 - Current Topics in 'Hardware/Software Systems' II

Module label: Current Topics in 'Hardware/Software Systems' II
Module code: inf361
Credit points: 3.0 KP
Workload: 90 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Technische Informatik

Contact person
Module responsibility:
- Andreas Hein
- Wolfgang Nebel
- Die im Modul Lehrenden

Authorized examiners:
- Andreas Hein
- Wolfgang Nebel
- Die im Modul Lehrenden

Entry requirements
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
Modullevel: AS (Akzentsetzung / Accentuation)
Modulart: je nach Studiengang Pflicht oder Wahlpflicht
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inf366 - Special Topics in 'Microrobotics and Control Engineering' I

Module label Special Topics in 'Microrobotics and Control Engineering' I
Module code inf366
Credit points 6.0 KP
Workload 180 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsanlage
- Master Informatik > Technische Informatik

Contact person

Module responsibility
- Andreas Hein
- Sergie Fatikow
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Sergie Fatikow
- Die im Modul Lehrenden

Entry requirements

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. „Nanomontage und Nanohandhabung“

Reader’s advisory
As announced in course

Links

Language of instruction German

Duration (semesters) 1 Semester
Module frequency jährlich
Module capacity unlimited
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| SWS | 2.00 |
| Frequency | SuSe or WiSe |
| Workload attendance | 28 h |
inf367 - Spezielle Themen aus dem Gebiet "Mikrorobotik und Regelungstechnik" II

Module label
Spezielle Themen aus dem Gebiet "Mikrorobotik und Regelungstechnik" II

Module code
inf367

Credit points
6.0 KP

Workload
180 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Technische Informatik

Contact person
Module responsibility
- Andreas Hein
- Sergej Fatikow
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Sergej Fatikow
- Die im Modul Lehrenden

Entry requirements

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

Reader's advisory
As announced in course

Links

Language of instruction
German

Duration (semesters)
1 Semester

Module frequency
unregelmäßig

Module capacity
unlimited

Modullevel
AS (Akzentsetzung / Accentuation)

Modulart
je nach Studiengang Pflicht oder Wahlpflicht
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inf368 - Aktuelle Themen aus dem Gebiet "Mikrorobotik und Regelungstechnik" I

Module label
Aktuelle Themen aus dem Gebiet "Mikrorobotik und Regelungstechnik" I

Module code
inf368

Credit points
3.0 KP

Workload
90 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Technische Informatik

Contact person
Module responsibility
- Andreas Hein
- Sergej Fatikow
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Sergej Fatikow
- Die im Modul Lehrenden

Entry requirements

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

Modullevel
AS (Akzentsetzung / Accentuation)

Modulart
je nach Studiengang Pflicht oder Wahlpflicht
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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

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Informatik > Technische Informatik

Contact person
Module responsibility
- Andreas Hein
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Die im Modul Lehrenden

Entry requirements

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
AS (Akzentsetzung / Accentuation)

Lern-Lehrform / Type of program
S or V
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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

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Technische Informatik

Contact person:
Module responsibility:
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Authorized examiners:
- Andreas Hein
- Martin Georg Fränzle
- Die im Modul Lehrenden

Entry requirements:

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. „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: AS (Akzentsetzung / Accentuation)
Modulart: je nach Studiengang Pflicht oder Wahlpflicht
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inf375 - Special Topics in 'Automotive' II

Module label: Special Topics in 'Automotive' II
Module code: inf375
Credit points: 6.0 KP
Workload: 180 h

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Technische Informatik

Contact person:
Module responsibility:
- Andreas Hein
- Die im Modul Lehrenden
Authorized examiners:
- Andreas Hein
- Die im Modul Lehrenden

Entry requirements:
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

Links:
Language of instruction: German
Duration (semesters): 1 Semester
Module frequency: unregelmäßig
Module capacity: unlimited
Module level: AS (Akzentsetzung / Accentuation)
Modulart: je nach Studiengang Pflicht oder Wahlpflicht
Lern-Lehreform / Type of program:
2 courses out of V, S, Ü, P, PR
Vorkenntnisse / Previous knowledge:
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inf376 - Current Topics in 'Automotive' I

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<td>Andreas Hein</td>
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**Entry requirements**

**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**

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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

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsfnodule
- Master Informatik > Technische Informatik

Contact person

Module responsibility
- Andreas Hein
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Die im Modul Lehrenden

Entry requirements

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

Modulelevel AS (Akzentsetzung / Accentuation)

Modulart je nach Studiengang Pflicht oder Wahlpflicht

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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

Used in course of study:
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Informatik > Theoretische Informatik

Contact person:
Module responsibility:
- Annegret Habel
- Die im Modul Lehrenden

Authorized examiners:
- Andreas Hein
- Die im Modul Lehrenden

Entry requirements:

Skills to be acquired in this module:

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
<table>
<thead>
<tr>
<th>Language of instruction</th>
<th>German</th>
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<td>Duration (semesters)</td>
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<td>je nach Studiengang Pflicht oder Wahlpflicht</td>
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**Lern-Lehrform / Type of program**

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

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<th>Type of examination</th>
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**Total time of attendance for the module**
56 h
inf453 - Combination of Specification Techniques

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<tr>
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<td>• Master Informatik &gt; Theoretische Informatik</td>
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</table>

**Contact person**

Module responsibility
- Andreas Hein
- Ernst-Rüdiger Olderog
- Die im Modul Lehrenden

Authorized examiners
- Andreas Hein
- Ernst-Rüdiger Olderog
- Die im Modul Lehrenden

**Entry requirements**

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:


Links

Language of instruction
German

Duration (semesters)
1 Semester

Module frequency
unregelmäßig

Module capacity
unlimited

Modullevel
---

Modulart
je nach Studiengang Pflicht oder Wahlpflicht

Lern-Lehrform / Type of program

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

Examination
Time of examination
Type of examination

Final exam of module
At the end of the lecture period
exercises and oral exam

Course type
Comment
SWS
Frequency
Workload attendance

Lecture
3.00
42 h

Exercises
1.00
14 h

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

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<td></td>
<td>Master Eingebettete Systeme und Mikrorobotik &gt; Akzentsetzungsmodule</td>
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<tr>
<td></td>
<td>Master Engineering of Socio-Technical Systems &gt; Systems Engineering</td>
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<td>Contact person</td>
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<td></td>
<td>Ernst-Rüdiger Olderog</td>
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<td>Die im Modul Lehrenden</td>
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<td>Authorized examiners</td>
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<td>Ernst-Rüdiger Olderog</td>
</tr>
<tr>
<td>Entry requirements</td>
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</tr>
<tr>
<td>Skills to be acquired in this module</td>
<td>Introduction to Milner's Calculus of Communicating Systems (CCS) and the ?-calculus.</td>
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<tr>
<td>Professional competence</td>
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<tr>
<td>The students:</td>
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<tr>
<td></td>
<td>Know the theory of the operational semantics of CCS and the ?-calculus</td>
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<tr>
<td></td>
<td>Perform equivalence proofs using simulations and bisimulations</td>
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<td></td>
<td>Specify communicating and mobile systems with CCS and the ?-calculus</td>
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<tr>
<td>Methodological competence</td>
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<tr>
<td>The students:</td>
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<tr>
<td></td>
<td>Learn about different views on mobility</td>
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<tr>
<td></td>
<td>Recognize equivalences as formal means for system correctness</td>
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<tr>
<td>Social competence</td>
<td></td>
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<tr>
<td>The students:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Work together in small groups to solve problems</td>
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<tr>
<td></td>
<td>Present their solutions to groups of other students</td>
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<tr>
<td>Self-competence</td>
<td></td>
</tr>
<tr>
<td>The students:</td>
<td></td>
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<tr>
<td></td>
<td>Learn persistence in pursuing difficult tasks</td>
</tr>
<tr>
<td></td>
<td>Learn precision in specifying problems</td>
</tr>
<tr>
<td>Module contents</td>
<td></td>
</tr>
<tr>
<td>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 ?-calculus. It enables a new modelling of communication, taking the location of the communication into account.</td>
<td></td>
</tr>
<tr>
<td>The ?-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 ?-calculus, which is based on operational semantics and a concept of behavioural equivalence. The theory will be explained in a step-by-step manner.</td>
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<tr>
<td>Topics:</td>
<td></td>
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<td></td>
<td>different views on mobility</td>
</tr>
<tr>
<td></td>
<td>transition systems with simulations and bisimulations</td>
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<tr>
<td></td>
<td>Milner's Calculus of Communicating Systems (CCS) and Milner's ?-calculus for mobile systems, both with operational semantics, structural congruence, strong equivalence and observational equivalence, relationship between reactions and transitions, solvability of recursive equations</td>
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<tr>
<td></td>
<td>formal specification of examples of communicating and mobile systems using CCS and the ?-calculus</td>
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<td></td>
<td>proof of strong equivalence and observational equivalence of given processes</td>
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specification of dynamic data structures in the \( \pi \)-calculus

Reader's advisory


Links

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<th>Languages of instruction</th>
<th>German, English</th>
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<td>Duration (semesters)</td>
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<td>Module frequency</td>
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<tr>
<td>Module level</td>
<td>AS (Akzentsetzung / Accentuation)</td>
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<td>Modulart</td>
<td>Pflicht o. Wahlpflicht / compulsory or optional</td>
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Vorkenntnisse / Previous knowledge: Theoretical Computer Science II

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Total time of attendance for the module: 56 h
**inf456 - Real-Time Systems**

<table>
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<td>6.0 KP</td>
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<td>Workload</td>
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**Used in course of study**
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodul
- Master Engineering of Socio-Technical Systems > Embedded Brain Computer Interaction
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Informatik > Theoretische Informatik

**Contact person**

**Module responsibility**
- Ernst-Rüdiger Olderog
- Die im Modul Lehrenden

**Authorized examiners**
- Die im Modul Lehrenden
- Ernst-Rüdiger Olderog

**Entry requirements**

**Skills to be acquired in this module**
Introduction to formal methods of the specification and verification of time sensitive systems and their combinations.

**Professional competence**
The students:
- 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**
The students:
- Recognize logic and automata as adequate forms for describing real-time systems

**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**
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:**

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68 / 83
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
Module level AS (Akzentsetzung / Accentuation)
Modulart Pflicht o. Wahlpflicht / compulsory or optional
Lern-/Lehrform / Type of program V+Ü
Vorkenntnisse / Previous knowledge Theoretical Computer Science I and II

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<td>Exercises and written or oral exam</td>
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<td>56 h</td>
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</table>
Inf458 - Term Rewriting Systems

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

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Theoretische Informatik

Contact person
Module responsibility
- Annegret Habel
- Die im Modul Lehrenden

Authorized examiners
- Annegret Habel
- Die im Modul Lehrenden

Entry requirements

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
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<td>Lecture</td>
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<td>Total time of attendance for the module</td>
<td>56 h</td>
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</tbody>
</table>
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:

• Ferber J.; Kirn, S.: "Multiagentensysteme: eine Einführung in die Verteilte Künstliche Intelligenz", Addison-Wesley, 2001

Co-Simulation


Versuchsplanung:

• Kleppmann, W.: "Versuchsplanung", Hanser, 2013
• Klein, B.: "Versuchsplanung - DoE", Oldenburg, 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

AS (Akzentsetzung / Accentuation)

Modulart

je nach Studiengang Pflicht oder Wahlpflicht

Lern-Lehrform / Type of program

Vorkenntnisse / Previous knowledge

- Programmierung mit Java
- Programmierung mit Python

Examination

Time of examination

Type of examination

Final exam of module

At the end of the semester

Oral exam

Course type

Practical
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<td>SWS</td>
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<tr>
<td>Frequency</td>
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<tr>
<td>Workload attendance</td>
<td>56 h</td>
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</table>
inf533 - Probabilistic Modelling I

Module label           Probabilistic Modelling I
Module code            inf533
Credit points          3.0 KP
Workload               90 h

Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodulle
- Master Engineering of Socio-Technical Systems > Systems Engineering
- Master Informatik > Angewandte Informatik
- Master Wirtschaftsinformatik > Bereichswahlmodule

Contact person

Module responsibility
- Claus Möbus
- Die im Modul Lehrenden

Authorized examiners
- Claus Möbus
- Die im Modul Lehrenden

Entry requirements

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
AS (Akzentsetzung / Accentuation)
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<td>Lern-Lehrform / Type of program</td>
<td>S</td>
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<tr>
<td>Vorkenntnisse / Previous knowledge</td>
<td>Basic programming skills</td>
</tr>
<tr>
<td>Examination Time of examination</td>
<td>Type of examination</td>
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<tr>
<td>Final exam of module</td>
<td>Will be announced in the lecture</td>
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<tr>
<td>Course type</td>
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<td>SWS</td>
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<td>Frequency</td>
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<tr>
<td>Workload attendance</td>
<td>28 h</td>
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inf534 - Probabilistic Modelling II

Module label | Probabilistic Modelling II
---|---
Module code | inf534
Credit points | 3.0 KP
Workload | 90 h
Used in course of study | 
- Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule
- Master Informatik > Angewandte Informatik
- Master Wirtschaftsinformatik > Bereichswahlmodule

Contact person
Module responsibility
- Claus Möbus
- Die im Modul Lehrenden
Authorized examiners
- Claus Möbus
- Die im Modul Lehrenden

Entry requirements
Skills to be acquired in this module
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
AS (Akzentsetzung / Accentuation)
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<td>Basic programming skills</td>
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<td>Type of examination</td>
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<td>seminar talk, reflective written summary</td>
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<td>Frequency</td>
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inf950 - Interdisciplinary Module I

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<tr>
<td>Module code</td>
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<tr>
<td>Credit points</td>
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<td>- Master Informatik &gt; Nicht Informatik</td>
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<td>Contact person</td>
<td>Module responsibility</td>
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<td>- Die im Modul Lehrenden</td>
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<td>- Die im Modul Lehrenden</td>
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<tr>
<td>Entry requirements</td>
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<td>Skills to be acquired in this module</td>
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<td>Module contents</td>
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<td>Reader's advisory</td>
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<td>Links</td>
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<td>Languages of instruction</td>
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<td>Duration (semesters)</td>
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<td>Type of examination</td>
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## inf951 - Interdisciplinary Module II

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<td>Workload</td>
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| Used in course of study           | • Master Eingebettete Systeme und Mikrorobotik > Akzentsetzungsmodule  
                                      • Master Informatik > Nicht Informatik |
| Contact person                    |                                                      |
| Entry requirements                |                                                      |
| Skills to be acquired in this module |                                                      |
| Module contents                   |                                                      |
| Reader's advisory                 |                                                      |
| Links                             |                                                      |
| Languages of instruction          |                                                      |
| Duration (semesters)              | 1 Semester                                           |
| Module frequency                  |                                                      |
| Module capacity                   | unlimited                                            |
| Modulelevel                       | ---                                                  |
| Modulart                          | je nach Studiengang Pflicht oder Wahlpflicht         |
| Lern-/Lehrform / Type of program  |                                                      |
| Vorkenntnisse / Previous knowledge|                                                      |
| Examination                       |                                                      |
| Time of examination               |                                                      |
| Type of examination               |                                                      |
| Final exam of module              |                                                      |
| M                                 |                                                      |
| Course type                       | Course selection                                     |
| SWS                               | 2.00                                                 |
| Frequency                         | WiSe                                                 |
| Workload attendance               | 28 h                                                 |

80 / 83
Abschlussmodul

mam - Master´s Thesis Module

<table>
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<tr>
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<td>Credit points</td>
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Used in course of study
- Master Eingebettete Systeme und Mikrorobotik > Abschlussmodul

Contact person

Module responsibility
- Michael Sonnenschein
- Lehrende der Informatik

Authorized examiners
- Lehrende der Informatik

Entry requirements

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

Module contents
The content of this module is an independent topic research. The research findings will be presented and discussed in a master’s thesis colloquium.

Reader’s advisory

Links
Languages of instruction
German, English
Duration (semesters)
1 Semester
Module frequency
halbjährlich
Module capacity
unlimited
Module level
Abschlussmodul (Abschlussmodul)
Modulart
Pflicht
Vorkenntnisse / Previous knowledge

Examination
Time of examination
Type of examination

Final exam of module
Master’s thesis, presentation and discussion.
Course type
Seminar

SWS
Frequency
Workload attendance
0 h