Modulhandbuch

Engineering of Socio-Technical Systems - Master's Programme

im Wintersemester 2023/2024

erstellt am 09/12/23
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**Modules for Engineering of Socio-Technical Systems**

**Fundamentals/Foundations**

*inf960* - Fundamental Competencies in Computing Science I: Signals and Dynamical Systems

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<th>Module label</th>
<th>Fundamental Competencies in Computing Science I: Signals and Dynamical Systems</th>
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<tr>
<td>Module abbreviation</td>
<td>inf960</td>
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<tr>
<td>Credit points</td>
<td>6.0 KP</td>
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<tr>
<td>Workload</td>
<td>180 h</td>
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<tr>
<td>Applicability of the module</td>
<td>- Master's Programme Engineering of Socio-Technical Systems (Master) &gt; Fundamentals/Foundations</td>
</tr>
<tr>
<td>Responsible persons</td>
<td>- Hein, Andreas (module responsibility)</td>
</tr>
<tr>
<td></td>
<td>- Fränzle, Martin Georg (module responsibility)</td>
</tr>
<tr>
<td></td>
<td>- Lehrenden, Dietrich (Prüfungsberechtigt)</td>
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<tr>
<td>Prerequisites</td>
<td>Module math040 Analysis II b: Differential equation of several variables</td>
</tr>
<tr>
<td>Skills to be acquired in this module</td>
<td>This course provides an introduction into digital signal processing. It covers the mathematical foundations necessary for understanding the impact digitization has on a continuous signal as well as the goal-directed synthesis of digital filters. As such, it lays the theoretical foundations preparing for understanding and designing applications of digital signal processing in a variety of fields relevant to the MSc EngSTS, like neurophysiological measurements, brain-computing interfaces, or embedded control. In contrast to subsequent modules of the study programme, the module itself does not aim at covering such applications, but at providing a solid grasp of the underlying principles and the fundamental constraints to digital signal processing. It is targeted at psychologists, but also at computer scientists who have not previously been exposed to a systematic mathematical treatment of the fundamentals of digital signal processing.</td>
</tr>
</tbody>
</table>

**Professional competences**

The students:

- name the concepts of signal and image processing in technical systems
- name the methods/algorithms of preprocessing, filtering, classification, interpretation and visualisation of signals and pictures
- select algorithms appropriately
- evaluate the effectiveness of algorithms
- design algorithms and processing chains and evaluate their quality

**Methodological competences**

The students:

- get used to specific subjects of signal and image processing

**Social competences**

The students:

- present solutions for specific questions in signal and image processing

**Self-competences**

The students:

- reflect their solutions by using methods learned in this course

**Module contents**

- Basic Concepts
- Signal Processing
- Signal Spaces and Signal Processing Systems
- Discrete and Constant Signals
- Labelling of Signal Transmitters with Test Signals
- Representations Areas and Transformations
- Time-Discrete Systems and Scanning
- Estimation and Filtering
- Construction with MATLAB
- Image Processing
- Introduction / Range of Applications
- Functional Transformation
- Image Enhancement/Filtering
• Segmentation
• 3D Reconstruction an Visualization

Recommended reading

- Meyer, M.; Signalverarbeitung: Analoge und digitale Signale, Systeme und Filter
- Grünningen, D. C. v.; Digitale Signalverarbeitung: mit einer Einführung in die kontinuierlichen Signale und Systeme
- Tönnies, K.; Grundlagen der Bildverarbeitung; Pearson Studium 2005
- Lehmann, Th.; Obenfeld, W.; Pelinak, E.; Peges, R.; Bildverarbeitung in der Medizin; Springer Verlag 1997
- Handels, H.; Medizinische Bildverarbeitung; Teubner Verlag, Stuttgart - Leipzig 2000

Links

Language of instruction: English
Duration (semesters): 1 Semester
Module frequency: annual
Module capacity: unlimited
Reference text: This course is part of the base curriculum of the MSc program "Engineering of Socio-Technical Systems". It provides students featuring a background in psychology with fundamental competences in computer science and related subjects. This course is also intended for students with a background in computer science lacking prior knowledge in digital signal processing

Module level

Type of module: 1VL + 1Ü

Previous knowledge: Module math040 Analysis II b: Differential equation of several variables

Examination: Examination times
Type of examination: Final exam of module
At the end of the lecture period
Hands-on exercises and written or oral exam

Type of course: Lecture
Comment: 2
SWS: 28
Frequency: WiSe
Workload of compulsory attendance: 28

Type of course: Exercises
Comment: 2
SWS: 28
Frequency: WiSe
Workload of compulsory attendance: 28

Total module attendance time: 56 h
**inf961 - Fundamental Competencies in Computing Science II: Mathematics**

**Module label**  
Fundamental Competencies in Computing Science II: Mathematics

**Module abbreviation**  
inf961

**Credit points**  
6.0 KP

**Workload**  
180 h

**Applicability of the module**  
- Master's Programme Engineering of Socio-Technical Systems
- (Master) > Fundamentals/Foundations

**Responsible persons**  
- Fränzle, Martin Georg (module responsibility)
- Heß, Florian (module responsibility)
- Stein, Andreas (module responsibility)
- Stein, Sandra (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**  
No participant requirement

**Skills to be acquired in this module**  
The courses provide an introduction to the fundamental methods of mathematical formalisation and proof, as well as to the central concepts of graph theory, elementary number theory, and algebra. The selection of topics is based on their particular relevance to computer science and related disciplines. Within the curriculum of the MSc EngSTS, this course provides students featuring a BSc in psychology or related subjects with the skills in mathematical formalization that are necessary for mastering subsequent courses in computer science.

**Professional competences**  
The students
- get acquainted with the formalisms and reasoning underlying modern mathematics, and they are able to apply these to concrete problems
- understand the central concepts and methods of graph theory, elementary number theory, and algebra relevant to computer science and related disciplines

**Methodological competences**  
The students
- are able to apply fundamental methods of mathematical formalisation and reasoning to concrete problems
- are able to retrieve the verdicts originating from such formal reasoning and to interpret them in terms of the original, informal problem description.

**Social competences**  
The students
- are able to explain mathematical formalizations to each other and to discuss their justification

**Self-competences**  
The students
- are able to reflect appropriateness of their formalisation and verification attempts

**Module contents**  
- Propositional logic;
- methods of mathematical proof;
- sets, relations, and functions;
- combinatorics;
- graphs and their applications;
- natural and integer numbers and their residue classes;
- groups and sime-groups.

The module consists of a lecture and an exercise part.

**Recommended reading**  
- B. Kreußler und G. Pfister: Mathematik für Informatiker, Springer-Verlag 2009 (available online from the university library)

**Links**
This course is part of the base curriculum of the MSc program "Engineering of Socio-Technical Systems". It provides students featuring a background in psychology with the fundamental competences in mathematical formalization that are necessary for mastering subsequent courses in computer science. This course is not intended for students with a background in computer science.
inf962 - Fundamental Competencies in Computing Science III: Algorithms and Computational Problem Solving

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<td>Workload</td>
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**Applicability of the module**

- Master Applied Economics and Data Science (Master) > Data Science
- Master's Programme Engineering of Socio-Technical Systems (Master) > Fundamentals/Foundations
- Master's Programme Environmental Modelling (Master) > Mastermodule

**Responsible persons**

- Vogel-Sonnenschein, Ute (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**

No specific knowledge is required to take part in this module.

**Skills to be acquired in this module**

Graduates of the module have acquired a deeper understanding of basic theories and techniques in computer science and can classify problems that arise. This enables students to structure and model simple tasks from their subject area using computer science, to design approaches to solutions and to estimate the effort required to solve them. They have a basic understanding of the design and use of relational databases.

This course provides students with fundamental computational problem-solving skills necessary to complete subsequent courses in computer science.

**Professional competences**

The students

- name the basic concepts of von Neumann's computer architecture,
- describe concepts of the computational representation of information and their limits,
- use basic data structures and algorithms and reason about their complexity,
- model simple problems with formal concepts such as automata and formal languages,
- design simple relational databases and identify the advantages of database-based storage.

**Methodological competences**

The students

- analyze problems from their area of application,
- design appropriate solutions for simple problems using the Python programming language and estimate the effort required to execute them,
- design simple object-oriented models
- use a simple IDE and implement scripts in Python,
discuss alternative computational representations of data and problems and draw informed conclusions from them

Social competences
The students
- present and discuss their solutions in an interdisciplinary team,
- develop solutions to simple problems cooperatively in a team.

Self-competences
The students
- critically reflect on fundamental design decisions in algorithms and data structures,
- deepen their time management skills.

Module contents
- von Neumann computer architecture,
- tasks of operating systems
- computer representation of information,
- formal languages, grammar and automata,
- basic data structures,
- algorithms and complexity,
- programming simple object-oriented solutions in Python
- basic concepts of SQL-based databases

Recommended reading

Reference text
This module provides students with non-computer science backgrounds with the computational problem-solving skills necessary to complete subsequent computer science courses. It is not intended for students with a computer science background.

Module level

Type of course

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inf963 - Foundations of STS Eng.: Cognitive Processes

Module label
Foundations of STS Eng.: Cognitive Processes

Module abbreviation
inf963

Credit points
6.0 KP

Workload
180 h

Applicability of the module
- Master's Programme Engineering of Socio-Technical Systems (Master) > Fundamentals/Foundations

Responsible persons
- Fränzle, Martin Georg (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
No participant requirement

Skills to be acquired in this module
The module aims to provide an overview of theories of cognitive processes. Part 1 will be a lecture on neurocognition. Students will first acquire a general understanding of the brain mechanisms of different cognitive functions and the methods used to study these functions:

- brain and cognition, methods of cognitive neuroscience
- attention, learning and memory
- emotional and social behavior
- language, executive functions

Part 2 will be a lecture on neurophysiology. Students will acquire specific knowledge about neurophysiology and neuroanatomy, learn the fundamental concepts of multi-channel EEG analysis, and acquire hands-on skills in using EEGLAB, an open-source software toolbox for advanced EEG analysis.

Competencies:
- understanding of basic concepts of biomedical signal processing;
- using EEG analysis tools interactively and independently;
- understanding the complete chain of EEG analysis steps, from data import to the illustration of results;
- ability to use open source tools for EEG analysis;
- application of theoretical knowledge to practical problems of physiology.

Part 3 will be a seminar on cognitive engineering. Students will be introduced to methods, tools, and techniques (MTTs) to evaluate and predict human performance in small use cases in different domains (Aviation, Air Traffic Control, Automotive, Maritime, or Healthcare). Each student is expected to study and apply the MTT based on material and software provided and present and discuss the modeling approach and the results achieved with the other participants and experts in the seminar.

Professional competences
The students:

- neuropsychological / neurophysiological knowledge

Methodological competences
The students:

- interdisciplinary knowledge & thinking

Social competences
The students:

- written and oral presentation and discussion of scientific and technical results with others.

Self-competences
The students:

- reading, understanding, summarizing and critically evaluating scientific texts/literature

Module contents
- The Student's Guide to Cognitive Neuroscience, Psychology Press
- Engineering Psychology & Human Performance Vicente, K (2002).
- The Psychology of Human-Computer Interaction

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<td>Duration (semesters)</td>
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<td>Module frequency</td>
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<td>Module capacity</td>
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<td>Examination</td>
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<td>Final exam of module</td>
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<td>Seminar</td>
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| Total module attendance time | 56 h |
inf964 - Foundations of STS Eng.: Psychology and Philosophy of Technology

Module label: Foundations of STS Eng.: Psychology and Philosophy of Technology
Module abbreviation: inf964
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module:
- Master's Programme Engineering of Socio-Technical Systems (Master) > Fundamentals/Foundations

Responsible persons:
- Lehrende, Die im Modul (Prüfungsberechtigt)
- Lehrende, Die im Modul (module responsibility)

Prerequisites:
No participant requirement

Skills to be acquired in this module:
The module aims to provide an overview of theories of (Neuro)Cognitive Psychology with potential for application, concepts for technology assessments and ethical principals and their applicability for the field of (Neuro)Cognitive Psychology. In addition to these learning aims, they will experience chances and limitations of technology assessments. Thus, it will cover core concepts of cognitive psychology, their neuronal basis, basic knowledge of neuroimaging and data analysis techniques. Special emphasis will be put on research aiming at complex real-world settings and translation of basic science in to practice. Examples of successful transfers will be analyzed. The lecture provides the theoretical basis. In the seminar the material is consolidated by examples from the literature will be presented and critically analyzed and discussed.

Professional competences:
The students:
- should have a repertoire of cognitive psychology concepts relevant for real world situations
- should be able to familiarize themselves with important ethical concepts, are able to explain them, and transmit them on scenarios of the technology assessment
- should know and be able to explain different forms and concepts of technology assessments (Expert, participatory, constructive, discursive Technology Assessment, Health Technology Assessment (HTA))
- should be able to reflect the collingridge dilemma

Methodological competences:
The students:
- should be able to transfer the learned theoretical concepts into practical contexts
- should be able to perform a systematic literature review
- should be able to evaluate potential issues arising in the process of translation
- should be able to do a risk-benefit analysis and cost-benefit analysis of given examples
- should know and can explain empirical methods for technology assessment
- methodological considerations: Generalization, validity of theories and research methods

Social competences:
The students:
- should be able to argue on different point of views based on different

Self-competences:
The students:
- should be able to reflect their own attitudes and able to explain them using ethical principles
- pursuing goals: Thinking, problem solving and acting

Module contents:
The module consists of a lecture and an seminar part:

Lecture:
- Neurocognitive Psychology with emphasis in real world context
- Ethical Principals an Concepts
- Forms and Concepts of Technology Assessment
- Chances and Limitations of Technology Assessment

General:
Presentation as well as critical evaluation and discussion of scientific literature, application of research methods, transfer of scientific paradigms (concepts and methods) to real-world situations.

**Seminar:**
The students write a thesis for a given technological innovation. In this, various concepts of ethical assessment and technology assessment are to be applied. The Innovation is to be discussed critically from different perspectives. Advantages against disadvantages, benefits against damage, opportunities against dangers, self-interest against common public interest are to be weighed.

**Recommended reading**

**Links**

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<tr>
<th>Language of instruction</th>
<th>English</th>
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<tr>
<td>Duration (semesters)</td>
<td>2 Semester</td>
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<tr>
<td>Module frequency</td>
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<tr>
<td>Module capacity</td>
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<td>Teaching/Learning method</td>
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<tr>
<td>Examination times</td>
<td>Type of examination</td>
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<tr>
<td>Final exam of module</td>
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<th>Comment</th>
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<th>Frequency</th>
<th>Workload of compulsory attendance</th>
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| Total module attendance time | 56 h |

**Workload of compulsory attendance**
inf965 - Foundations of STS Eng.: Systems Engineering

Module label: Foundations of STS Eng.: Systems Engineering

Module abbreviation: inf965

Credit points: 6.0 KP

Workload: 180 h

Applicability of the module:
- Master's Programme Engineering of Socio-Technical Systems (Master) > Fundamentals/Foundations

Responsible persons:
- Hahn, Axel (module responsibility)
- Fränzle, Martin Georg (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
No participant requirement

Skills to be acquired in this module:

Professional competences:
The students:
- Designing and maintaining complex artefacts are a mayor challenge of engineering for decades. System Engineering is an approach to handle this complexity.
- are aware of the challenges of complexity by completing this module
- know how systems engineering can address these while designing complex but reliable, dependable and safe products. A major cornerstone is to know the concept of a system and to describe it using appropriate modelling techniques. The student
- starts think in systems as an aggregation of components systems that may again be a component of an aggregated system up to the concepts of systems of systems. They
- are able to understand the effects of single components attributes on the system as a hole including humans a elements of complex systems.

Methodological competences:
The students:
- are able to apply system-engineering methodologies and methods to understand requirements, to design, implement and test systems.

Recommended reading:

Module contents:
The module consists of a lecture and an exercise part: Lecture: Introduction to the concepts of systems, methodologies and methods of systems engineering. As special emphasis is put on the usage of SYSML as a modelling approach. Exercises: Own design experiences by using engineering methods and tools.

Suggested reading:

Language of instruction: English

Duration (semesters): 2 Semester

Module frequency: every semester

Module capacity: unlimited

Type of module: Teaching/Learning method: 1 VL + 1 Ü

Previous knowledge: none
<table>
<thead>
<tr>
<th>Examination</th>
<th>Examination times</th>
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<td><strong>Final exam of module</strong></td>
<td>At the end of the lecture period</td>
<td>Portfolio</td>
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**Total module attendance time** 56 h
inf966 - Foundations of STS Eng.: Statistics and Programming

Module label: Foundations of STS Eng.: Statistics and Programming
Module abbreviation: inf966
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module:
- Master's Programme Engineering of Socio-Technical Systems (Master) > Fundamentals/Foundations

Responsible persons:
- Timmer, Antje (module responsibility)
- Hein, Andreas (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
No participant requirement

Skills to be acquired in this module

Professional competences:
The students
- learn to plan, program and interpret statistical data evaluation via programming.

Methodological competences:
The students:
- understand the main statistical methods and their practical use through application
- can evaluate statistical methods regarding the qualities and their limits
- learn the use of statistical software in application scenarios
- can implement programs via a programming language
- know how to program statistical data analyses

Social competences:
The students
- gain experience in interdisciplinary work.

Self-competences:
The students:
- gain experiences in Pursuing goals: Thinking, problem solving and acting
- learn to analyze and evaluate the effects an relevance of datasets for specific research questions

Module contents
The module consists of a lecture and an exercise part:

Lecture: Introduction to the concepts and methods for computer supported statistically data evaluation. Special emphasis is put on statistically methodical as well as on a basic understanding of programming languages.

1. Fundamental Computer Science Concepts in regard to the handling of imperative programming languages including:
   - variable types and variable handling
   - typical code structures (such as "while / for loops" or "if-then else" statements)
   - data-handling and computation approaches

2. Fundamental static methodology such as:
   - estimating parameters through the method of maximum likelihood
   - confidence intervals and classical significance testing
   - classical regression analysis
   - modern advancements in regression analysis

Exercises: Stepwise practical or paper based use of the learned concepts, methods and tools.

Recommended reading

Links

Language of instruction: English
Duration (semesters): 1 Semester
Module frequency: annual
Module capacity: unlimited
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inf970 - Fundamental Competencies in Psychology I: Psychology

**Module label**
Fundamental Competencies in Psychology I: Psychology

**Module abbreviation**
inf970

**Credit points**
6.0 KP

**Workload**
180 h

**Applicability of the module**
- Master's Programme Engineering of Socio-Technical Systems
  (Master) > Fundamentals/Foundations

**Responsible persons**
- Herrmann, Christoph Siegfried (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
No participant requirement

**Skills to be acquired in this module**
The lecture will be based mainly on the textbook by Atkinson & Hilgards. It will introduce the students to selected topics of Experimental Psychology which are relevant for socio-technical systems (e.g. learning & memory, perception, language, emotion). It will also cover aspects of Social Psychology, Psychological Disorders, and Individual Psychology. It thereby provides students with a background in computer science or a related discipline with fundamental skills in experimental psychology necessary for mastering the subsequent courses from psychology featured in the curriculum.

**Professional competence**
The students:
- will acquire basic knowledge in selected topics of Psychology

**Methodological competence**
The students:
- learn selected methods and theories of Psychology

**Social competence**
The students:
- will learn to work together in small groups
- will communicate scientific theories

**Self-competences**
The students:
- will learn to apply their knowledge in other, more specific Psychology courses

**Module contents**

**Recommended reading**

**Language of instruction**
English

**Duration (semesters)**
1 Semester

**Module frequency**
annual

**Module capacity**
unlimited

**Reference text**
This course is part of the base curriculum of the MSc program “Engineering of Socio-Technical Systems”. It provides students featuring a background in computer science with fundamental competences in experimental psychology as necessary for mastering the courses from psychology subsequently featured in the curriculum. This course is not intended for students with a background in psychology.

**Module level**

**Type of module**

**Teaching/Learning method**
1VL + 1Ü

**Previous knowledge**
none

**Examination**

**Examination times**

**Type of examination**
Written exam

**Final exam of module**
During the last lecture appointment
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<td>2</td>
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</table>

**Total module attendance time** 56 h
The module inf972 Fundamental Competences in Psychology III: Experiments and Studies forms a basic curriculum in the MSc Engineering Socio-Technical Systems for students with a degree in computer science to complement their scientific education in the field of designing, planning and carrying out scientific experiments and studies. The course focuses on methods for studying human machine interaction in socio-technical systems as they are addressed in this MSc degree. The module introduces on standard methods of scientific experiments. The module is based on standard introductory text books in Psychology, as for example the standard text book "Das psychologische Experiment, Eine Einführung, Osswald Huber, 2005" (will be taught in English of course) or in the standard textbook in the field of Human Computer Interaction: Research Methods in HCI, Jonathan Lazar, Jinjuan Heidi Feng, Harry Hochheiser, John Wiley and Sons Ltd, 2009. With this module, students with a background in Computer Science can complement their expertise in the field of scientific experiments and methods and provide them with a basis knowledge in this area. It will give them prerequisites to jointly attend courses and get practical assignments in later terms of their studies together with the students with a background in psychology for whom the methods and tools for scientific experiments are part of their BSc studies. This module provides students without prior knowledge of designing, planning, and carrying out scientific experiments and studies with the basic knowledge in that field as relevant for mastering subsequent modules in the curriculum. The course is compulsory for students featuring a background in computer science and lacking fundamental competences in psychology. It is not intended for students already featuring a background in psychology.

Professional competences

The students:

Methodological competences

The students:

- are introduced into the design, implementation and also the analysis and interpretation of experiments.

Social competences

The students:

Self-competences

The students:

- have knowledge of the tools and methods used for experiment design and evaluation
- are able to choose the right methods for their specific experiment. They are able to design and run experiments.

Module contents

Content of the module: Introduction into experimental psychology

- Variables, dependent and independent variables
- Formulating Hypotheses / Hypothesis testing
- Correlation and Cause
- Quantitative and qualitative methods
- Surveys, Experiments, Observational Studies Experiment design / Study designs
- Between-Subjects Experiments
- Within-Subjects Experiments
- Randomized Control Trials
- Practical Considerations
- Complex Research Designs
- Single-Subject Research
Lab studies vs. Studies in the wild
- Single factor vs. multifactor designs Participants
- Recruiting participants
- Participants sampling
- Randomization
- Power Calculation Tools
- SoSci Survey for online survey
- Statistical Tools Analysis
- Descriptive Statistics
- Descriptive statistics and Correlation coefficients
- Statistical analysis of the data
- Internal and external validity
- Institutional Review Boards
- Informed Consent

The module consists of a lecture and an exercise part:

**Lecture:** Theoretical introduction into the concepts and scientific methods of experiment design.

**Exercises:** Deepening the understanding of the experiments by planning and carrying out a survey and an experimental study in teams over the course of the term.

**Recommended reading**
- Das psychologische Experiment, Eine Einführung, Osswald Huber, 2005
- How to Design and Report Experiments, Andy Field, sage 2003
- Research Methods in HCI, Jonathan Lazar, Jinjuan Heidi Feng, Harry Hochheiser, John Wiley and Sons Ltd, 2009
- Allgemeine Psychologie, Müsseler, Jochen, Berlin ; Heidelberg: Springer, 2017

**Links**

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**Module level**

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| Total module attendance time | 56 h |

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<td>- Rieger, Jochem (module responsibility)</td>
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<td>- Feuerstack, Sebastian (module responsibility)</td>
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<td>- Unni, Anirudh (module responsibility)</td>
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Human-Computer Interaction

inf100 - Human Computer Interaction

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

Responsible persons
- Boll-Westermann, Susanne (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
Useful previous knowledge: Interactive Systems

Skills to be acquired in this module
With the help of suitable resources, the students can design, prototype, and evaluate a human-machine interface following the user-centered design process (HCD).

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

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

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

Self-competence:
The students:

- can accept and learn from mistakes made during the design process.

### Module contents

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

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

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

During the practical project, a concrete human-computer interface will be designed, developed and evaluated.

### Recommended reading

- Literature in the reserve shelf in the university bibliography.
- Link list in Stud.IP.

### Links

https://uol.de/en/media-informatics/teaching/courses

### Languages of instruction

German, English

### Duration (semesters)

1 Semester

### Module frequency

every summer term

### Module capacity

unlimited

### Reference text

- 

### Module level

- 

### Type of module

- 

### Teaching/Learning method

1VL + 1Ü

### Previous knowledge

Useful previous knowledge: Interactive Systems

### Examination

Examination times

<table>
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<tbody>
<tr>
<td>The completed practical projects will be presented on a single project day, which will take place at the end of the lecture period. The oral exam takes place within the last two weeks of the lecture period. If necessary, re-examinations will take place at the end of the term. Details on the schedule can be found on the websites of the department and in Stud.IP.</td>
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### Final exam of module

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### Total module attendance time

56 h
inf131 - Advanced Topics in Human Computer Interaction

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<td>• Master's Programme Computing Science (Master) &gt; Angewandte Informatik</td>
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<td>• Master's Programme Engineering of Socio-Technical Systems (Master) &gt; Human-Computer Interaction</td>
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<td>• Boll-Westermann, Susanne (module responsibility)</td>
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<td>• Lehrenden, Die im Modul (Prüfungsberechtigt)</td>
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<td>Skills to be acquired in this module</td>
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This course aims to provide a sample of some of the most recent and significant advances in this exciting area. Topics may include: situational awareness, designing for attention, ambient/peripheral interaction, computer support cooperative work and social computing (CSCW), ubiquitous and context-aware computing, haptic and gestural interaction, audio interaction, gaze-based interaction, biometric interfaces, and embedded, physical and tangible computing, mobile and wearable interfaces. This course is explicitly not focused on the methods used in HCI practice (i.e., user-centered design cycle), but rather focuses on (recent) research.

**Professional competences**
The students:

• demonstrate a systematic understanding of knowledge and critical awareness of a selection of the recent research advances in the area of HCI  
• evaluate and critique recent developments in the field of HCI on scientific and technological grounds  
• develop ability to conceptualize, design, implement, and evaluate user-centered systems and techniques.  
• plan an implement exploratory projects directed at envisioning and prototyping novel interactive artifacts

**Methodological competences**
The students:

• analyze, review and critique research papers  
• carry out original research from start to finish  
• summarize and present research findings  
• work in a team to produce and evaluate prototypes of novel interactive artifact

**Social competences**
The students:

• work collaboratively in groups to analyze and review research papers  
• summarize and present research findings to rest of class  
• discuss how HCI concepts and methods can be applied in analysis, design, and evaluation of interactive technologies.  
• discuss social and ethical implications of interactive technologies

**Self-competences**
The students:

• are comfortable tackling original research questions  
• show aptitude in conceptualizing and running both qualitative and quantitative HCI experiments  
• acquire the ability to summarize, analyze, and critique published (peer-review) research papers
Module contents

HCI is a fast-growing field, where scientific research in this area crosses multiple disciplines. The body of theoretical and empirical knowledge that can inform the design of effective systems is rapidly developing, which underscores the importance of current research in the field. This course aims to provide a sample of some of the most recent and significant advances in this exciting area. Topics may include: situational awareness, designing for attention, ambient/peripheral interaction, computer support cooperative work and social computing (CSCW), ubiquitous and context-aware computing, haptic and gestural interaction, audio interaction, gaze-based interaction, biometric interfaces, and embedded, physical and tangible computing, mobile and wearable interfaces.

The course will consist of lectures and lab sessions. Lab sessions will cover assignments (writing paper reviews, presentations, and peer assessment). In addition to assignments and a final exam, a small part of the course includes a mini group-based HCI project.

Recommended reading


Links

https://uol.de/en/media-informatics/teaching/courses

Language of instruction

English

Duration (semesters)

1 Semester

Module frequency

every winter term

Module capacity

24

Reference text

Module level

Type of module

Teaching/Learning method

1 VL + 1 Ü

Previous knowledge

Useful previous knowledge: Interactive Systems

Examination

Examination times

Type of examination

Final exam of module

At the end of the lecture period

Project and oral exam

Missing the exam: If you cannot attend the exam with valid reasons (medical reason, exam schedule conflicts), you need to inform us before the exam, and submit a scanned copy of the evidence (medical certificate, course registration, boarding passes) within 5 days after the exam.

- If the reason for missing the exam is valid, you will do your first try of the exam for the parts that you missed on the same date as the second chance exam.
- If the reason is not valid, you will not get any score from that exam. If your overall score passed the course, you will not have a chance to take the exam again.
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Total module attendance time 56 h
inf174 - Special Topics in 'Media Informatics and Multimedia Systems' I

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| Applicability of the module | Master's Programme Computing Science (Master) > Praktische Informatik  
Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction |
| Responsible persons | Boll-Westermann, Susanne (module responsibility)  
Lehrenden, Die im Modul (Prüfungsberechtigt) |
| Prerequisites | No participant requirements |
| Skills to be acquired in this module | The aim of the module is to integrate the latest developments in the field of “Media Informatics and Multimedia Systems” appropriately into a course of study.  
**Professional competences**  
The students:  
- define and contrast special themes in computer science, and reflect on computer science practices in general.  
- recognize and evaluate applied techniques and methods and their limits  
- identify, structure and solve problems/tasks, in new or developing subject areas  
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines  
- recognize 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 and utilize them appropriately  
- combine new and original approaches and methods creatively  
- reflect on problems/tasks, including new or developing subject areas in their discipline and apply computer science methods for investigation and resolution  
**Social competences**  
The students:  
- integrate their skills in a team environment.  
**Self-competences**  
The students:  
- pursue the further development of computer science in general and in this particular sub-field critically  
- innovatively conduct professional activities effectively and independently |
| Module contents | According to the assigned course |
| Recommended reading | As announced in course |
| Links | https://uol.de/en/media-informatics/teaching/courses |
| Languages of instruction | German, English |
| Duration (semesters) | 1 Semester |
| Module frequency | irregularly |
| Module capacity | unlimited |
| Module level |  |
| Type of module |  |
| Teaching/Learning method | 1VL + 1Ü |
| Previous knowledge | none |
| Examination | Examination times  
Type of examination |
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inf175 - Special Topics in 'Media Informatics and Multimedia Systems' II

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

**Responsible persons**
- Boll-Westermann, Susanne (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
No participant requirements

**Skills to be acquired in this module**
The aim of the module is to integrate the latest developments in the field of "Media Informatics and Multimedia Systems" appropriately into a course of study.

**Professional competences**
The students:
- define and contrast special themes in computer science, and reflect on computer science practices in general.
- recognize and evaluate applied techniques and methods and their limits
- identify, structure and solve problems/tasks, in new or developing subject areas
- apply state of the art and innovative methods to solve problems, if necessary from other disciplines
- recognize 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 and utilize them appropriately
- combine new and original approaches and methods creatively
- reflect on problems/tasks, including new or developing subject areas in their discipline and apply computer science methods for investigation and resolution.

**Social competence**
The students:
- integrate their skills into team processes

**Self-competences**
The students:
- pursue the further development of computer science in general and in this particular sub-field critically.
- innovatively conduct professional activities effectively and independently.

**Module contents**
According to the assigned course

**Recommended reading**
Literature will be announced in the assigned course

**Links**
[https://uol.de/en/media-informatics/teaching/courses](https://uol.de/en/media-informatics/teaching/courses)

**Languages of instruction**
German, English

**Duration (semesters)**
1 Semester

**Module frequency**
irregularly

**Module capacity**
unlimited

**Module level**

**Type of module**

**Teaching/Learning method**
1VL + 1Ü

**Previous knowledge**
one
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**inf301 - Machine-oriented Systems Engineering**

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

**Responsible persons**
- Fränzle, Martin Georg (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Skills to be acquired in this module**

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.

**Recommended reading**
Lecturers notes, hardware manuals and data sheets, and development tool manuals

**Languages of instruction**
German, English

**Duration (semesters)**
1 Semester

**Module frequency**
annual

**Module capacity**
unlimited

**Module level**

**Type of module**

**Teaching/Learning method**
1VL + 1P

**Previous knowledge**
none

**Examination**

**Type of examination**

**Final exam of module**
At the end of the lecture period
Portfolio (Design, development and implementation of embedded systems, colloquium)
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**Total module attendance time**

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

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| Applicability of the module | - Master's Programme Computing Science (Master) > Angewandte Informatik  
- Master's Programme Computing Science (Master) > Technische Informatik  
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction  
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction  
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering |
| Responsible persons | Fatikow, Sergej (module responsibility)  
- Lehrenden, Die im Modul (Prüfungsberechtigt) |
| Prerequisites | No participant requirements |
| Skills to be acquired in this module | Experts in different branches try to approach their application-specific control and information processing problems by using fuzzy logic and artificial neural networks (ANN). The experiences gathered up to now prove robotics and automation technology to be predestined fields of application of both these approaches. The major topics of the course are control problems in robotics and automation technology, principles of fuzzy logic and ANN and their practical applications, comparison of conventional and advanced control methods, combination of fuzzy logic and ANN in control systems. The course gives a comprehensive treatment of these advanced approaches for interested students.  
**Professional competence**  
The students:  
- recognise control problems in robotics and automation technology,  
- name principles of fuzzy logic and ANN and their practical applications,  
- compare conventional and advanced control methods, - characterise the combination of fuzzy logic and ANN in control systems  
**Methodological competence**  
The students:  
- will acquire knowledge of the tools, methods and applications in fuzzy logic and ANN  
- deepen their knowledge for the practical use of the given methods  
- can use common software tools for design and application of fuzzy logic and ANN  
**Social competence**  
The students:  
- gain experience in interdisciplinary work  
- are integrated into the recent research work Objective of the module / skills:  
**Self-competence**  
The students:  
- are able to transfer the gained knowledge for later use in their theses or studies for 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 |
Recommended reading

Essentiell:
- Vorlesungs-skript in Buchform (erhältlich im Sekretariat, A1-3-303)

Empfohlen:

Gute Sekundärliteratur:
- Altrock, M. O. R.: Fuzzy Logic, R. Oldenbourg Verlag, 1993
- Kahlert, J. und Hubert, F.: Fuzzy-Logik und Fuzzy-Control, Vieweg, 1993
- Kratzer, K.P.: Neurionale Netze, Carl Hanser, 1993
- Lawrence, J.: Neurionale Netze, Systhema Verlag, München, 1992
- Patterson, D.W.: Künstliche neuronale Netze, Prentice Hall, 1996
- Zimmermann H.-J. (Hrsg.): Datenanalyse, VDI-Verlag, 1995

Links

Languages of instruction
English, German

Duration (semesters)
1 Semester

Module frequency
annual

Module capacity
unlimited

Module level

Type of module
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**Total module attendance time**: 56 h
inf305 - Medical Technology

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

**Responsible persons**
- Hein, Andreas (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
Useful knowledge in:
- Signal and Image Processing
- Control Engineering

**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)

**Recommended reading**

*essential:*
- Kramme, R.: Medizintechnik. Verfahren, Systeme und
Informationssysteme, Springer Verlag, 2002 (2. Auflage)

- Lecture slides
- recommended:
- Lehmann, Th.; Oberschelp, W.; Pelikan, E.; Pepges, R.:
  Bildverarbeitung in der Medizin. Springer Verlag, 1997
- Dugas, M.; Schmidt, K.: Medizinische Informatik und Bioinformatik.
  Springer Verlag, 2003

**secondary literature:**

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**Total module attendance time** 56 h
inf307 - Robotics

Module label  Robotics
Module abbreviation  inf307
Credit points  6.0 KP
Workload  180 h

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

Responsible persons
- Hein, Andreas (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
No participant 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

Recommended reading
essential:
42 / 211
• lecture nodes

recommended:


secondary literature:


Links

Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency
annual

Module capacity
unlimited

Module level

Type of module

Teaching/Learning method
1VL + 1Ü

Previous knowledge
none

Examination

Examination times
Type of examination

Final exam of module
At the end of the lecture periode
Portfolio: Hands-on exercises, report, and written or oral exam

Type of course

Comment
SWS
Frequency
Workload of compulsory attendance

Lecture
3
SoSe
42

Exercises
1
SoSe
14

Total module attendance time
56 h
inf308 - Microrobotics II

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**Applicability of the module**

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

**Responsible persons**

- Fatikow, Sergej (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**

- Microrobotics and Microsystems Engineering

**Skills to be acquired in this module**

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

**Professional competence**

The students:

- name and recognise the basic concepts of nanotechnology, in particular, micro- and nanorobotics approaches
- differentiate the development, control and application of micro- and nanorobotics systems - implement and design application-specific micro- and nanorobotics systems

**Methodological competence**

The students:

- transfer their control engineering and image processing abilities on interdisciplinary problems
- transfer their hands-on experience to develop controls and applications of microrobotic systems on new tasks

**Social competence**

The students:

- work in a team

**Self-competence**

The students:

- reflect their problem-solving behaviour and use hands-on experience to develop, control and application of microrobotics

**Module contents**

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

- Lecture notes (can be obtained in secretariat, A1-3-303)

**Links**

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**Teaching/Learning method**

- 1VL + 1Ü

**Previous knowledge**

- Microrobotics and Microsystems Engineering

**Examination**

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**Final exam of module**

**Type of course**

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**Total module attendance time**

56 h
inf336 - Application Area Automotive

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Skills to be acquired in this module

This module introduces the application area Automotive.

Professional competences:
The students:

- discuss core-concepts of the transportation domain
- discuss different modes of transportation (focus on the automotive sector)
- discuss automated and connected driving (short introduction/overview)
- discuss human factors in the automotive sector
- discuss traffic infrastructure (focus on intersections)
- discuss basic principles in traffic management

Methodological competences:
The students:

- analyze vehicle systems
- analyze traffic infrastructure
- analyze cooperative vehicle/infrastructure systems
- analyze socio-technical systems

Social competences:
The students:

- work in teams
- discuss their outcomes appropriately

Self-competences:
The students:

- acknowledge the limits of their ability to cope with pressure during the work on the topics of the module

Module contents

- Core-concepts of the transportation domain
- Modes of transportation (focus on the automotive sector)
- Automated and connected driving (short introduction/overview)
- Human factors in the automotive sector
- Traffic infrastructure (focus on intersections)
- Basic principles in traffic management

Recommended reading

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# Design of Autonomous Systems

**Module label**  
Design of Autonomous Systems

**Module abbreviation**  
inf338

**Credit points**  
6.0 KP

**Workload**  
180 h

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

### Responsible persons
- Lehrenden, Die im Modul (Prüfungsberechtigt)
- Fränzle, Martin Georg (module responsibility)

### Prerequisites
No participant requirements

### Skills to be acquired in this module

#### Professional competences
The students are enabled to analyze and build autonomous systems.

#### Methodological competences
The students
- know examples of existing autonomous systems, understand the elements involved in their architectural design and the rationale behind decomposing the problem into obligations for the respective system components.
- analyze existing architectures for autonomous systems with respect to their performance and safety.
- learn how to decompose a problem of designing an autonomous system into an architecture
- are able to derive design obligations for its components, and can structure a pertinent safety case.
- understand the software and hardware components necessary for achieving system autonomy and are able to design or instantiate these.

#### Social competences
The students
- acquire hands-on experience in designing components for autonomous systems in small teams and present the underlying theory, their particular design decisions, and their personal evaluation to fellow students.

#### Self-competences
The students
- can judge adequacy of their methodological skills for designing particular autonomous solutions
- are able to assess the safety impact of such a solution and are therefore able to develop a personal ethical stance towards its realization

### Module contents
The module consists of a lecture and an exercise part

### Recommended reading

### Links

**Language of instruction**  
English

**Duration (semesters)**  
1 Semester

**Module frequency**  
annual

**Module capacity**  
unlimited

**Module level**

**Type of module**

**Teaching/Learning method**  
1VL + 1Ü

**Previous knowledge**  
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Total module attendance time 56 h
mar364 - Time Series Analysis

Module label: Time Series Analysis
Module abbreviation: mar364
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module:
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering
- Master's Programme Environmental Modelling (Master) > Mastermodule
- Master's Programme Marine Environmental Sciences (Master) > Mastermodule
- Master's Programme Marine Sensors (Master) > Mastermodule

Responsible persons:
- Freund, Jan (module responsibility)

Prerequisites:
- Keine

Skills to be acquired in this module:

Module contents:
Charakteristika eines stochastischen Prozesses und deren Schätzer, Komponentenmodell, Trendbereinigung, spektrale Methoden, Filterung, lineare Prozesse, und nichtlineare Prozesse, Einbettungsverfahren, Kenngrößen der nichtlinearen Zeitreihenanalyse, symbolische Dynamik

Recommended reading:
- R. Schlittgen: Angewandte Zeitreihenanalyse mit R. Oldenbourg;
- R. Schlittgen & B. Streitberg: Zeitreihenanalyse. Oldenbourg;

Links

Languages of instruction: German, English
Duration (semesters): 1 Semester
Module frequency: jährlich
Module capacity: unlimited
Module level
Type of module
Teaching/Learning method
Previous knowledge

Examination
Examination times
Type of examination
Final exam of module
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inf535 - Computational Intelligence I

Module label: Computational Intelligence I
Module abbreviation: inf535
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module
- Master Applied Economics and Data Science (Master) > Data Science
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering
- Master's Programme Environmental Modelling (Master) > Mastermodule

Responsible persons
- Kramer, Oliver (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
- Basics of statistics

Skills to be acquired in this module
After successful completion of the course, students should have acquired the ability to master the presented methods in theory and practice. The students should be able to recognize and model corresponding optimization and data analysis problems themselves and to apply the methods unerringly.

Professional competence
The students:
- recognise optimisation problems
- implement simple algorithms of heuristic optimisation
- critically discuss solutions and selection of methods
- deepen previous knowledge of analysis and linear algebra

Methodological competence
The students:
- deepen programming skills
- apply modelling skills
- learn about the relation between problem class and method selection

Social competence
The students:
- cooperatively implement content introduced in lecture
- evaluate own solutions and compare them with those of their peers

Self-competence
The students:
- evaluate own skills with reference to peers
- realize personal limitations
- adapt own problem solving approaches with reference to required method competences

Module contents
Computational Intelligence comprises intelligent and adaptive methods for optimisation and learning. The module "Computational Intelligence I" concentrates on methods for evolutionary optimisation and heuristic approaches. The exercises introduce and deepen practical aspects of the implementation and algorithmic design, also taking into account application aspects.

Overview of Content:
- foundations of optimisation
- genetic algorithms and evolution strategies
- parameter control and self-adaptation
- runtime analysis
- swarm algorithms
- constrained optimisation
- multi-objective optimisation
- meta-modeling

Recommended reading


Links

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inf536 - Computational Intelligence II

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<td>• Kramer, Oliver (module responsibility)</td>
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Skills to be acquired in this module

In the lecture "Convolutional Neural Networks" you will learn the basics of Convolutional Neural Networks, from methodological understanding to implementation.

Professional competence

The Students:

• will learn Deep Learning expertise, which are essential qualifications as AI experts and Data Scientists.

Methodological competence

The Students:

• learn the methods mentioned as well as the implementation in Python, NymPy and Keras.

Social competence

The Students:

• are encouraged to discuss the taught content in groups and work together to implement the programming tasks in the exercises

Self-competence

The Students:

• are guided to conduct independent research on advanced methods as the teaching field changes dynamically

Module contents

Students learn the basics of machine learning and in particular the topics of dense layers, cross-entropy, backpropagation, SGD, momentum, Adam, batch normalization, regularization, convolution, pooling, ResNet, DenseNet, and convolutional SOMs

Recommended reading

• Deep Learning by Aaron C. Courville, Ian Goodfellow und Yoshua Bengio
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inf537 - Intelligent Systems

Module label: Intelligent Systems
Module abbreviation: inf537
Credit points: 6.0 KP
Workload: 180 h

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

Responsible persons:
- Sauer, Jürgen (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
Production oriented business informatics

Skills to be acquired in this module:

Professional competence
The students:
- name the structure of agent-based systems
- use problem-solving methods for complex problems
- characterise the application area of process planning
- evaluate the suitability of processes regarding to specific problems

Methodological competence
The students:
- assign problem-solving methods to different problems

Social competence
The students:
- implement selected methods in small teams

Self-competence
The students:
- develop own solutions for given problems

Module contents:
A lot of application areas use “intelligent” problem-solving methods. These are the main focus of this lecture. They will be illustrated by examples in order to enhance the students’ problem-solving abilities. **These include:**

- A brief introduction into AI
- Agent systems and
- Solution methods of AI like heuristics, meta-heuristics, soft computing methods. To apply and foster the contents of the lecture, an intelligent planning system is implemented in practical exercises.

Recommended reading:

Suggested reading:
- Ghallab/ Nau/Traverso: Automated Planning, Morgan Kaufman, 2004

Links:
www.wi-ol.de

Languages of instruction:
German, English

Duration (semesters):
1 Semester

Module frequency:
annual

Module capacity:
unlimited
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inf663 - Application Area Maritime

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

**Responsible persons**
- Hahn, Axel (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
- No participant requirements

**Skills to be acquired in this module**

**Professional competences**
The students:
- gain knowledge about ship handling and navigation and
- learn to understand maritime transportation as a system of systems with systems on board for stability, propulsion and steering as for bridge resource management.
- understand the latter as a mayor contribution to organize navigation as a hierarchical team concept of a safety critical sociotechnical system.
- are aware of the special technical and physical challenges of navigation.

**Methodological competences**
The students:
- can apply system engineering methods to describe, analyse and design maritime systems. By looking on maritime transporation the gain transferable knowledge on other cyber physical systems.
- learned to how systems can deal with harsh environmental conditions in a resilient way.

**Social competences**
The students:
- Maritime transportation is a mayor basis of a global economy. Typically, students do not have an understanding of these transportation systems nor their technical and systemic challenges. Therefore, the student knows the concepts of maritime transportation and its role in international transportation networks after finishing this module.

**Self-Competences**
The students:
- Especially their competences cover an understanding as maritime transportation as a systems of system with high requirements on reliability, dependability and safety in combination with efficiency to be competitive in a global economy.

**Module contents**
The module consists of a lecture and an exercise part:
- **Lecture:** Maritime Transportation in global and local supply chains, Base concepts of ship handling and navigation, maritime system dynamics, bridge resource management, eNAvigation and high automation systems.
- **Seminar:** Covering aspects of maritime transportation

**Recommended reading**
- Bernhard Berking, Werner Huth (Herausgeber), Handbuch Nautik 1: Navigatorische Schiffsführung, Seehafen Verlag, 2010

**Links**
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**Module level**

**Type of module**

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**Total module attendance time**

56 h
inf650 - Transport Systems

Module label: Transport Systems
Module abbreviation: inf650
Credit points: 6.0 KP
Workload: 180 h

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

Responsible persons:
- Sauer, Jürgen (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
Production-oriented business informatics

Skills to be acquired in this module:
Objective of the module/skills:
The Module Transport systems deals with planning and controlling systems of internal and external company logistics as well as public transport. It provides basic knowledge and recent research topics. The focus is on a resource orientated holistic view of company logistics as well as the planning of transport infrastructure. Furthermore, trends such as autonomous vehicles and intelligent transport systems are discussed.

Professional competence:
The students:
- name the basics of planning and controlling company logistics
- assess transport systems of companies
- name methods and approaches of computer aided transport systems and classify them
- characterise software to plan complex logistics

Methodological competence:
The students:
- display topics and concepts of transport systems
- simulate transport and its systems with appropriate methods

Social competence:
The students:
- work in groups
- discuss their results appropriately

Self-competence:
The students:
- realise their limits while working on a project containing aspects of modelling and implementation
- question the presentation of their results

Module contents:
- Transport and logistics concepts
- Data acquisition of company logistics
- Planning- and simulation software for complex logistics- and transport processes
- Energy- and resource efficient transport systems
- Resource oriented transport cost calculations (e.g. CO2, noise pollution)
- Planning models for transport infrastructure

Recommended reading:

Suggested reading:
## Reference text

Dieses Modul ist im Rahmen der Projekte FlF und FoL konzipiert worden.

## Languages of instruction

German, English

## Duration (semesters)

1 Semester

## Module frequency

annual

## Module capacity

unlimited

## Module level

Type of module

Teaching/Learning method

1VL + 1Ü

Previous knowledge

Production-oriented business informatics

Examination

Examination times

Type of examination

Final exam of module

At the end of the lecture period

Exercises and written exam

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Total module attendance time

56 h
inf604 - Business Intelligence I

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**Applicability of the module**

- Master Applied Economics and Data Science (Master) > Data Science
- Master of Education Programme (Vocational and Business Education) Computing Science (Master of Education) > Akzentsetzungsbereich
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodul Bereich Wirtschaftsinformatik
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodul der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

**Responsible persons**

- Marx Gómez, Jorge (Prüfungsberechtigt)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**

No participant requirement

**Skills to be acquired in this module**

**Objective of the module/skills:**

Current module provides basics of business intelligence with focus on enterprises and strong emphasis on data warehousing technologies. Students of the course are provided with knowledge, which reflects current research and development in a data analytic domain.

**Professional competence**

The students:

- name and recognize the role of business intelligence as part of daily business process
- being able to analyse advantages and disadvantages of different approaches and methods of the data analytics and being able to apply them in simple case studies
- obtain theoretical knowledge about data collection and modelling processes, including most applicable approaches and best practices

**Methodological competence**

The students:

- being able to execute typical tasks of business intelligence, and also being able to deepen knowledge on different approaches and methods
- gain a hands on experience and being able to understand advantages and disadvantages of different methods and being able to use obtained knowledge in most efficient ways

**Social competence**

The students:

- build solutions based on case studies given to the group, for example solving the issue of a factless fact table
- discuss solutions on a technical level
- present obtained case studies solutions as part of the exercises

**Self-competence**

The students:

- critically review provided data and information

**Module contents**

Data warehouse technology together with business intelligence are increasingly being used by business in order to get better decision support and enrich ongoing processes with data-rich decisions. Data warehouse technology enables an integration of data from heterogeneous sources, whereas business intelligence builds data processing on top of it. For instance, business intelligence allows to build reporting on very large volumes of data (including historical) coming primary from data warehouse.

As past of the current module following contents are taught:
• Definition and scope of business intelligence.
• Procedures and objectives of data warehousing.
• Process of extracting, transforming and loading (ETL) of data.
• Phases of data modelling, data capturing and reporting in conjunction with a plausible case studies/scenarios.
• Prospects for further and evolving topics for business intelligence (e.g. Adaptive Business Intelligence, In-MemoryComputing, etc.)
• Introduction to Data Mining.
• Case studies based practical exercises and assessments in order to impart practical knowledge.

Recommended reading

• Marx Gómez, Rautenstrauch, Cissek (2008): Einführung in die Business Intelligence mit SAP NetWeaver 7.0.
• Moss, Atre (2006): Business Intelligence Roadmap, Addison-Wesley, Boston.
• Loshin (2003): Business Intelligence, Kaufmann, Amsterdam.
• Müller, Lenz (2013): Business Intelligence.

Links
http://www.wi-ol.de

Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency
annual

Module capacity
unlimited

Module level

Type of module

Teaching/Learning method
1VL + 1Ü

Previous knowledge
none

Examination
Examination times
Type of examination

Final exam of module
At the end of the lecture period
Written exam max. 120 minutes

Type of course
Comment
SWS
Frequency
Workload of compulsory attendance

Lecture
2
WiSe
28

Exercises
2
WiSe
28

Total module attendance time
56 h
inf607 - Business Intelligence II

Module label: Business Intelligence II

Module abbreviation: inf607

Credit points: 6.0 KP

Workload: 180 h

Applicability of the module:
- Master Applied Economics and Data Science (Master) > Data Science
- Master's Programme Business Informatics (Master) > Akzentsetzungs module der Informatik
- Master's Programme Business Informatics (Master) > Akzentsetzungs module der Wirtschaftsinformatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons:
- Marx Gómez, Jorge (Prüfungsberechtigt)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
- No participant requirement

Skills to be acquired in this module:
Current module provides advanced business intelligence, data science with focus on enterprises and strong emphasis on big data and data analytics. Students of the course are provided with knowledge, which reflects current research and development in a data analytics domain.

Professional competence:
The students:
- name and recognize the role of data analytics / data science as past of a daily business process in a particular company
- able to organize from management perspective data analytics project
- being able to analyse advantages and disadvantages of different approaches and methods of the data analytics and being able to apply them in simple case studies
- obtain theoretical knowledge about data collection and modelling processes, including state of the art approaches and available best practices

Methodological competence:
The students:
- being able to execute typical tasks of data analysis, and also being able to proceed deeper with respect to different approaches and methods
- gain a hands on experience and being able to understand advantages and disadvantages of different methods and being able to use obtained knowledge

Social competence:
The students:
- build solutions based on case studies given to the group, for example design of regression model based on provided dataset
- discuss solutions on a technical level
- present obtained case studies solutions as part of the exercises

Self-competence:
The students:
- critically review provided offered information

Module contents:
After current course students will get advanced knowledge in the domains such as business intelligence and data analytics. Besides that, students will have a chance to have a deeper look into related technical fields such as InMemory Computing, Data Mining and Machine Learning, Big Data Processing with Distributed Systems (e.g. Apache Hadoop / Spark) from both, research and practical, perspectives. Students will be provided with real-world experience gather from business intelligence and data science related projects. Materials of the course are believed to be justified with current demands of data analytics market. Thus, providing students with relevant knowledge in order to give them advantages in future job.
### Recommended reading

- Jürgen Cleve, Uwe Lämmel (2014): "Data mining" (Deutsch)
- Max Bramer (2013): "Principles of data mining" (English)
- Ian Witten, Eibe Frank, Mark Hall (2011): "Data mining : practical machine learning tools and techniques" (English)
- Jure Leskovec, Anand Rajaraman, Jeffrey Ullman (2014): "Mining of massive datasets" (English)

### Links
http://www.wi-ol.de/

### Languages of instruction
German, English

### Duration (semesters)
1 Semester

### Module frequency
annual

### Module capacity
unlimited

### Module level

### Type of module

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### Previous knowledge
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### Examination

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### Total module attendance time
56 h
inf657 - Product Engineering

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

**Responsible persons**
- Sauer, Jürgen (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
- No participant requirement

**Skills to be acquired in this module**
Focus of this module is to learn and apply the product engineering process. A project will enable the students to design a product from the idea to the prototype. More specifically, a systematic, partial domain-specific, approach to solve technical problems and aspects of project management will be learned. Regular meetings are used to train the presentation capabilities of the students and to schedule working packages within the teams.

**Professional competence**
The students:
- learn and try out the handling of virtual and physical prototypes
- learn and try out the construction and validation of virtual prototypes with the aid of CAD-applications
- learn and combine different basic development concepts from the mechanical engineering, microelectronics, control engineering and software engineering

**Methodological competence**
The students:
- learn and try out project management concepts
- learn and recognise the connections of different development concepts from different fields, e.g. mechanical engineering, control engineering, microelectronics and software engineering
- develop own products with creativity techniques
- schedule and organise the product development supported by project management techniques independently
- learn the systematic refining of their own product idea with SysML
design and test products with state-of-the-art CAD-applications

**Social competence**
The students:
- impart their structure and mode of action to other people
- develop their own products in small teams
- present their solutions to groups
- integrate criticism to their solutions
- support other groups by giving appropriate criticism

**Self-competence**
The students:
- recognise and reflect their own limitations to get familiar and to plan a project in an unknown field (e.g. maritime construction/industries)

**Module contents**
This module is a lecture accompanied by a hands-on project. The students work on one product development task. The product development starts with the idea-finding/brainstorming process which is used to create a digital product concept. During the semester a digital prototype will be created and validated by its initial requirements. Finally, a physical prototype is produced with a 3D-Printer (Rapid Prototyping). The progress of the project has to be documented and presented at different milestones.

**Recommended reading**
| Links | www.wi-ol.de |
| Languages of instruction | German, English |
| Duration (semesters) | 1 Semester |
| Module frequency | annual |
| Module capacity | unlimited |
| Reference text | The lecture material contains English parts |

**Module level**

**Type of module**

| Teaching/Learning method | 1VL + 1Ü |
| Previous knowledge | none |

**Examination**

| Examination | Examination times | Type of examination |
| Final exam of module | At the end of the lecture period | Written exam or oral exam, or written documentation or Presentation or Portfolio |

**Type of course**

| Type of course | Comment | SWS | Frequency | Workload of compulsory attendance |
| Lecture | 2 | WiSe | 28 |
| Exercises | 2 | WiSe | 28 |

**Total module attendance time** 56 h
inf203 - Embedded Systems I

Module label
Embedded Systems I

Module abbreviation
inf203

Credit points
6.0 KP

Workload
180 h

Applicability of the module
- Bachelor's Programme Computing Science (Bachelor) > Akzentsetzungsbereich - Wahlbereich Informatik
- Dual-Subject Bachelor's Programme Computing Science (Bachelor) > Wahlpflicht Technische Informatik (30 KP)
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons
- Fränzle, Martin Georg (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
- Basics of technical computer science
- Computer Engineering

Skills to be acquired in this module
This module provides an introduction to the design of digital embedded systems.

Professional competence
The students:
- name functional and non-functional requirements to specify embedded systems
- discuss design space and associated embedded systems design methods
- name control and feedback control systems' core concepts
- characterise the fundamental digital signal processing algorithms

Methodological competence
The students:
- design and develop embedded feedback control systems with modelling tools
- implement an embedded hardware/software system according to a given specification
- analyze various specification languages according to different properties

Social competence
The students:
- implement solutions to given problems in teams
- present results of computer science problems to groups
- organize themselves as a team to solve a larger problem using project management methods

Self-competence
The students:
- acknowledge the limits of their ability to cope with pressure during the implementation process of systems
- solve exercises self-responsibly

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 overview of embedded systems and their design. The process of digital signals is...
especially important for telecommunications and multimedia. For this purpose, the module introduces digital signal processing algorithms. The principles of feedback control are introduced by exemplary transport applications. Subsequently, the module provides the specifications and language characteristics of the embedded system design. For this purpose, graphical data-flow modelling languages (for instance Simulink) and control-flow specifications (for instance State Charts) are presented. The module closes with the concepts of possible architectures and communication models. Hands-on exercises with the tools Matlab/Simulink/StateFlow support the module contents.

Recommended reading


Secondary literature:

- Artikelserie zum MPEG-2-Standard 3/94 10/94 und das Tutorial "Digitale Bildcodierung" 1/92 1/93, beides in "Fernseh- und Kinotechnik" (BIS: Z elt ZA 1536)
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**Total module attendance time**  
56 h
inf339 - Industrie 4.0 Digitalization in Industrial Manufacturing

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

**Responsible persons**
- Fränzle, Martin Georg (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
No participant requirements

**Skills to be acquired in this module**

The module consists of a lecture part and a seminar part, in which special topics of the lecture are prepared and presented by the students on the basis of examples. This gives a clear insight into the different aspects and allows further discussion. The preparation and presenting a presentation with subsequent discussion on the respective topic area offers a deeper understanding.

**Professional competence**
The student:
- Recognize fundamental relationships of the digitization in industrial manufacturing
- Gain knowledge about key competences of the digitization in industrial manufacturing
- Develop practical knowledge about special topics of the digitization in industrial manufacturing
- Put concrete approaches for discussion

**Methodological competence**
The student:
- Capture needed information and analyze them
- Prepare the recorded information according to target group
- Form an understanding of the digitization in industrial manufacturing

**Social competence**
The student:
- present and discuss their own work on a technical level

**Self-competence**
The student:
- understand their own level of knowledge
- learn how to prepare and present a specific topic

**Module contents**
The module conveys basic knowledge about the digitization of industrial production (Industrie 4.0). In addition to an overview of economic and technical aspects and opportunities of digitizing production, the module focuses on technologies for data acquisition, communication and control in production plants. Networked machine tools, Production planning and control, organization, Quality and IT systems for planning and operation, The Gentelligent workpiece, Intelligent tools, Transfer systems, Assembly 4.0, Cyber Security, Convertible modular automation systems, Production transformation strategy, Business models

**Recommended reading**
- Handbuch Industrie 4.0 – Geschäftsmodelle, Prozesse, Technik*, Gunther Reinhart, 2017
- Handbuch Industrie 4.0 Bd.1 – Produktion*, Birgit Vogel-Heuser, Thomas Bauernhansl, Michael ten Hompel, 2017
- Handbuch Industrie 4.0 Bd.2 – Automatisierung*, Birgit Vogel-Heuser
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| Total module attendance time | 56 h |
inf5122 - Learning-Based Control in Digitalised Energy Systems

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**Applicability of the module**
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Digitalised Energy Systems (Master) > Digitalised Energy System Design and Assessment
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

**Responsible persons**
- Rauh, Andreas (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
Basic knowledge of control of linear continuous-time and/or discrete-timesystems and/or robust control

**Skills to be acquired in this module**
The students identify fundamentals of learning-based control for dynamic systems.

**Professional competences**
The students:
- identify fundamentals of learning-based control for dynamic systems
- characterise problem-specific learning techniques
- are aware of software implementations for selected test rigs

**Methodological competences**
The students:
- analyse problems of learning-based control
- generalise them independently toward novel research-oriented application scenarios

**Social competences**
The students:
- develop solution ideas for real-life control problems within an accompanying project/lab course in small teams
- explain the obtained results in short presentations

**Self competences**
The students:
- critically reflect the achieved results of their project work
- acknowledge limitations of various approaches for learning-based control design

**Module contents**
1. Iterative learning control (ILC)
   - Grundlegende 2D-Systemstrukturen
   - Stability criteria
   - Ausgewählte Optimierungsansätze
2. Data-driven neural network modelling vs. first-principle modelling
   - Static function approximations
   - NARX-modelling
3. Design of neural network-based controllers
4. Stability of neural network-based controllers

**Recommended reading**
- Jian Xin Xu; Ying Tan. Linear and Nonlinear Iterative Learning
Control. Springer-Verlag, 2003
- Rauh, A. Folien/ Skript zur Vorlesung „Learning-Based Control in DES”

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inf5408 - Applied Deep Learning in PyTorch

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

Responsible persons
- Strodthoff, Nils (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
- knowledge of fundamental theoretical understanding in the field of machine learning and practical programming skills in Python.

Skills to be acquired in this module

Professional competence
The students
- have an overview of the components of deep learning frameworks
- are familiar with application areas of deep learning methods across various data modalities, and common solution strategies and model architectures
- can appropriately adapt deep learning methods to new problems in the respective domains and apply them independently.

Methodological competence
The students
- independently develop theoretical and practical concepts with the help of in-person events, provided materials, and specialized literature.

Social competence
The students
- can present solution approaches for problems in this area to the plenary and defend them in discussions.

Self-competence
The students
- are able to assess their own subject-specific and methodological competence
- take responsibility for their competence development and learning progress and reflect on these independently
- independently work on learning content and can critically reflect on the content.

Module contents
This lecture provides a comprehensive introduction to contemporary Deep Learning methods, with a specific emphasis on their practical application. Concurrently, it serves as a primer for the widely-used PyTorch Deep Learning framework, assuming only a basic familiarity with Python. The course encompasses a wide range of prevalent machine learning tasks across various data types, including tabular, image, text, audio, and graph data. Throughout the course, we delve into the most crucial and up-to-date model architectures within these domains. This encompasses convolutional neural networks, recurrent neural networks,
and transformer models. The lecture is complemented by hands-on exercise sessions, where students will gain practical proficiency with PyTorch. Simultaneously, they will acquire practical insights to effectively apply contemporary deep learning methods within their specific fields of interest.

### Recommended reading

### Links

<table>
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<tr>
<th>Language of instruction</th>
<th>English</th>
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### Duration (semesters)

<table>
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### Module frequency

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### Module capacity

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### Module level

### Teaching/Learning method

<table>
<thead>
<tr>
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<th>1VL + 1Ü</th>
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### Previous knowledge

<table>
<thead>
<tr>
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<th>knowledge of fundamental theoretical understanding in the field of machine learning and practical programming skills in Python.</th>
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### Examination

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<th>Examination times</th>
<th>Type of examination</th>
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<td>Written / oral exam</td>
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### Type of course

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inf5452 - Current Topics in Trustworthy Machine Learning

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

**Responsible persons**
- Strodthoff, Nils (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
The seminar requires attending a foundational lecture in the field of Machine Learning and/or Deep Learning.

**Skills to be acquired in this module**

**Professional competence**
The students
- gain an exemplary overview of challenges and existing solution approaches in their respective problem domains and can contextualize these within the broader methodological context.

**Methodological competence**
The students
- can independently explore topics using current research literature and critically reflect upon them.

**Social competence**
The students
- can present solution approaches for problems in this area to the plenary and defend them in discussions.

**Self-competence**
The students
- are able to assess their own subject-specific and methodological competence. They take responsibility for their competence development and learning progress and reflect on these independently. In addition, they independently work on learning content and can critically reflect on the content.

**Module contents**
This seminar provides insights into various aspects of trustworthy Machine Learning. Depending on the instantiation of the module, different focuses should be set, such as interpretability/explainability, uncertainty quantification, or robustness.

**Recommended reading**

**Links**

**Language of instruction**
- English

**Duration (semesters)**
- 1 Semester

**Module frequency**
- every winter term

**Module capacity**
- unlimited
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<td>Basic lecture in the field of machine learning, deep learning Prior knowledge desirable.</td>
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Embedded Brain Computer Interaction

inf100 - Human Computer Interaction

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

**Responsible persons**
- Boll-Westermann, Susanne (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
Useful previous knowledge: Interactive Systems

**Skills to be acquired in this module**
With the help of suitable resources, the students can design, prototype, and evaluate a human-machine interface following the user-centered design process (HCD).

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

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

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

**Self-competence:**
The students:
- can accept and learn from mistakes made during the design process.

**Module contents**

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

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

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

During the practical project, a concrete human-computer interface will be designed, developed and evaluated.

**Recommended reading**

- Literature in the reserve shelf in the university bibliography.
- Link list in Stud.IP.

**Links**

https://uol.de/en/media-informatics/teaching/courses

**Languages of instruction**

German, English

**Duration (semesters)**

1 Semester

**Module frequency**

every summer term

**Module capacity**

unlimited

**Reference text**

**Module level**

**Type of module**

**Teaching/Learning method**

1VL + 1Ü

**Previous knowledge**

Useful previous knowledge: Interactive Systems

**Examination**

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<th>Examination times</th>
<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. Details on the schedule can be found on the websites of the department and in Stud.IP.</td>
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**Type of course**

<table>
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<th>Workload of compulsory attendance</th>
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**Total module attendance time**

56 h
inf300 - Hybrid Systems

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<td>6.0 KP</td>
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<td>Workload</td>
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| Applicability of the module | • Master's Programme Computing Science (Master) > Technische Informatik  
                          | • Master's Programme Computing Science (Master) > Theoretische Informatik  
                          | • Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction  
                          | • Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering  |
| Responsible persons   | Fränzle, Martin Georg (module responsibility)  
                          | Lehrenden, Die im Modul (Prüfungsberechtigt)  |
| Prerequisites         |                                                     |
| Skills to be acquired in this module | The module gives an introduction to hybrid discrete-continuous systems, as arising by embedding digital hardware into physical environments, and it elaborates on state of the art methods for the mathematical modelling and the analysis of such systems. It thus provides central competences for understanding and designing reliable cyber-physical systems.  |
|                       | **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 interweavings 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.  |
| Recommended reading   |                                                     |
### Links


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<table>
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<tr>
<th>Languages of instruction</th>
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#### Module level

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<tr>
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<td>Bachelor in Computing Science or knowledge of ordinary differential equations. The lecture assumes knowledge of modeling and analysis of reactive systems.</td>
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#### Examination

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<th>Semester project including written work and final presentation</th>
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#### Type of course

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inf301 - Machine-oriented Systems Engineering

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

**Responsible persons**
- Fränzle, Martin Georg (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
- No participant requirements

**Skills to be acquired in this module**

**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.

**Recommended reading**

Lecturers notes, hardware manuals and data sheets, and development tool manuals

**Languages of instruction**

German, English

**Duration (semesters)**

1 Semester

**Module frequency**

annual

**Module capacity**

unlimited

**Module level**

**Type of module**

**Teaching/Learning method**

1VL + 1P

**Previous knowledge**

none

**Examination**

**Examination times**

Type of examination

Portfolio (Design, development and implementation of embedded systems, colloquium)
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<th>Workload of compulsory attendance</th>
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**Total module attendance time** 56 h
inf303 - Fuzzy Control and Artificial Neural Networks in Robotics and Automation

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**Applicability of the module**

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

**Responsible persons**

- Fatikow, Sergej (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**

No participant requirements

**Skills to be acquired in this module**

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

**Professional competence**

The students:

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

**Methodological competence**

The students:

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

**Social competence**

The students:

- gain experience in interdisciplinary work
- are integrated into the recent research work Objective of the module / skills:

**Self-competence**

The students:

- are able to transfer the gained knowledge for later use in their theses or studies for 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

### Recommended reading

**Essentiell:**

- Vorlesungsskript in Buchform (erhältlich im Sekretariat, A1-3-303)

**Empfohlen:**


**Gute Sekundärliteratur:**

- Altrock, M. O. R.: Fuzzy Logic, R. Oldenbourg Verlag, 1993
- Kahlert, J. und Hubert, F.: Fuzzy-Logik und Fuzzy-Control, Vieweg, 1993
- Kratzer, K.P.: Neuronale Netze, Carl Hanser, 1993
- Lawrence, J.: Neuronale Netze, Systhema Verlag, München, 1992
- Patterson, D.W.: Künstliche neuronale Netze, Prentice Hall, 1996
- Zakharian, S. Ladewig-Riebler, P. und Thoer, St.: Neuronale Netze für Ingenieure, Vieweg, Wiesbaden, 1998
- Zimmermann H.-J. (Hrsg.): Datenanalyse, VDI-Verlag, 1995

### Links

<table>
<thead>
<tr>
<th>Languages of instruction</th>
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<tbody>
<tr>
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86 / 211
<table>
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<tr>
<td>Previous knowledge</td>
<td>Knowledge in Control Engineering</td>
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<th>Type of examination</th>
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<tbody>
<tr>
<td>Final exam of module</td>
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<td>Hands-on-exercises and oral Exam</td>
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<th>Comment</th>
<th>SWS</th>
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**Total module attendance time** 56 h
### Inf305 - Medical Technology

<table>
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<tr>
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<tbody>
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<td>Credit points</td>
<td>6.0 KP</td>
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<tr>
<td>Workload</td>
<td>180 h</td>
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**Applicability of the module**
- Master's Programme Computing Science (Master) > Interdisziplinäre Module
- Master's Programme Computing Science (Master) > Technische Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

**Responsible persons**
- Hein, Andreas (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
- useful knowledge in
  - Signal and Image Processing
  - Control Engineering

**Skills to be acquired in this module**

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

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

**Social competence**
- Present solutions for specific questions

**Self-competence**
- 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)

**Recommended reading**

<table>
<thead>
<tr>
<th>essential:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kramme, R.: Medizintechnik. Verfahren, Systeme und</td>
</tr>
</tbody>
</table>
Informationssysteme, Springer Verlag, 2002 (2. Auflage)

- Lecture slides
- recommended:

**secondary literature:**

### Links

<table>
<thead>
<tr>
<th>Languages of instruction</th>
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| Type of module          | 1VL + 1Ü       |
| Teaching/Learning method|                |

| Previous knowledge       | useful knowledge in |
|                         | - Signal and Image Processing |
|                         | - Control Engineering     |

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<td>Portfolio: Hands-on exercises, report, and written or oral exam</td>
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</table>
inf307 - Robotics

Module label: Robotics
Module abbreviation: inf307
Credit points: 6.0 KP
Workload: 180 h

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

Responsible persons
- Hein, Andreas (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
No participant 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

Recommended reading
essential:
90 / 211
• lecture nodes

recommended:


secondary literature:


Links

Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency
annual

Module capacity
unlimited

Module level

Type of module

Teaching/Learning method
1VL + 1Ü

Previous knowledge
none

Examination
Examination times
Type of examination

Final exam of module
At the end of the lecture periode
Portfolio: Hands-on exercises, report, and written or oral exam

Type of course
Comment
SWS
Frequency
Workload of compulsory attendance

Lecture
3
SoSe
42

Exercises
1
SoSe
14

Total module attendance time
56 h
inf308 - Microrobotics II

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

**Responsible persons**
- Fatikow, Sergej (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
- Microrobotics and Microsystems Engineering

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

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

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

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

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

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

- Lecture notes (can be obtained in secretariate, A1-3-303)

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Module level

Type of module

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Previous knowledge

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Final exam of module

Type of course

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Total module attendance time

<table>
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inf311 - Low Energy System Design

Module label: Low Energy System Design
Module abbreviation: inf311
Credit points: 6.0 KP
Workload: 180 h

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

Responsible persons:
- Fatikow, Sergej (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:

Skills to be acquired in this module:

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

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

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

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

Module contents:

According to Moore’s Law the number of integratable transistors on a computer chip doubles every two years. In addition, new circuits are getting faster and faster. This leads not only to an increased functionality of a system, but it also increases the electrical power consumption. This electrical power consumption is problematic from two different points of view: Firstly, the electrical power must be supplied. Secondly, the resulting heat has to dissipate from the system. An increased power consumption always causes lower battery life and higher energy costs. The heat generation reduces the reliability and life of integrated circuits. The cooling (ceramic housings, cooling elements, fans, etc.) increases the system’s costs. Today the development of heat, caused by power dissipation, needs to be considered during the embedded system design process. This knowledge takes the system’s reliability and operation costs into account. This module introduces the estimation of power dissipation and optimisation.

Recommended reading:
- Designing CMOS Circuits for Low Power – Dimitros Soudris, Christian Piguet, Costas Goutis
- Leakage in Nanometer CMOS Technologies – Siva G. Narendra, Anantha Chandrakasan
- Entwurf von digitalen Schaltungen und Systemen mit HDLs und FPGAs – F. Kessl, 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

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<td>- Fundamentals of Computer Engineering,</td>
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<td></td>
<td>- Embedded Systems I,</td>
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<td></td>
<td>- Embedded Systems II</td>
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<tr>
<td>Examination times</td>
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<td>at the end of the lecture period</td>
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<td>Workload of compulsory</td>
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<td>attendance</td>
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<tr>
<td>Lecture</td>
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inf331 - Automated and Connected Driving

Module label: Automated and Connected Driving

Module abbreviation: inf331

Credit points: 6.0 KP

Workload: 180 h

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

Responsible persons:
- Köster, Frank (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
- useful knowledge in
  - Computer Engineering,
  - Embedded Systems I,
  - Embedded Systems II

Skills to be acquired in this module:
This module introduces the principles of automated driving.

Professional competences:
The students:
- discuss different levels of automated driving (eg. SAE-Level) and the differences
- discuss different levels of connected driving and the differences
- discuss core-domains of automated vehicles
- discuss important technological pillars in the areas sense, plan, and act
- discuss transition between different levels of automation
- discuss the impact of connected vehicle functions on automated driving
- discuss the impact of automated vehicle functions on connected driving
- characterise the impact of automated and connected driving on road traffic
- characterise the interaction of humans and automated and connected vehicles
- design an abstract procedure for the change of different levels of automation
- design a rough vehicle architecture for automated and connected driving

Methodological competences:
The students:
- analyze complex automated and connected vehicles (-> domains)
- analyze core-functions of automated and connected vehicles (-> functions)

Social competences:
The students:
- work in teams
- discuss their outcomes appropriately

Self-competences:
The students:
- acknowledge the limits of their ability to cope with pressure during the analysis of complex (automated and connected) socio-technical systems

Module contents:
- levels of automated driving (eg. SAE-Level)
- levels of connected driving - core-domains of automated vehicles
- sense, plan, and act in the context of automated and connected vehicles
- transition between different levels of automation
- selected connected vehicle functions
- selected automated vehicle functions
- human factors and socio-technical systems
- vehicle architectures

Recommended reading

Suggested reading:
Links

Language of instruction | English
Duration (semesters) | 1 Semester
Module frequency | annual
Module capacity | unlimited

Module level

Type of module

Teaching/Learning method | 1VL + 1Ü

Previous knowledge

Knowledge in
- Computer Engineering,
- Embedded Systems I,
- Embedded Systems II

Examination

Examination times | Type of examination
Final exam of module | At the end of the lecture period | Praktical work and oral exam

Type of course | Comment | SWS | Frequency | Workload of compulsory attendance
Lecture | 2 | SoSe | 28
Exercises | 2 | SoSe | 28

Total module attendance time | 56 h
inf332 - Practice Robotics

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<tr>
<td>Responsible persons</td>
<td>Hein, Andreas (module responsibility)</td>
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<td>Lehrenden, Die im Modul (Prüfungsberechtigt)</td>
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<tr>
<td>Prerequisites</td>
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<td>Professional competences</td>
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<td>The students learn:</td>
</tr>
<tr>
<td></td>
<td>- programming of robots (mobile or stationary)</td>
</tr>
<tr>
<td></td>
<td>- implementation of elementary operations</td>
</tr>
<tr>
<td></td>
<td>- integration of operations into a small application scenario</td>
</tr>
<tr>
<td></td>
<td>- programming using Robot Operating System (ROS)</td>
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<td>The students learn:</td>
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<td>- systematic development process with team members</td>
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<tr>
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<td>- systematic evaluation of the application</td>
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<tr>
<td></td>
<td>- designing a robotic application using basic and advanced robotic concepts</td>
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<td>- project management</td>
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<td>- team work</td>
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<td>- organization of the team</td>
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<td>Self-competences</td>
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<td>- time management</td>
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<tr>
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<td>- autodidactic work (literature search, technical specs, related work)</td>
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<tr>
<td>Module contents</td>
<td>Robotic systems will be provided to the students. They will then define the project/application scenario of the robots by their own and complete the project as a small team with self-organization and work distribution among the team members. The module consists of a lecture and an exercise part: Lecture: 2-3 lectures for introduction onto the module and introduction into the Robot Operating System (ROS) as well as the concepts of the projects. Exercises: After the introduction period, the students will work self-organized to complete the proposed project. Work can be distributed weekly or on as concentrated time blocks.</td>
</tr>
<tr>
<td>Recommended reading</td>
<td>John J. Craig, Introduction to Robotics: Mechanics and Control Patrick Goebel, ROS By Example</td>
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<tr>
<td>Links</td>
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<td>Examination times</td>
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**Total module attendance time** 56 h
# inf334 - System Level Design

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<td>Master's Programme Engineering of Socio-Technical Systems (Master) &gt; Embedded Brain Computer Interaction</td>
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<td>Master's Programme Engineering of Socio-Technical Systems (Master) &gt; Systems Engineering</td>
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<tr>
<td>Responsible persons</td>
<td>Lehrenden, Die im Modul (Prüfungsberechtigt)</td>
</tr>
<tr>
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<td>Lehrenden, Die im Modul (module responsibility)</td>
</tr>
<tr>
<td>Prerequisites</td>
<td>No participant requirements</td>
</tr>
</tbody>
</table>

## Skills to be acquired in this module

### Professional competences

The students:
- ability to describe and analyze system components and architectures using system level description languages SpecC and SystemC
- capabilities for partitioning and parallelizing of applications

### Methodological competences

The students:
- knowledge of refinement and transformation techniques for transferring an initial specification into a real implementation
- knowledge of the phases of a system-level design flow
- knowledge of current design methods and tools in system level design
- knowledge about formal models of computation of specification languages
- knowledge of current research results and trends in system level design
- capabilities for partitioning and parallelizing of applications
- ability to evaluate and explore design decisions
- ability to implement a complete system design-to-implementation specification

### Social competences

The students:
- implement solutions of given problems in teams
- discuss their outcomes appropriately

### Self-competences

The students:
- presentation skills
- reflect their solutions by using methods learned in this course

## Module contents

The ever-increasing integration densities of integrated circuits enable the implementation of increasingly powerful and complex systems. This can be on the one hand the integration of several sub-components on the same chip (system-on-chip) or on the other hand the implementation of more powerful algorithms. However, traditional design techniques are hardly able to cope with the increasing complexity of today's embedded systems. Therefore, in research and practice efforts through new methods and tools, there is a significant increase in productivity in the design process, thus closing the so-called "design productivity gap". This is achieved, for example, by a stronger abstraction, in which the behavior of components is described only at the algorithmic level and is automatically translated into hardware or software implementations by high-level synthesis techniques. The final system implementation is achieved by means of a structured refinement and exploration processes. Throughout this refinement flow, system properties (for example, timing, energy consumption, chip area and costs) are estimated on each abstraction level and guide the designer in the iterative decision process. By means of techniques such as virtual prototyping, entire systems can be simulated and verified on each refinement layer, even without the availability of a full implementation for all system components. This module builds on the modules Embedded Systems I and II, deepens the knowledge acquired there.
for the design of hardware/software systems and expands them with current methods and tools. With SystemC, a language is presented that is already widely used in industry and research for the design and verification of hardware/software systems and supports several abstraction levels from clock cycle accurate hardware description, over transaction level models to process based functional specifications.

Recommended reading

Suggested reading:
Main textbooks:

Optional books:

Links
https://www.uni-oldenburg.de/informatik/ehs/lehre/vorlesungen/system-level-design/

Language of instruction
English

Duration (semesters)
1 Semester

Module frequency
annual

Module capacity
unlimited

Module level

Type of module
Teaching/Learning method 1 VL + 1 Ü

Previous knowledge
none

Examination
Examination times Type of examination
Final exam of module at the end of the lecture period hands-on exercises and oral exam

Type of course Comment SWS Frequency Workload of compulsory attendance

Lecture 2 SoSe 28
Exercises 2 SoSe 28

Total module attendance time 56 h
inf336 - Application Area Automotive

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

**Responsible persons**
- Köster, Frank (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
- No participant requirements

**Skills to be acquired in this module**

**Professional competences:**
The students:
- discuss core-concepts of the transportation domain
- discuss different modes of transportation (focus on the automotive sector)
- discuss automated and connected driving (short introduction/overview)
- discuss human factors in the automotive sector
- discuss traffic infrastructure (focus on intersections)
- discuss basic principles in traffic management

**Methodological competences:**
The students:
- analyze vehicle systems
- analyze traffic infrastructure
- analyze cooperative vehicle/infrastructure systems
- analyze socio-technical systems

**Social competences:**
The students:
- work in teams
- discuss their outcomes appropriately

**Self-competences:**
The students:
- acknowledge the limits of their ability to cope with pressure during the work on the topics of the module

**Module contents**
- Core-concepts of the transportation domain
- Modes of transportation (focus on the automotive sector)
- Automated and connected driving (short introduction/overview)
- Human factors in the automotive sector
- Traffic infrastructure (focus on intersections)
- Basic principles in traffic management

**Recommended reading**
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<td>At the end of the lecture period</td>
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inf338 - Design of Autonomous Systems

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<td>Professional competences</td>
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<tr>
<td>The students</td>
<td></td>
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<tr>
<td>are enabled to analyze and build autonomous systems.</td>
<td></td>
</tr>
<tr>
<td>Methodological competences</td>
<td>The students</td>
</tr>
<tr>
<td>know examples of existing autonomous systems, understand the elements involved in their architectural design and the rationale behind decomposing the problem into obligations for the respective system components.</td>
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<tr>
<td>analyze existing architectures for autonomous systems with respect to their performance and safety.</td>
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<tr>
<td>learn how to decompose a problem of designing an autonomous system into an architecture</td>
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<tr>
<td>are able to derive design obligations for its components, and can structure a pertinent safety case.</td>
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<tr>
<td>understand the software and hardware components necessary for achieving system autonomy and are able to design or instantiate these.</td>
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<tr>
<td>Social competences</td>
<td>The students</td>
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<tr>
<td>acquire hands-on experience in designing components for autonomous systems in small teams and present the underlying theory, their particular design decisions, and their personal evaluation to fellow students.</td>
<td></td>
</tr>
<tr>
<td>Self-competences</td>
<td>The students</td>
</tr>
<tr>
<td>can judge adequacy of their methodological skills for designing particular autonomous solutions</td>
<td></td>
</tr>
<tr>
<td>are able to assess the safety impact of such a solution and are therefore able to develop a personal ethical stance towards its realization</td>
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<td>The module consists of a lecture and an exercise part</td>
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<td>2</td>
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**Total module attendance time** 56 h
inf456 - Real-Time Systems

Module label Real-Time Systems
Module abbreviation inf456
Credit points 6.0 KP
Workload 180 h

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

Responsible persons
- Olderog, Ernst-Rüdiger (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
Theoretical Computer Science I + II

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:
- 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

Recommended reading
Essential:


Recommended:


Links

Languages of instruction German, English
Duration (semesters) 1 Semester
Module frequency irregular
Module capacity unlimited

Module level

Type of course Teaching/Learning method 1VL + 1Ü
Previous knowledge Theoretical Computer Science I + II

Final exam of module Examination
Examination times At the end of the lecture period Exercises and written or oral exam
Type of course Lecture
Comment
SWS 3
Frequency SoSe oder WiSe
Workload of compulsory attendance 42
Lecture Exercises
Comment
SWS 1
Frequency SoSe oder WiSe
Workload of compulsory attendance 14

Total module attendance time 56 h
inf535 - Computational Intelligence I

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Applicability of the module

- Master Applied Economics and Data Science (Master) > Data Science
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodul der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering
- Master's Programme Environmental Modelling (Master) > Mastermodule

Responsible persons

- Kramer, Oliver (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites

Basics of statistics

Skills to be acquired in this module

After successful completion of the course, students should have acquired the ability to master the presented methods in theory and practice. The students should be able to recognize and model corresponding optimization and data analysis problems themselves and to apply the methods unerringly.

**Professional competence**

The students:

- recognise optimisation problems
- implement simple algorithms of heuristic optimisation
- critically discuss solutions and selection of methods
- deepen previous knowledge of analysis and linear algebra

**Methodological competence**

The students:

- deepen programming skills
- apply modelling skills
- learn about the relation between problem class and method selection

**Social competence**

The students:

- cooperatively implement content introduced in lecture
- evaluate own solutions and compare them with those of their peers

**Self-competence**

The students:

- evaluate own skills with reference to peers
- realize personal limitations
- adapt own problem solving approaches with reference to required method competences

Module contents

Computational Intelligence comprises intelligent and adaptive methods for optimisation and learning. The module “Computational Intelligence I” concentrates on methods for evolutionary optimisation and heuristic approaches. The exercises introduce and deepen practical aspects of the implementation and algorithmic design, also taking into account application aspects.

**Overview of Content:**

- foundations of optimisation
- genetic algorithms and evolution strategies
- parameter control and self-adaptation
- runtime analysis
- swarm algorithms
- constrained optimisation
- multi-objective optimisation
• meta-modeling

Recommended reading


Links

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inf536 - Computational Intelligence II

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**Applicability of the module**

- Master Applied Economics and Data Science (Master) > Data Science
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodul der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering
- Master's Programme Environmental Modelling (Master) > Mastermodule

**Responsible persons**

- Kramer, Oliver (module responsibility)
- Lehrende, Die im Modul (Prüfungsberechtigt)

**Prerequisites**

useful previous knowledge: Linear Algebra, Stochastics

**Skills to be acquired in this module**

In the lecture "Convolutional Neural Networks" you will learn the basics of Convolutional Neural Networks, from methodological understanding to implementation.

**Professional competence**

The Students:

- will learn Deep Learning expertise, which are essential qualifications as AI experts and Data Scientists.

**Methodological competence**

The Students:

- learn the methods mentioned as well as the implementation in Python, Numpy and Keras.

**Social competence**

The Students:

- are encouraged to discuss the taught content in groups and work together to implement the programming tasks in the exercises

**Self-competence**

The Students:

- are guided to conduct independent research on advanced methods as the teaching field changes dynamically

**Module contents**

Students learn the basics of machine learning and in particular the topics of dense layers, cross-entropy, backpropagation, SGD, momentum, Adam, batch normalization, regularization, convolution, pooling, ResNet, DenseNet, and convolutional SOMs

**Recommended reading**

- Deep Learning by Aaron C. Courville, Ian Goodfellow and Yoshua Bengio

**Links**
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<td>28</td>
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| Total module attendance time | 56 h   |
**inf537 - Intelligent Systems**

**Module label**  
Intelligent Systems

**Module abbreviation**  
inf537

**Credit points**  
6.0 KP

**Workload**  
180 h

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

**Responsible persons**
- Sauer, Jürgen (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
- Production oriented business informatics

**Skills to be acquired in this module**

**Professional competence**
The students:
- name the structure of agent-based systems
- use problem-solving methods for complex problems
- characterise the application area of process planning
- evaluate the suitability of processes regarding to specific problems

**Methodological competence**
The students:
- assign problem-solving methods to different problems

**Social competence**
The students:
- implement selected methods in small teams

**Self-competence**
The students:
- develop own solutions for given problems

**Module contents**
A lot of application areas use "intelligent" problem-solving methods. These are the main focus of this lecture. They will be illustrated by examples in order to enhance the students' problem-solving abilities. **These include**:

- A brief introduction into AI
- Agent systems and
- Solution methods of AI like heuristics, meta-heuristics, soft computing methods. To apply and foster the contents of the lecture, an intelligent planning system is implemented in practical exercises.

**Recommended reading**

**Suggested reading**:
- Ghallab/ Nau/Traverso: Automated Planning, Morgan Kaufman, 2004

**Languages of instruction**
- German, English

**Duration (semesters)**
1 Semester

**Module frequency**
annual

**Module capacity**
unlimited
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inf604 - Business Intelligence I

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<tr>
<td>Workload</td>
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Applicability of the module

- Master Applied Economics and Data Science (Master) > Data Science
- Master of Education Programme (Vocational and Business Education) Computing Science (Master of Education) > Akzentsetzungsbereich
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule Bereich Wirtschaftsinformatik
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons

- Marx Gómez, Jorge (Prüfungsberechtigt)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites

No participant requirement

Skills to be acquired in this module

Objective of the module/skills:

Current module provides basics of business intelligence with focus on enterprises and strong emphasis on data warehousing technologies. Students of the course are provided with knowledge, which reflects current research and development in a data analytic domain.

Professional competence

The students:

- name and recognize the role of business intelligence as past of daily business process
- being able to analyse advantages and disadvantages of different approaches and methods of the data analytics and being able to apply them in simple case studies
- obtain theoretical knowledge about data collection and modelling processes, including most applicable approaches and best practices

Methodological competence

The students:

- being able to execute typical tasks of business intelligence, and also being able to deepen knowledge on different approaches and methods
- gain a hands on experience and being able to understand advantages and disadvantages of different methods and being able to use obtained knowledge in most efficient ways

Social competence

The students:

- build solutions based on case studies given to the group, for example solving the issue of a factless fact table
- discuss solutions on a technical level
- present obtained case studies solutions as part of the exercises

Self-competence

The students:

- critically review provided data and information

Module contents

Data warehouse technology together with business intelligence are increasingly being used by business in order to get better decision support and enrich ongoing processes with data-rich decisions. Data warehouse technology enables an integration of data from heterogeneous sources, whether business intelligence builds data processing on top of it. For instance, business intelligence allows to build reporting on very large volumes of data (including historical) coming primary from data warehouse.

As past of the current module following contents are taught:
• Definition and scope of business intelligence.
• Procedures and objectives of data warehousing.
• Process of extracting, transforming and loading (ETL) of data.
• Phases of data modelling, data capturing and reporting in conjunction with a plausible case studies/scenarios.
• Prospects for further and evolving topics for business intelligence (e.g. Adaptive Business Intelligence, In-MemoryComputing, etc.)
• Introduction to Data Mining.
• Case studies based practical exercises and assessments in order to impart practical knowledge.

Recommended reading

• Marx Gómez, Rautenstrauch, Cissek (2008): Einführung in die Business Intelligence mit SAP NetWeaver 7.0.
• Moss, Atre (2006): Business Intelligence Roadmap, Addison-Wesley, Boston.
• Loshin (2003): Business Intelligence, Kaufmann, Amsterdam.
• Müller, Lenz (2013): Business Intelligence.

Links
http://www.wi-ol.de

Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency
annual

Module capacity
unlimited

Module level

Type of module

Teaching/Learning method
1VL + 1Ü

Previous knowledge
none

Examination

Examination times
At the end of the lecture period

Type of examination
Written exam max. 120 minutes

Type of course
SWS
Frequency
Workload of compulsory attendance

Lecture
2
WiSe
28

Exercises
2
WiSe
28

Total module attendance time
56 h
## inf607 - Business Intelligence II

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### Applicability of the module
- Master Applied Economics and Data Science (Master) > Data Science
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule Bereich Wirtschaftsinformatik
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

### Responsible persons
- Marx Gómez, Jorge (Prüfungsberechtigt)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

### Prerequisites
- No participant requirement

### Skills to be acquired in this module
Current module provides advanced business intelligence, data science with focus on enterprises and strong emphasis on big data and data analytics. Students of the course are provided with knowledge, which reflects current research and development in a data analytics domain.

#### Professional competence
The students:
- name and recognize the role of data analytics / data science as past of a daily business process in a particular company
- able to organize from management perspective data analytics project
- being able to analyse advantages and disadvantages of different approaches and methods of the data analytics and being able to apply them in simple case studies
- obtain theoretical knowledge about data collection and modelling processes, including state of the art approaches and available best practices

#### Methodological competence
The students:
- being able to execute typical tasks of data analysis, and also being able to proceed deeper with respect to different approaches and methods
- gain a hands on experience and being able to understand advantages and disadvantages of different methods and being able to use obtained knowledge

#### Social competence
The students:
- build solutions based on case studies given to the group, for example design of regression model based on provided dataset
- discuss solutions on a technical level
- present obtained case studies solutions as part of the exercises

#### Self-competence
The students:
- critically review provided offered information

### Module contents
After current course students will get advanced knowledge in the domains such as business intelligence and data analytics. Besides that, students will have a chance to have a deeper look into related technical fields such as InMemory Computing, Data Mining and Machine Learning, Big Data Processing with Distributed Systems (e.g. Apache Hadoop / Spark) from both, research and practical, perspectives. Students will be provided with real-world experience gather from business intelligence and data science related projects. Materials of the course are believed to be justified with current demands of data analytics market. Thus, providing students with relevant knowledge in order to give them advantages in future job.
### Recommended reading

- Jürgen Cleve, Uwe Lämmel (2014): "Data mining" (Deutsch)
- Max Bramer (2013): "Principles of data mining" (English)
- Ian Witten, Eibe Frank, Mark Hall (2011): "Data mining : practical machine learning tools and techniques" (English)
- Jure Leskovec, Anand Rajaraman, Jeffrey Ullman (2014): "Mining of massive datasets" (English)

### Links

- http://www.wi-ol.de/

### Languages of instruction

- German, English

### Duration (semesters)

- 1 Semester

### Module frequency

- annual

### Module capacity

- unlimited

### Module level

### Type of module

### Teaching/Learning method

- 1VL + 1S

### Previous knowledge

- none

### Examination

#### Examination times

### Type of examination

- Final exam of module
- At the end of the lecture period
- Written exam (max. 120 min.)

#### Type of course

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### Total module attendance time

- 56 h
inf650 - Transport Systems

Module label: Transport Systems
Module abbreviation: inf650
Credit points: 6.0 KP
Workload: 180 h

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

Responsible persons:
- Sauer, Jürgen (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
Production-oriented business informatics

Skills to be acquired in this module:
Objective of the module/skills:
The Module Transport systems deals with planning and controlling systems of internal and external company logistics as well as public transport. It provides basic knowledge and recent research topics. The focus is on a resource orientated holistic view of company logistics as well as the planning of transport infrastructure. Furthermore, trends such as autonomous vehicles and intelligent transport systems are discussed.

Professional competence:
The students:
- name the basics of planning and controlling company logistics
- assess transport systems of companies
- name methods and approaches of computer aided transport systems and classify them
- characterise software to plan complex logistics

Methodological competence:
The students:
- display topics and concepts of transport systems
- simulate transport and its systems with appropriate methods

Social competence:
The students:
- work in groups
- discuss their results appropriately

Self-competence:
The students:
- realise their limits while working on a project containing aspects of modelling and implementation
- question the presentation of their results

Module contents:
- Transport and logistics concepts
- Data acquisition of company logistics
- Planning- and simulation software for complex logistics- and transport processes
- Energy- and resource efficient transport systems
- Resource oriented transport cost calculations (e.g. CO2, noise pollution)
- Planning models for transport infrastructure

Recommended reading:

Suggested reading:
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inf663 - Application Area Maritime

Module label: Application Area Maritime
Module abbreviation: inf663
Credit points: 6.0 KP
Workload: 180 h

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

Responsible persons:
- Hahn, Axel (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
No participant requirements

Skills to be acquired in this module:

Professional competences:
The students:
- gain knowledge about ship handling and navigation and
- learn to understand maritime transportation as a system of systems with systems on board for stability, propulsion and steering as for bridge resource management.
- understand the latter as a mayor contribution to organize navigation as a hierarchical team concept of a safety critical sociotechnical system.
- are aware of the special technical and physical challenges of navigation.

Methodological competences:
The students:
- can apply system engineering methods to describe, analyse and design maritime systems. By looking on maritime transporation the gain transferable knowledge on other cyber physical systems.
- learned to how systems can deal with harsh environmental conditions in a resilient way.

Social competences:
The students:
- Maritime transportation is a mayor basis of a global economy. Typically, students do not have an understanding of these transportation systems nor their technical and systemic challenges. Therefore, the student knows the concepts of maritime transportation and its role in international transportation networks after finishing this module.

Self-Competences:
The students:
- Especially their competences cover an understanding as maritime transportation as a systems of system with high requirements on reliability, dependability and safety in combination with efficiency to be competitive in a global economy.

Module contents:
The module consists of a lecture and an exercise part:
Lecture:
Maritime Transportation in global and local supply chains, Base concepts of ship handling and navigation, maritime system dynamics, bridge resource management, eNAvigation and high automation systems.
Seminar:
Covering aspects of maritime transportation

Recommended reading:
- Bernhard Berking, Werner Huth (Herausgeber), Handbuch Nautik 1: Navigatorische Schiffsführung, Seehafen Verlag, 2010

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### inf973 - Psychological practicum fNIRS, EEG

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<td>Responsible persons</td>
<td>- Rieger, Jochem (Prüfungsberechtigt)</td>
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<td>- Lehrenden, Die im Modul (Prüfungsberechtigt)</td>
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<tr>
<td></td>
<td>The students:</td>
</tr>
<tr>
<td></td>
<td>- will acquire Knowledge of planning, performing, and analysis of a neurocognitive study</td>
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<td></td>
<td><strong>Methodological competences</strong></td>
</tr>
<tr>
<td></td>
<td>The students:</td>
</tr>
<tr>
<td></td>
<td>- learn to arrange a scientific report</td>
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<td>- be taught in the methods of psychophysiology, e.g. EEG, MEG, fMRI, or fNIRS</td>
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<td><strong>Social competences</strong></td>
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<tr>
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<td>The students:</td>
</tr>
<tr>
<td></td>
<td>- will work within a team</td>
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<tr>
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<td>- will have to apply time management</td>
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<tr>
<td>Module contents</td>
<td>The module consists of a practical part. The students will obtain knowledge of literature search, comprehension of scientific texts. They will acquire skills in conducting experimental research.</td>
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<tr>
<td>Language of instruction</td>
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<tr>
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inf974 - Human Computer Interaction and Brain Computer Interfacing

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| Applicability of the module      | • Master's Programme Engineering of Socio-Technical Systems  
                                     (Master) > Embedded Brain Computer Interaction |
| Responsible persons              | • Rieger, Jochem (module responsibility)  
                                     • Lehrenden, Die im Modul (Prüfungsberechtigt) |
| Prerequisites                    | No participant requirement                              |
| Skills to be acquired in this module | Professional competences  
                                           The students:  
                                           • human computer interaction (HCI) in its interdisciplinary requirements  
                                                             focusing on the perspective from neurocognitive psychology.  
                                           • basic knowledge of Brain Computer Interfacing  
                                           
                                           Methodological competences  
                                           The students:  
                                           • will acquire basic knowledge of neuroimaging and data analysis techniques.  
                                           • will acquire Methodological competences required for deriving statistical models to link brain and cognition/behavior.  
                                           • will acquire skills and knowledge to critically reflect basic science theories in naturalistic context.  
                                           
                                           Social competences  
                                           The students:  
                                           
                                           Self-competences  
                                           The students:  
                                           • will have knowledge of common experimental designs, data acquisition,  
                                                             and analysis methods and will have an insight of how to chose appropriate methods for their specific experiment  
                                           • are able to design and run a simple HCI/BCI experiment.  

| Module contents                   | The module consists of a lecture and an exercise part:  
                                           Lecture:  
                                           • Background and concepts of cognitive psychology relevant for human computer interaction  
                                           • Sensation, perception, action  
                                           • Data acquisition and processing methods for brain computer interfacing. |
| Recommended reading               | • Dornhege et al. (2007) Toward Brain Machine Interfacing, The MIT-Press |

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### Previous knowledge
none

### Examination

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### Type of course

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### Total module attendance time
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mar364 - Time Series Analysis

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**Applicability of the module**
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering
- Master's Programme Environmental Modelling (Master) > Mastermodule
- Master's Programme Marine Environmental Sciences (Master) > Mastermodule
- Master's Programme Marine Sensors (Master) > Mastermodule

**Responsible persons**
- Freund, Jan (module responsibility)

**Prerequisites**
Keine

**Skills to be acquired in this module**

**Module contents**
- Charakteristika eines stochastischen Prozesses und deren Schätzverfahren
- Komponentenmodell, Trendbereinigung, spektrale Methoden, Filterung, lineare Prozesse, und nichtlineare Prozesse, Einbettungsverfahren, Kenngrößen der nichtlinearen Zeitreihenanalyse, symbolische Dynamik

**Recommended reading**
- R. Schlittgen: Angewandte Zeitreihenanalyse mit R. Oldenbourg;
- R. Schlittgen & B. Streitberg: Zeitreihenanalyse. Oldenbourg;

**Links**

**Languages of instruction**
German, English

**Duration (semesters)**
1 Semester

**Module frequency**
jährlich

**Module capacity**
unlimited

**Module level**

**Type of module**

**Teaching/Learning method**

**Previous knowledge**

**Examination**
- Examination times
- Type of examination

**Final exam of module**
- Klausur am Ende der Veranstaltungszeit oder fachpraktische Übungen oder mündliche Prüfung oder Portfolio nach Maßgabe der Dozentin oder des
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**Total module attendance time** 56 h
inf203 - Embedded Systems I

Module label
Embedded Systems I

Module abbreviation
inf203

Credit points
6.0 KP

Workload
180 h

Applicability of the module
- Bachelor's Programme Computing Science (Bachelor) > Akzentsetzungsbereich - Wahlbereich Informatik
- Dual-Subject Bachelor's Programme Computing Science (Bachelor) > Wahlpflicht Technische Informatik (30 KP)
- Master's Programme Computing Science (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons
- Fränzle, Martin Georg (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
- Basics of technical computer science
- Computer Engineering

Skills to be acquired in this module
This module provides an introduction to the design of digital embedded systems.

Professional competence
The students:
- name functional and non-functional requirements to specify embedded systems
- discuss design space and associated embedded systems design methods
- name control and feedback control systems’ core concepts
- characterise the fundamental digital signal processing algorithms

Methodological competence
The students:
- design and develop embedded feedback control systems with modelling tools
- implement an embedded hardware/software system according to a given specification
- analyze various specification languages according to different properties

Social competence
The students:
- implement solutions to given problems in teams
- present results of computer science problems to groups
- organize themselves as a team to solve a larger problem using project management methods

Self-competence
The students:
- acknowledge the limits of their ability to cope with pressure during the implementation process of systems
- solve exercises self-responsibly

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 overview of embedded systems and their design. The process of digital signals is
especially important for telecommunications and multimedia. For this purpose, the module introduces digital signal processing algorithms. The principles of feedback control are introduced by exemplary transport applications. Subsequently, the module provides the specifications and language characteristics of the embedded system design. For this purpose, graphical data-flow modelling languages (for instance Simulink) and control-flow specifications (for instance State Charts) are presented. The module closes with the concepts of possible architectures and communication models. Hands-on exercises with the tools Matlab/Simulink/StateFlow support the module contents.

Recommended reading

Slides and:


Secondary literature:

- Artikelserie zum MPEG-2-Standard 3/94 10/94 und das Tutorial "Digitale Bildcodierung" 1/92 1/93, beides in "Fernseh- und Kinotechnik" (BIS: Z ell ZA 1536)
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inf204 - Embedded Systems II

Module label: Embedded Systems II
Module abbreviation: inf204
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module:
- Bachelor's Programme Computing Science (Bachelor) > Akzentsetzungsbereich - Wahlbereich Informatik
- Dual-Subject Bachelor's Programme Computing Science (Bachelor) > Wahlpflicht Technische Informatik (30 KP)
- Master of Education Programme (Gymnasium) Computing Science (Master of Education) > Wahlpflichtmodule (Technische Informatik)
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons:
- Fränzle, Martin Georg (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
No participant requirement

Skills to be acquired in this module:

Professional competence:
The students:
- name embedded systems architectures
- name specific hardware components and -architecture designs, particularly processor designs
- characterise the design spaces and associated embedded systems design techniques
- decompose subcomponents of feedback control systems and implement their tasks in different design spaces
- develop software-/hardware components
- describe fault-tolerance architecture principles
- describe real-time and safety requirements analysing techniques
- characterise hardware synthesis

Methodological competence:
The students:
- estimate the consequences of design decisions in terms of energy usage, performance and reliability component allocations, and designs
- implement an embedded hardware-/software system according to a given specification
- model hardware with a hardware description languages - analyze Hardware-/Software systems using event-bases simulation

Social competence:
The students:
- implement solutions to given problems in teams
- present results of computer science problems to groups
- organize themselves as a team to solve a larger problem using project management methods

Self-competence:
The students:
- acknowledge the limits of their ability to cope with pressure during the implementation process of systems
- deal self responsibly with exercises

Module contents:
Embedded systems support complex feedback problems, control problems and data processing tasks. They have an important value creation potential for telecommunication, 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 is the continuation of the module "Eingebettete Systeme I" and deals with different architectures of embedded systems and processors. The module provides system partitioning methods and the synthesis of hardware components. Hands-on exercises with development tools, hardware description languages and simulation support the
**Recommended reading**


**Secondary literature:**


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**Links**

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**Module level**

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### inf340 - Uncertainty Modeling for Control in Digitalised Energy Systems

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**Applicability of the module**
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodul der Informatik
- Master's Programme Computing Science (Master) > Technische Informatik
- Master's programme Digitalised Energy Systems (Master) > Digitalised Energy System Design and Assessment
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

**Responsible persons**
- Rauh, Andreas (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
- Basic knowledge of the control of linear time-continuous and/or time-discrete systems and/or robust control

**Skills to be acquired in this module**
- The students identify fundamentals of uncertainty modelling in control systems as well as problem-specific methods for the consideration of uncertainty during simulation and observer synthesis.

**Professional competences**
- The students:
  - identify fundamentals of uncertainty modeling in control systems
  - characterize problem-specific solution techniques for systems with stochastic and set-based uncertainty
  - are aware of software implementations in simulation, control, and state estimation.

**Methodological competences**
- The students:
  - students identify fundamentals of uncertainty modelling in control systems
  - characterise problem-specific solution techniques for systems with stochastic and set-based uncertainty
  - are aware of software implementations in simulation, control, and state estimation.

**Social competences**
- The students:
  - analyse problems of control-oriented uncertainty modelling
  - analyse fundamental solution techniques on a theoretical basis as well as transfer and generalise them independently toward novel research-oriented application scenarios.

**Self competences**
- The students:
  - critically reflect the achieved results of their project work
  - acknowledge limitations of various approaches for a control-oriented uncertainty modeling.

**Module contents**

1. Mathematical modeling of uncertainty in linear and nonlinear dynamic systems
2. Stochastic modeling approaches
   - Probability distributions
   - Bayesian state estimation for discrete-time systems (linear/nonlinear) and for continuous-time systems (linear)
   - Linear estimation techniques in an extended state-space (Carleman linearization for special system classes)
Monte-Carlo methods

3. Estimation of states, parameters and simulation of uncertain processes
   - Outlook: Markov models
   - Outlook: Bayesian networks

4. Set-based approaches
   - Set-based algorithms: Forward-backward contractor and bisection techniques
   - Interval methods for a verified solution of ordinary differential equations and for a stability proof of uncertain systems
   - Estimation of states and parameters as well as simulation of uncertain processes

5. Outlook: Synthesis of controllers and state observers under an explicit description of uncertainty

Recommended reading

- Rauh, A. Folien / Skript zur Vorlesung „Uncertainty Modelling for Control in DES“.

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| Type of module          | 1VL + 1Ü |

| Previous knowledge      | Basic knowledge of the control of linear time-continuous and/or time-discrete systems and/or robust control |

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| Total module attendance time | 4 h |

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inf341 - Robust Control and State Estimation in Digitalised Energy Systems

Module label: Robust Control and State Estimation in Digitalised Energy Systems
Module abbreviation: inf341
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Technische Informatik
- Master's programme Digitalised Energy Systems (Master) > Digitalised Energy System Automation, Control and Optimisation
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons
- Rauh, Andreas (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
- Basic knowledge of the control of linear continuous-time and/or discrete-time systems or of robust control

Skills to be acquired in this module
The students identify fundamentals of robust control and state estimation as well as problem-specific solution techniques and their corresponding software implementation.

Professional competences
The students
- identify fundamentals of robust control and state estimation
- characterize problem-specific solution techniques for different classes of uncertainty
- are aware of reliable software implementations.

Methodological competences
The students
- analyze problems of robust control and state estimation for dynamic systems
- analyze fundamental solution techniques on a theoretical basis
- transfer as well as generalize those independently to new fields of applications.

Social competences
The students
- develop solution ideas for real-life control problems within an accompanying project in small teams
- explain the obtained results in short presentations.

Self competences
The students
- critically reflect the achieved results of their project work
- acknowledge limitations of various approaches for robust control and state estimation.

Module contents

1. Robustness of linear systems/ system analysis
   - Boundary crossing theorem of Frazer and Duncan
   - Mikhailov criterion
   - Khantionov criterion
   - Frequency response approaches

2. Selected control design techniques/ control synthesis
   - Parameter-space approach of Ackermann and Kaesbauer
   - Eigenvalue and eigenvalue domain assignment
   - H-infinity control
   - Frequency response approaches (Sensitivity function approaches in the frequency domain)
3. Robust LMI-based control techniques
   - Lyapunov stability
   - Polytopic uncertainty modeling
   - Optimality of solutions
4. Duality between control and observer synthesis
   - Robust state estimation
   - Sliding mode observers
5. Interval methods: Solution of static and dynamic problems (Enclosing
   function values, Branch-and-bound techniques, Verification techniques
   for differential equations)
6. Fundamentals: Fault detection and fault-tolerant control

Recommended reading

- Gu, D.-W.; Petkov, P.H.; Konstantinov, M.M., Robust Control Design
  with MATLAB, Springer-Verlag, 2013
- Osterlag, E. Mono- and Multivariable Control and Estimation, Springer-
  Verlag, 2011
- Rauh, A. Folien/ Skript zur Vorlesung „Robuste Regelung und
  Zustandsschätzung“.
- Weinmann, A. Uncertain Models and Robust Control, Springer-Verlag, 1991

Links

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inf5122 - Learning-Based Control in Digitalised Energy Systems

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**Applicability of the module**
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's programme Digitalised Energy Systems (Master) > Digitalised Energy System Design and Assessment
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

**Responsible persons**
- Rauh, Andreas (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
Basic knowledge of control of linear continuous-time and/or discrete-timesystems and/or robust control

**Skills to be acquired in this module**
- The students identify fundamentals of learning-based control for dynamic systems.

**Professional competences**
The students:
- identify fundamentals of learning-based control for dynamic systems
- characterise problem- specific learning techniques
- are aware of software implementations for selected test rigs.

**Methological competences**
The students:
- analyse problems of learning-based control
- generalise them independently toward novel research-oriented application scenarios.

**Social competences**
The students:
- develop solution ideas for real-life control problems within an accompanying project/lab course in small teams
- explain the obtained results in short presentations.

**Self competences**
The students:
- critically reflect the achieved results of their project work
- acknowledge limitations of various approaches for learning-based control design.

**Module contents**
1. Iterative learning control (ILC)
   - Grundlegende 2D-Systemstrukturen
   - Stability criteria
   - Ausgewählte Optimierungsansätze
2. Data-driven neural network modelling vs. first-principle modelling
   - Static function approximations
   - NARX-modelling
3. Design of neural network- based controllers
4. Stability of neural network-based controllers

**Recommended reading**
- Jian Xin Xu; Ying Tan. Linear and Nonlinear Iterative Learning
Control. Springer-Verlag, 2003
- Rauh, A. Folien/ Skript zur Vorlesung „Learning-Based Control in DES”

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inf5408 - Applied Deep Learning in PyTorch

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<td>Prerequisites</td>
<td>knowledge of fundamental theoretical understanding in the field of machine learning and practical programming skills in Python.</td>
</tr>
<tr>
<td>Skills to be acquired in this module</td>
<td></td>
</tr>
<tr>
<td>Professional competence</td>
<td>The students</td>
</tr>
<tr>
<td></td>
<td>* have an overview of the components of deep learning frameworks</td>
</tr>
<tr>
<td></td>
<td>* are familiar with application areas of deep learning methods across various data modalities, and common solution strategies and model architectures</td>
</tr>
<tr>
<td></td>
<td>* can appropriately adapt deep learning methods to new problems in the respective domains and apply them independently.</td>
</tr>
<tr>
<td>Methodological competence</td>
<td>The students</td>
</tr>
<tr>
<td></td>
<td>* independently develop theoretical and practical concepts with the help of in-person events, provided materials, and specialized literature.</td>
</tr>
<tr>
<td>Social competence</td>
<td>The students</td>
</tr>
<tr>
<td></td>
<td>* can present solution approaches for problems in this area to the plenary and defend them in discussions.</td>
</tr>
<tr>
<td>Self-competence</td>
<td>The students</td>
</tr>
<tr>
<td></td>
<td>* are able to assess their own subject-specific and methodological competence</td>
</tr>
<tr>
<td></td>
<td>* take responsibility for their competence development and learning progress and reflect on these independently</td>
</tr>
<tr>
<td></td>
<td>* independently work on learning content and can critically reflect on the content.</td>
</tr>
</tbody>
</table>

Module contents

This lecture provides a comprehensive introduction to contemporary Deep Learning methods, with a specific emphasis on their practical application. Concurrently, it serves as a primer for the widely-used PyTorch Deep Learning framework, assuming only a basic familiarity with Python. The course encompasses a wide range of prevalent machine learning tasks across various data types, including tabular, image, text, audio, and graph data. Throughout the course, we delve into the most crucial and up-to-date model architectures within these domains. This encompasses convolutional neural networks, recurrent neural networks,
and transformer models. The lecture is complemented by hands-on exercise sessions, where students will gain practical proficiency with PyTorch. Simultaneously, they will acquire practical insights to effectively apply contemporary deep learning methods within their specific fields of interest.

Recommended reading

Links

<table>
<thead>
<tr>
<th>Language of instruction</th>
<th>English</th>
</tr>
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<tbody>
<tr>
<td>Duration (semesters)</td>
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<tr>
<td>Module frequency</td>
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</tr>
<tr>
<td>Module capacity</td>
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Module level

<table>
<thead>
<tr>
<th>Type of module</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Teaching/Learning method

1VL + 1Ü

Previous knowledge

knowledge of fundamental theoretical understanding in the field of machine learning and practical programming skills in Python.

Examination

<table>
<thead>
<tr>
<th>Examination</th>
<th>Examination times</th>
<th>Type of examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final exam of module</td>
<td>at the end of the lecture period</td>
<td>Written / oral exam</td>
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</table>

Type of course

<table>
<thead>
<tr>
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<th>Comment</th>
<th>SWS</th>
<th>Frequency</th>
<th>Workload of compulsory attendance</th>
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Total module attendance time

0 h
inf5452 - Current Topics in Trustworthy Machine Learning

Module label: Current Topics in Trustworthy Machine Learning
Module abbreviation: inf5452
Credit points: 3.0 KP
Workload: 90 h

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

Responsible persons
- Strodthoff, Nils (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
The seminar requires attending a foundational lecture in the field of Machine Learning and/or Deep Learning.

Skills to be acquired in this module

Professional competence
The students
- gain an exemplary overview of challenges and existing solution approaches in their respective problem domains and can contextualize these within the broader methodological context.

Methodological competence
The students
- can independently explore topics using current research literature and critically reflect upon them.

Social competence
The students
- can present solution approaches for problems in this area to the plenary and defend them in discussions.

Self-competence
The students
- are able to assess their own subject-specific and methodological competence. They take responsibility for their competence development and learning progress and reflect on these independently. In addition, they independently work on learning content and can critically reflect on the content.

Module contents
This seminar provides insights into various aspects of trustworthy Machine Learning. Depending on the instantiation of the module, different focuses should be set, such as interpretability/explainability, uncertainty quantification, or robustness.

Recommended reading

Links
Language of instruction: English
Duration (semesters): 1 Semester
Module frequency: every winter term
Module capacity: unlimited
<table>
<thead>
<tr>
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<tr>
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<td>Basic lecture in the field of machine learning, deep learning Prior knowledge desirable.</td>
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<td>Examination</td>
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<td>Workload Präsenzzeit</td>
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Systems Engineering

inf300 - Hybrid Systems

<table>
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<tr>
<th>Module label</th>
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<tr>
<td>Module abbreviation</td>
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</tr>
<tr>
<td>Credit points</td>
<td>6.0 KP</td>
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<tr>
<td>Workload</td>
<td>180 h</td>
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**Applicability of the module**
- Master's Programme Computing Science (Master) > Technische Informatik
- Master's Programme Computing Science (Master) > Theoretische Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

**Responsible persons**
- Fränzle, Martin Georg (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**

**Skills to be acquired in this module**

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

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

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

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

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

Recommended reading


Links

Languages of instruction: English, German
Duration (semesters): 1 Semester
Module frequency: annual
Module capacity: unlimited
Module level: 
Type of module: 
Teaching/Learning method: 1V+1Ü
Previous knowledge: Bachelor in Computing Science or knowledge of ordinary differential equations
The lecture assumes knowledge of modeling and analysis of reactive systems.

Examination

<table>
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<tr>
<th>Examination</th>
<th>Examination times</th>
<th>Type of examination</th>
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<td>Semester project including written work and final presentation</td>
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<th>SWS</th>
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Total module attendance time: 56 h
Inf301 - Machine-oriented Systems Engineering

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<td>Credit points</td>
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<tr>
<td>Workload</td>
<td>180 h</td>
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<td>Applicability of the module</td>
<td>- Master's Programme Computing Science (Master) &gt; Technische Informatik</td>
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<td>- Master's Programme Engineering of Socio-Technical Systems (Master) &gt; Embedded Brain Computer Interaction</td>
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<td>- Master's Programme Engineering of Socio-Technical Systems (Master) &gt; Human-Computer Interaction</td>
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<tr>
<td></td>
<td>- Master's Programme Engineering of Socio-Technical Systems (Master) &gt; Systems Engineering</td>
</tr>
<tr>
<td>Responsible persons</td>
<td>Fränzle, Martin Georg (module responsibility)</td>
</tr>
<tr>
<td></td>
<td>Lehrenden, Die im Modul (Prüfungsberechtigt)</td>
</tr>
<tr>
<td>Prerequisites</td>
<td>No participant requirements</td>
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<tr>
<td>Skills to be acquired in this module</td>
<td>The module provides practical relevance to the design of digital embedded systems.</td>
</tr>
<tr>
<td>Professional competence</td>
<td>The students:</td>
</tr>
<tr>
<td></td>
<td>- characterise the structure of microprocessor systems</td>
</tr>
<tr>
<td></td>
<td>- name control aspects of time sensitive external components</td>
</tr>
<tr>
<td></td>
<td>- program efficient embedded systems</td>
</tr>
<tr>
<td>Methodological competence</td>
<td>The students:</td>
</tr>
<tr>
<td></td>
<td>- use specifications from electrical components data sheets</td>
</tr>
<tr>
<td>Social competence</td>
<td>The students:</td>
</tr>
<tr>
<td></td>
<td>- work in a team</td>
</tr>
<tr>
<td></td>
<td>- discuss solutions</td>
</tr>
<tr>
<td>Module contents</td>
<td>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.</td>
</tr>
<tr>
<td>Recommended reading</td>
<td>Lecturers notes, hardware manuals and data sheets, and development tool manuals</td>
</tr>
<tr>
<td>Links</td>
<td></td>
</tr>
<tr>
<td>Languages of instruction</td>
<td>German, English</td>
</tr>
<tr>
<td>Duration (semesters)</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Module frequency</td>
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<td>Module capacity</td>
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<tr>
<td>Module level</td>
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<td>Type of module</td>
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</tr>
<tr>
<td>Teaching/Learning method</td>
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<tr>
<td>Previous knowledge</td>
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</tr>
<tr>
<td>Examination</td>
<td>Examination times</td>
</tr>
<tr>
<td></td>
<td>Type of examination</td>
</tr>
<tr>
<td>Final exam of module</td>
<td>At the end of the lecture period</td>
</tr>
<tr>
<td></td>
<td>Portfolio (Design, development and implementation of embedded systems, colloquium)</td>
</tr>
<tr>
<td>Type of course</td>
<td>Comment</td>
</tr>
<tr>
<td>--------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Lecture</td>
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</tr>
<tr>
<td>Practical training</td>
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<tr>
<td><strong>Total module attendance time</strong></td>
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</table>
inf303 - Fuzzy Control and Artificial Neural Networks in Robotics and Automation

<table>
<thead>
<tr>
<th>Module label</th>
<th>Fuzzy Control and Artificial Neural Networks in Robotics and Automation</th>
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<tbody>
<tr>
<td>Module abbreviation</td>
<td>inf303</td>
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<tr>
<td>Credit points</td>
<td>6.0 KP</td>
</tr>
<tr>
<td>Workload</td>
<td>180 h</td>
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</table>

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

**Responsible persons**
- Fatikow, Sergej (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
- No participant requirements

**Skills to be acquired in this module**

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

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

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

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

**Objective of the module / skills:**
- 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

**Recommended reading**

**Essentiell:**
- Vorlesungs-skript in Buchform (erhältlich im Sekretariat, A1-3-303)

**Empfohlen:**

**Gute Sekundärliteratur:**
- Altrock, M. O. R.: Fuzzy Logic, R. Oldenbourg Verlag, 1993
- Kahlert, J. und Hubert, F.: Fuzzy-Logik und Fuzzy-Control, Vieweg, 1993
- Kratzer, K.P.: Neuronale Netze, Carl Hanser, 1993
- Lawrence, J.: Neuronale Netze, Sytemtha Verlag, München, 1992
- Patterson, D.W.: Künstliche neuronale Netze, Prentice Hall, 1996
- Zakharian, S. Ladewig-Riebler, P. und Thoer, St.: Neuronale Netze für Ingenieure, Vieweg, Wiesbaden, 1998
- Zimmermann H.-J. (Hrsg.): Datenanalyse, VDI-Verlag, 1995

**Links**

<table>
<thead>
<tr>
<th>Languages of instruction</th>
<th>English, German</th>
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<tr>
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<td>1 Semester</td>
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<tr>
<td>Module frequency</td>
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<td>Module capacity</td>
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<td>Type of module</td>
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<tr>
<td><strong>Teaching/Learning method</strong></td>
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<tr>
<td>-----------------------------</td>
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<tr>
<td><strong>Previous knowledge</strong></td>
<td>Knowledge in Control Engineering</td>
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<tr>
<td><strong>Examination</strong></td>
<td><strong>Examination times</strong></td>
</tr>
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<td>Final exam of module</td>
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<tr>
<td><strong>Type of course</strong></td>
<td><strong>Comment</strong></td>
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<tr>
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<td><strong>Total module attendance time</strong></td>
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inf305 - Medical Technology

Module label: Medical Technology
Module abbreviation: inf305
Credit points: 6.0 KP
Workload: 180 h

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

Responsible persons:
- Hein, Andreas (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
useful knowledge in
- Signal and Image Processing
- Control Engineering

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)

Recommended reading:
essential:
- Kramme, R.: Medizintechnik. Verfahren, Systeme und
Informationssysteme, Springer Verlag, 2002 (2. Auflage)
- Lecture slides
- recommended:

**secondary literature:**

### Links

<table>
<thead>
<tr>
<th>Languages of instruction</th>
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<td>Duration (semesters)</td>
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<td>Module frequency</td>
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<td>Module capacity</td>
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**Module level**
- Type of module
  - 1VL + 1Ü

**Previous knowledge**
- useful knowledge in
  - Signal and Image Processing
  - Control Engineering

**Examination**
- **Examination times**
  - Final exam of module: At the end of the lecture period
- **Type of examination**
  - Portfolio: Hands-on exercises, report, and written or oral exam

**Type of course**

<table>
<thead>
<tr>
<th>Type of course</th>
<th>Comment</th>
<th>SWS</th>
<th>Frequency</th>
<th>Workload of compulsory attendance</th>
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<tr>
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**Total module attendance time**
- 56 h
inf307 - Robotics

Module label: Robotics
Module abbreviation: inf307
Credit points: 6.0 KP
Workload: 180 h

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

Responsible persons
- Hein, Andreas (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
No participant 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

Recommended reading

essential:
• lecture nodes

recommended:


secondary literature:


Links

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inf308 - Microrobotics II

Module label: Microrobotics II
Module abbreviation: inf308
Credit points: 6.0 KP
Workload: 180 h

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

Responsible persons:
- Fatikow, Sergej (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
Microrobotics and Microsystems Engineering

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

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

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

Social competence
The students:
- work in a team

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

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

- Lecture notes (can be obtained in secretariate, A1-3-303)

Links

Languages of instruction: English, German
Duration (semesters): 1 Semester
Module frequency: annual
Module capacity: unlimited
Module level:
Type of module:
Teaching/Learning method: 1VL + 1Ü
Previous knowledge: Microrobotics and Microsystems Engineering
Examination:
Examination times: At the end of the lecture period
Type of examination: Oral Exam and exercises
Final exam of module:
Type of course
Comment
SWS
Frequency
Workload of compulsory attendance
Lecture: 3
Exercises: 1
Total module attendance time: 56 h

Workload of compulsory attendance

SoSe

Frequency

42

14

56 h
inf311 - Low Energy System Design

Module label: Low Energy System Design
Module abbreviation: inf311
Credit points: 6.0 KP
Workload: 180 h

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

Responsible persons:
- Fatikow, Sergej (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Skills to be acquired in this module:

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

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

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

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

Module contents:

According to Moore’s Law the number of integratable transistors on a computer chip doubles every two years. In addition, new circuits are getting faster and faster. This leads not only to an increased functionality of a system, but it also increases the electrical power consumption. This electrical power consumption is problematic from two different points of view: Firstly, the electrical power must be supplied. Secondly, the resulting heat has to dissipate from the system. An increased power consumption always causes lower battery life and higher energy costs. The heat generation reduces the reliability and life of integrated circuits. The cooling (ceramic housings, cooling elements, fans, etc.) increases the system’s costs. Today the development of heat, caused by power dissipation, needs to be considered during the embedded system design process. This knowledge takes the system’s reliability and operation costs into account. This module introduces the estimation of power dissipation and optimisation.

Recommended reading:
- Designing CMOS Circuits for Low Power – Dimitros Soudris, Christian Piguet, Costas Goutis
- Leakage in Nanometer CMOS Technologies – Siva G. Narendra, Anantha Chandrakasan
- Entwurf von digitalen Schaltungen und Systemen mit HDLs und FPGAs – F. Kesei, 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

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| Previous knowledge | Knowledge in:  
  - Fundamentals of Computer Engineering,  
  - Embedded Systems I,  
  - Embedded Systems II |

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<td>WiSe</td>
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| Total module attendance time | 56 h |
inf334 - System Level Design

Module label: System Level Design
Module abbreviation: inf334
Credit points: 6.0 KP
Workload: 180 h

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

Responsible persons
- Lehrende, Die im Modul (Prüfungsberechtigt)
- Lehrende, Die im Modul (module responsibility)

Prerequisites
No participant requirements

Skills to be acquired in this module

Professional competences
The students:
- ability to describe and analyze system components and architectures using system level description languages SpecC and SystemC
- capabilities for partitioning and parallelizing of applications

Methodological competences
The students:
- knowledge of refinement and transformation techniques for transferring an initial specification into a real implementation
- knowledge of the phases of a system-level design flow
- knowledge of current design methods and tools in system level design
- knowledge about formal models of computation of specification languages
- knowledge of current research results and trends in system level design
- capabilities for partitioning and parallelizing of applications
- ability to evaluate and explore design decisions
- ability to implement a complete system design-to-implementation specification

Social competences
The students:
- implement solutions of given problems in teams
- discuss their outcomes appropriately

Self-competences
The students:
- presentation skills
- reflect their solutions by using methods learned in this course

Module contents
The ever-increasing integration densities of integrated circuits enable the implementation of increasingly powerful and complex systems. This can be on the one hand the integration of several sub-components on the same chip (system-on-chip) or on the other hand the implementation of more powerful algorithms. However, traditional design techniques are hardly able to cope with the increasing complexity of today's embedded systems. Therefore, in research and practice efforts through new methods and tools, there is a significant increase in productivity in the design process, thus closing the so-called “design productivity gap”. This is achieved, for example, by a stronger abstraction, in which the behavior of components is described only at the algorithmic level and is automatically translated into hardware or software implementations by high-level synthesis techniques. The final system implementation is achieved by means of a structured refinement and exploration processes. Throughout this refinement flow, system properties (for example, timing, energy consumption, chip area and costs) are estimated on each abstraction level and guide the designer in the iterative decision process. By means of techniques such as virtual prototyping, entire systems can be simulated and verified on each refinement layer, even without the availability of a full implementation for all system components. This module builds on the modules Embedded Systems I and II, deepens the knowledge acquired there...
for the design of hardware/software systems and expands them with current methods and tools. With SystemC, a language is presented that is already widely used in industry and research for the design and verification of hardware/software systems and supports several abstraction levels from clock cycle accurate hardware description, over transaction level models to process based functional specifications.

**Recommended reading**

**Suggested reading:**

**Main textbooks:**


**Optional books:**


Additional reading material posted on Stud.IP

**Links**

https://www.uni-oldenburg.de/informatik/ehs/lehre/vorlesungen/system-level-design/

**Language of instruction**

English

**Duration (semesters)**

1 Semester

**Module frequency**

annual

**Module capacity**

unlimited

**Module level**

Teaching/Learning method

1VL + 1Ü

**Previous knowledge**

none

**Examination**

Examination times

Type of examination

Final exam of module at the end of the lecture period hands-on exercises and oral exam

**Type of course**

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**Total module attendance time**

56 h
inf336 - Application Area Automotive

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<td>6.0 KP</td>
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<tr>
<td>Workload</td>
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**Applicability of the module**
- Master's Programme Computing Science (Master) > Technische Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

**Responsible persons**
- Köster, Frank (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
- No participant requirements

**Skills to be acquired in this module**

**Professional competences:**
The students:
- discuss core-concepts of the transportation domain
- discuss different modes of transportation (focus on the automotive sector)
- discuss automated and connected driving (short introduction/overview)
- discuss human factors in the automotive sector
- discuss traffic infrastructure (focus on intersections)
- discuss basic principles in traffic management

**Methodological competences:**
The students:
- analyze vehicle systems
- analyze traffic infrastructure
- analyze cooperative vehicle/infrastructure systems
- analyze socio-technical systems

**Social competences:**
The students:
- work in teams
- discuss their outcomes appropriately

**Self-competences:**
The students:
- acknowledge the limits of their ability to cope with pressure during the work on the topics of the module

**Module contents**
- Core-concepts of the transportation domain
- Modes of transportation (focus on the automotive sector)
- Automated and connected driving (short introduction/overview)
- Human factors in the automotive sector
- Traffic infrastructure (focus on intersections)
- Basic principles in traffic management

**Recommended reading**
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inf338 - Design of Autonomous Systems

Module label: Design of Autonomous Systems
Module abbreviation: inf338
Credit points: 6.0 KP
Workload: 180 h

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

Responsible persons:
- Lehrenden, Die im Modul (Prüfungsberechtigt)
- Fränzle, Martin Georg (module responsibility)

Prerequisites:
No participant requirements

Skills to be acquired in this module:

Professional competences
The students are enabled to analyze and build autonomous systems.

Methodological competences
The students
- know examples of existing autonomous systems, understand the elements involved in their architectural design and the rationale behind decomposing the problem into obligations for the respective system components.
- analyze existing architectures for autonomous systems with respect to their performance and safety.
- learn how to decompose a problem of designing an autonomous system into an architecture
- are able to derive design obligations for its components, and can structure a pertinent safety case.
- understand the software and hardware components necessary for achieving system autonomy and are able to design or instantiate these.

Social competences
The students
- acquire hands-on experience in designing components for autonomous systems in small teams and present the underlying theory, their particular design decisions, and their personal evaluation to fellow students.

Self-competences
The students
- can judge adequacy of their methodological skills for designing particular autonomous solutions
- are able to assess the safety impact of such a solution and are therefore able to develop a personal ethical stance towards its realization

Module contents:
The module consists of a lecture and an exercise part

Recommended reading

Language of instruction:
English

Duration (semesters):
1 Semester

Module frequency:
annual

Module capacity:
unlimited

Module level:

Type of module:
1VL + 1Ü

Previous knowledge:
none
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**Total module attendance time** 56 h
inf454 - Communicating and Mobile Systems

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

Responsible persons
- Olderog, Ernst-Rüdiger (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
No participant requirements

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

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

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

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

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

Module contents
Communication is one of the basic concepts of computer science. It occurs between computers in a network as well as between components of a computer. The focus of the course is on Robin Milner’s \( \tau \)-calculus. It enables a new modelling of communication, taking the location of the communication into account. The \( \tau \)-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 \( \tau \)-calculus, which is based on operational semantics and a concept of behavioural equivalence. The theory will be explained in a step-by-step manner.

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

Recommended reading

Links

Languages of instruction  German, English
Duration (semesters)  1 Semester
Module frequency  irregular
Module capacity  unlimited

Module level

Type of module
Teaching/Learning method  1VL + 1Ü
Previous knowledge  Theoretical Computer Science II
Examination  Examination times  Type of examination
Final exam of module  At the end of the lecture period  written exam or oral exam

Type of course  Comment  SWS  Frequency  Workload of compulsory attendance
Lecture  3  WiSe  42
Exercises  1  WiSe  14

Total module attendance time  56 h
inf456 - Real-Time Systems

Module label
Real-Time Systems

Module abbreviation
inf456

Credit points
6.0 KP

Workload
180 h

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

Responsible persons
- Olderog, Ernst-Rüdiger (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
Theoretical Computer Science I + II

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:
- 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

Recommended reading

Essential:
  Automatic Verification, Cambridge University Press, 2008

Recommended:
- C. Heitmeyer and D. Madrioli, editors. Formal Methods for Real-Time
- M. Joseph, editor. Real-time Systems -- Specification, Verification and

Links

Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency
irregular

Module capacity
unlimited

Module level

Type of module

Teaching/Learning method
1VL + 1Ü

Previous knowledge
Theoretical Computer Science I + II

Examination
Examination times
Type of examination
At the end of the lecture period Exercises and written or oral exam

Type of course
Comment
SWS
Frequency
Workload of compulsory attendance

Lecture
3
SoSe oder WiSe
42

Exercises
1
SoSe oder WiSe
14

Total module attendance time
56 h
inf502 - Simulation

Module label: Simulation
Module abbreviation: inf502
Credit points: 6.0 KP
Workload: 180 h

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

Responsible persons
- Hahn, Axel (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
Programming knowledge, primarily in Java, is mandatory

Skills to be acquired in this module
Simulation is a major tool for gaining knowledge about systems and their behavior. It can be used to gain system understanding and prediction future system status. The module covers mathematical basic as well a basic simulation technology. The module completes itself by addressing application examples. By seminar and practical work, the students get hands on experience of simulation technologies.

Professional competence
The students:
- get an overview on methods, tools and application areas of simulation. They know what simulation can do and what are its limitation. Covered application are mainly in transportation and production domain.

Methodological competence
The students:
- know simulation technologies and model building basics
- understand the handling of time and problems of discretization.
- can solve problems with simulation after lecture. This includes modeling, use of simulation environment and evaluation of results.
- will be learned cause of practical use, the independent handling of research questions and the use of simulation as research method

Social competence
The students:
- gain team and social skills by self-organized development of simulation.

Self-competence
The students:
- can apply simulation technologies on scientific research questions.

Module contents
In lectures the students get background information and simulation basics. Then they apply their knowledge by developing an own simulation by using state of the art simulation environments

Recommended reading

Links
Languages of instruction: German, English
Duration (semesters): 1 Semester
Module frequency: annual
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</table>
inf537 - Intelligent Systems

Module label
Intelligent Systems

Module abbreviation
inf537

Credit points
6.0 KP

Workload
180 h

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

Responsible persons
- Sauer, Jürgen (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
Production oriented business informatics

Skills to be acquired in this module
Professional competence
The students:
- name the structure of agent-based systems
- use problem-solving methods for complex problems
- characterise the application area of process planning
- evaluate the suitability of processes regarding to specific problems

Methodological competence
The students:
- assign problem-solving methods to different problems

Social competence
The students:
- implement selected methods in small teams

Self-competence
The students:
- develop own solutions for given problems

Module contents
A lot of application areas use "intelligent" problem-solving methods. These are the main focus of this lecture. They will be illustrated by examples in order to enhance the students' problem-solving abilities. These include:

- A brief introduction into AI
- Agent systems and
- Solution methods of AI like heuristics, meta-heuristics, soft computing methods. To apply and foster the contents of the lecture, an intelligent planning system is implemented in practical exercises.

Recommended reading
Suggested reading:
- Ghallab/ Nau/Traverso: Automated Planning, Morgan Kaufman, 2004

Links
www.wi-ol.de

Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency
annual

Module capacity
unlimited
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<td>Practical exercises and oral exam or practical exercises and written exam or portfolio</td>
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inf604 - Business Intelligence I

Module label: Business Intelligence I
Module abbreviation: inf604
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module:
- Master Applied Economics and Data Science (Master) > Data Science
- Master of Education Programme (Vocational and Business Education) Computing Science (Master of Education) > Akzentsetzungsbereich
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodul Bereich Wirtschaftsinformatik
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons:
- Marx Gómez, Jorge (Prüfungsberechtigt)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
No participant requirement

Skills to be acquired in this module:
Objective of the module/skills:
Current module provides basics of business intelligence with focus on enterprises and strong emphasis on data warehousing technologies. Students of the course are provided with knowledge, which reflects current research and development in a data analytic domain.

Professional competence
The students:
- name and recognize the role of business intelligence as part of daily business process
- being able to analyse advantages and disadvantages of different approaches and methods of the data analytics and being able to apply them in simple case studies
- obtain theoretical knowledge about data collection and modelling processes, including most applicable approaches and best practices

Methodological competence
The students:
- being able to execute typical tasks of business intelligence, and also being able to deepen knowledge on different approaches and methods
- gain a hands on experience and being able to understand advantages and disadvantages of different methods and being able to use obtained knowledge in most efficient ways

Social competence
The students:
- build solutions based on case studies given to the group, for example solving the issue of a factless fact table
- discuss solutions on a technical level
- present obtained case studies solutions as part of the exercises

Self-competence
The students:
- critically review provided data and information

Module contents:
Data warehouse technology together with business intelligence are increasingly being used by business in order to get better decision support and enrich ongoing processes with data-rich decisions. Data warehouse technology enables an integration of data from heterogeneous sources, whether business intelligence builds data processing on top of it. For instance, business intelligence allows to build reporting on very large volumes of data (including historical) coming primary from data warehouse.
As past of the current module following contents are taught:
• Definition and scope of business intelligence.
• Procedures and objectives of data warehousing.
• Process of extracting, transforming and loading (ETL) of data.
• Phases of data modelling, data capturing and reporting in conjunction with a plausible case studies/scenarios.
• Prospects for further and evolving topics for business intelligence (e.g. Adaptive Business Intelligence, In-MemoryComputing, etc.)
• Introduction to Data Mining.
• Case studies based practical exercises and assessments in order to impart practical knowledge.

Recommended reading

• Marx Gómez, Rautenstrauch, Cissek (2008): Einführung in die Business Intelligence mit SAP NetWeaver 7.0.
• Moss, Atre (2006): Business Intelligence Roadmap, Addison-Wesley, Boston.
• Loshin (2003): Business Intelligence, Kaufmann, Amsterdam.
• Möller, Lenz (2013): Business Intelligence.

Links
http://www.wi-ol.de

Languages of instruction
German, English

Duration (semesters)
1 Semester

Module frequency
annual

Module capacity
unlimited

Module level

Type of module

Teaching/Learning method
1VL + 1Ü

Previous knowledge
none

Examination

Examination times
Type of examination

Final exam of module
At the end of the lecture period
Written exam max. 120 minutes

Type of course

Comment
SWS
Frequency
Workload of compulsory attendance

Lecture
2
WiSe
28

Exercises
2
WiSe
28

Total module attendance time
56 h
## inf607 - Business Intelligence II

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<td>Workload</td>
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### Applicability of the module
- Master Applied Economics and Data Science (Master) > Data Science
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodul Bereich Wirtschaftsinformatik
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodul Bereiche Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

### Responsible persons
- Marx Gómez, Jorge (Prüfungsberechtigt)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

### Prerequisites
- No participant requirement

### Skills to be acquired in this module

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<tbody>
<tr>
<td>The students:</td>
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<tr>
<td>- name and recognize the role of data analytics / data science as past of a daily business process in a particular company</td>
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<tr>
<td>- able to organize from management perspective data analytics project</td>
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<tr>
<td>- being able to analyse advantages and disadvantages of different approaches and methods of the data analytics and being able to apply them in simple case studies</td>
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<tr>
<td>- obtain theoretical knowledge about data collection and modelling processes, including state of the art approaches and available best practices</td>
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<table>
<thead>
<tr>
<th>Methodological competence</th>
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<tbody>
<tr>
<td>The students:</td>
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<tr>
<td>- being able to execute typical tasks of data analytics, and also being able to proceed deeper with respect to different approaches and methods</td>
</tr>
<tr>
<td>- gain a hands on experience and being able to understand advantages and disadvantages of different methods and being able to use obtained knowledge</td>
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<table>
<thead>
<tr>
<th>Social competence</th>
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<tbody>
<tr>
<td>The students:</td>
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<tr>
<td>- build solutions based on case studies given to the group, for example design of regression model based on provided dataset</td>
</tr>
<tr>
<td>- discuss solutions on a technical level</td>
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<td>- present obtained case studies solutions as part of the exercises</td>
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<table>
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<tr>
<th>Self-competence</th>
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<tbody>
<tr>
<td>The students:</td>
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<tr>
<td>- critically review provided offered information</td>
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### Module contents
After current course students will get advanced knowledge in the domains such as business intelligence and data analytics. Besides that, students will have a chance to have a deeper look into related technical fields such as InMemory Computing, Data Mining and Machine Learning, Big Data Processing with Distributed Systems (e.g. Apache Hadoop / Spark) from both, research and practical, perspectives. Students will be provided with real-world experience gather from business intelligence and data science related projects. Materials of the course are believed to be justified with current demands of data analytics market. Thus, providing students with relevant knowledge in order to give them advantages in future job.
Recommended reading

- Jürgen Cleve, Uwe Lämmel (2014): "Data mining" (Deutsch)
- Max Bramer (2013): "Principles of data mining" (English)
- Ian Witten, Eibe Frank, Mark Hall (2011): "Data mining : practical machine learning tools and techniques" (English)
- Jure Leskovec, Anand Rajaraman, Jeffrey Ullman (2014): "Mining of massive datasets" (English)

Links

http://www.wi-ol.de/

Languages of instruction

German, English

Duration (semesters)

1 Semester

Module frequency

annual

Module capacity

unlimited

Module level

Type of module

Teaching/Learning method

1VL + 1S

Previous knowledge

none

Examination

Examination times

Type of examination

Final exam of module

At the end of the lecture period

Written exam (max. 120 min.)

Type of course

Comment

SWS

Frequency

Workload of compulsory attendance

Lecture

2

SoSe

28

Exercises

2

SoSe

28

Total module attendance time

56 h
inf650 - Transport Systems

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

**Responsible persons**
- Sauer, Jürgen (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
Production-oriented business informatics

**Skills to be acquired in this module**

**Objective of the module/skills:**
The Module Transport systems deals with planning and controlling systems of internal and external company logistics as well as public transport. It provides basic knowledge and recent research topics. The focus is on a resource orientated holistic view of company logistics as well as the planning of transport infrastructure. Furthermore, trends such as autonomous vehicles and intelligent transport systems are discussed.

**Professional competence**
The students:
- name the basics of planning and controlling company logistics
- assess transport systems of companies
- name methods and approaches of computer aided transport systems and classify them
- characterise software to plan complex logistics

**Methodological competence**
The students:
- display topics and concepts of transport systems
- simulate transport and its systems with appropriate methods

**Social competence**
The students:
- work in groups
- discuss their results appropriately

**Self-competence**
The students:
- realise their limits while working on a project containing aspects of modelling and implementation
- question the presentation of their results

**Module contents**

- Transport and logistics concepts
- Data acquisition of company logistics
- Planning- and simulation software for complex logistics- and transport processes
- Energy- and resource efficient transport systems
- Resource oriented transport cost calculations (e.g. CO2, noise pollution)
- Planning models for transport infrastructure

**Recommended reading**

**Suggested reading:**
<table>
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<tr>
<th>Links</th>
<th><a href="http://wi-ol.de">http://wi-ol.de</a></th>
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inf657 - Product Engineering

Module label
Product Engineering

Module abbreviation
inf657

Credit points
6.0 KP

Workload
180 h

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

Responsible persons
- Sauer, Jürgen (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
No participant requirement

Skills to be acquired in this module
Focus of this module is to learn and apply the product engineering process. A project will enable the students to design a product from the idea to the prototype. More specifically, a systematic, partial domain-specific, approach to solve technical problems and aspects of project management will be learned. Regular meetings are used to train the presentation capabilities of the students and to schedule working packages within the teams.

Professional competence
The students:
- learn and try out the handling of virtual and physical prototypes
- learn and try out the construction and validation of virtual prototypes with the aid of CAD-applications
- learn and combine different basic development concepts from the mechanical engineering, microelectronics, control engineering and software engineering

Methodological competence
The students:
- learn and try out project management concepts
- learn and recognise the connections of different development concepts from different fields, e.g. mechanical engineering, control engineering, microelectronics and software engineering
- develop own products with creativity techniques
- schedule and organise the product development supported by project management techniques independently
- learn the systematic refining of their own product idea with SysML
design and test products with state-of-the-art CAD-applications

Social competence
The students:
- impart their structure and mode of action to other people
- develop their own products in small teams
- present their solutions to groups
- integrate criticism to their solutions
- support other groups by giving appropriate criticism

Self-competence
The students:
- recognise and reflect their own limitations to get familiar and to plan a project in an unknown field (e.g. maritime construction/industries)

Module contents
This module is a lecture accompanied by a hands-on project. The students work on one product development task. The product development starts with the idea-finding/brainstorming process which is used to create a digital product concept. During the semester a digital prototype will be created and validated by its initial requirements. Finally, a physical prototype is produced with a 3D-Printer (Rapid Prototyping). The progress of the project has to be documented and presented at different milestones.

Recommended reading
### Links
- [www.wi-ol.de](http://www.wi-ol.de)

### Languages of instruction
- German, English

### Duration (semesters)
- 1 Semester

### Module frequency
- Annual

### Module capacity
- Unlimited

### Reference text
- The lecture material contains English parts

### Module level

#### Type of module

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#### Previous knowledge
- None

#### Examination

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<td>Written exam or oral exam, or written documentation or Presentation or Portfolio</td>
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#### Final exam of module

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#### Total module attendance time
- 56 h
inf663 - Application Area Maritime

Module label: Application Area Maritime

Module abbreviation: inf663

Credit points: 6.0 KP

Workload: 180 h

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

Responsible persons:
- Hahn, Axel (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
No participant requirements

Skills to be acquired in this module:

Professional competences
The students:
- gain knowledge about ship handling and navigation and
- learn to understand maritime transportation as a system of systems with systems on board for stability, propulsion and steering as for bridge resource management.
- understand the latter as a mayor contribution to organize navigation as a hierarchical team concept of a safety critical sociotechnical system.
- are aware of the special technical and physical challenges of navigation.

Methodological competences
The students:
- can apply system engineering methods to describe, analyse and design maritime systems. By looking on maritime transporation the gain transferable knowledge on other cyber physical systems.
- learned to how systems can deal with harsh environmental conditions in a resilient way.

Social competences
The students:
- Maritime transportation is a mayor basis of a global economy. Typically, students do not have an understanding of these transportation systems nor their technical and systemic challenges. Therefore, the student knows the concepts of maritime transportation and its role in international transportation networks after finishing this module.

Self-Competences
The students:
- Especially their competences cover an understanding as maritime transportation as a systems of system with high requirements on reliability, dependability and safety in combination with efficiency to be competitive in a global economy.

Module contents:
The module consists of a lecture and an exercise part:
Lecture:
Maritime Transportation in global and local supply chains, Base concepts of ship handling and navigation, maritime system dynamics, bridge resource management, eNAvigation and high automation systems.
Seminar:
Covering aspects of maritime transportation

Recommended reading:
- Bernhard Berking, Werner Huth (Herausgeber), Handbuch Nautik 1: Navigatorische Schiffsführung, Seehafen Verlag, 2010

Links

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**Module level**

**Type of module**

**Teaching/Learning method** 1VL + 1S

**Previous knowledge** none

**Examination**

**Examination times** At the end of the lecture period

**Type of examination** Oral exam and documentation

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<th>Comment</th>
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<th>Workload of compulsory attendance</th>
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<td>SoSe und WiSe</td>
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<td>Seminar</td>
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<td>SoSe und WiSe</td>
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**Total module attendance time** 56 h
inf900 - Group Project

Module label | Group Project
---|---
Module abbreviation | inf900
Credit points | 24.0 KP
Workload | 720 h

Applicability of the module
- Master's Programme Business Informatics (Master) > Kernmodule
- Master's Programme Computing Science (Master) > Kernmodule
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons
- Peter, Andreas (module responsibility)
- Marx Gómez, Jorge (module responsibility)
- Boll-Westermann, Susanne (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
- Programming course
- Software Engineering
- Soft Skills

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.

Recommended reading
According to the assigned task

Links
https://www.uni-oldenburg.de/informatik/studium-lehre/infos-zum-studium/projektgruppen-im-masterstudium/
<table>
<thead>
<tr>
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<tr>
<td><strong>Duration (semesters)</strong></td>
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<tr>
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<tr>
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<td>Dieses Modul ist im Rahmen der Projekte FliF und FoL konzipiert worden</td>
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**Module level**

<table>
<thead>
<tr>
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</tr>
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<tbody>
<tr>
<td><strong>Teaching/Learning method</strong></td>
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</table>
| **Previous knowledge**           | - Programming course  
                                 | - Software Engineering  
                                 | - Soft Skills |
| **Examination**                  | Examination times  
                                 | Type of examination |
| **Final exam of module**         | At the End of the semester term  
                                 | Active involvement, presentation, final report, project assessment |

**Type of course**

| **Project group** |

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<tr>
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### inf903 - Research Project I

<table>
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<tbody>
<tr>
<td><strong>Module abbreviation</strong></td>
<td>inf903</td>
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<tr>
<td><strong>Credit points</strong></td>
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</tr>
<tr>
<td><strong>Workload</strong></td>
<td>360 h</td>
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</table>
| **Applicability of the module** | - Master's Programme Business Informatics (Master) > Kernmodule  
- Master's Programme Computing Science (Master) > Kernmodule  
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering |
| **Responsible persons** | - Marx Gómez, Jorge (module responsibility)  
- Peter, Andreas (module responsibility)  
- Boll-Westermann, Susanne (module responsibility)  
- Lehrenden, Die im Modul (Prüfungsbeauftragte) |
| **Prerequisites** | No participant requirement |

**Skills to be acquired in this module**

The Module practices the scientific competencies in preparation of the master thesis. It is intended to replace the project group with the two "Research Project" modules to ensure studyability and to enable students to perform research projects at foreign universities. Additionally, it is also intended to embed the student into the research activities of the supervisor in preparation of a potential doctoral work after finishing the program.

**Module contents**

Definition of a research question, identifying the state of the art, development of a research plan, performing research tasks, scientific writing, presentation of results.

**Professional competence**

The students:

- will extend their competences in the required technologies of the research area

**Methodological competence**

The students:

- will extend their competences in scientific methodologies, methods, and tools regarding the research area

**Social competence**

The students:

- will be integrated in the working group of the supervisor of the work and have to present as well as discuss the results within the working group

**Self-competence**:

The students:

- 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 hypothesis to theories independently  
- work in their field independently

**Recommended reading**

Will be announced by the supervisor according to the research topic.

**Languages of instruction**

English, German

**Duration (semesters)**

1 Semester

**Module frequency**

every semester

**Module capacity**

unlimited

**Module level**


**Type of module**

**Teaching/Learning method**

P

**Previous knowledge**

none

**Examination**

Examination times

**Type of examination**

Projekt

**Final exam of module**

At the end of the lecture period
<table>
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mar364 - Time Series Analysis

Module label: Time Series Analysis
Module abbreviation: mar364
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module:
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering
- Master's Programme Environmental Modelling (Master) > Mastermodule
- Master's Programme Marine Environmental Sciences (Master) > Mastermodule
- Master's Programme Marine Sensors (Master) > Mastermodule

Responsible persons:
- Freund, Jan (module responsibility)

Prerequisites:
- Keine

Skills to be acquired in this module:

Module contents:
- Charakteristika eines stochastischen Prozesses und deren Schätzer, Komponentenmodell, Trendbereinigung, spektrale Methoden, Filterung, lineare Prozesse, und nichtlineare Prozesse, Einbettungsverfahren, Kenngrößen der nichtlinearen Zeitreihenanalyse, symbolische Dynamik

Recommended reading:
- R. Schlittgen: Angewandte Zeitreihenanalyse mit R. Oldenbourg;
- R. Schlittgen & B. Streitberg: Zeitreihenanalyse. Oldenbourg;

Links
Languages of instruction: German, English
Duration (semesters): 1 Semester
Module frequency: jährlich
Module capacity: unlimited
Module level
Type of module
Teaching/Learning method
Previous knowledge

Examination
Examination times:
Type of examination
Final exam of module:
Klausur am Ende der Veranstaltungszeit oder fachpraktische Übungen oder mündliche Prüfung oder Portfolio nach Maßgabe der Dozentin oder des
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inf203 - Embedded Systems I

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<td>Workload</td>
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**Applicability of the module**
- Bachelor's Programme Computing Science (Bachelor) > Akzentsetzungsbereich - Wahlbereich Informatik
- Dual-Subject Bachelor's Programme Computing Science (Bachelor) > Wahlpflicht Technische Informatik (30 KP)
- Master of Education Programme (Gymnasium) Computing Science (Master of Education) > Wahlpflichtmodule (Technische Informatik)
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

**Responsible persons**
- Fränzle, Martin Georg (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**
- Basics of technical computer science
- Computer Engineering

**Skills to be acquired in this module**
This module provides an introduction to the design of digital embedded systems.

**Professional competence**
The students:
- name functional and non-functional requirements to specify embedded systems
- discuss design space and associated embedded systems design methods
- name control and feedback control systems' core concepts
- characterise the fundamental digital signal processing algorithms

**Methodological competence**
The students:
- design and develop embedded feedback control systems with modelling tools
- implement an embedded hardware/software system according to a given specification
- analyze various specification languages according to different properties

**Social competence**
The students:
- implement solutions to given problems in teams
- present results of computer science problems to groups
- organize themselves as a team to solve a larger problem using project management methods

**Self-competence**
The students:
- acknowledge the limits of their ability to cope with pressure during the implementation process of systems
- solve exercises self-responsibly

**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 overview of embedded systems and their design. The process of digital signals is
especially important for telecommunications and multimedia. For this purpose, the module introduces digital signal processing algorithms. The principles of feedback control are introduced by exemplary transport applications. Subsequently, the module provides the specifications and language characteristics of the embedded system design. For this purpose, graphical data-flow modelling languages (for instance Simulink) and control-flow specifications (for instance State Charts) are presented. The module closes with the concepts of possible architectures and communication models. Hands-on exercises with the tools Matlab/Simulink/StateFlow support the module contents.

**Recommended reading**


**Secondary literature:**

- Artikelserie zum MPEG-2-Standard 3/94 10/94 und das Tutorial "Digitale Bildcodierung" 1/92 1/93, beides in "Fernseh- und Kinotechnik" (BIS: Z elt ZA 1536)

**Links**

- **Language of instruction**: English
- **Duration (semesters)**: 1 Semester
- **Module frequency**: annual
- **Module capacity**: unlimited
- **Reference text**: This module is compulsory for students who are specialising in "Eingebettete Systeme und Mikrorobotik". **Associates with the modules:** In the module "Eingebettete Systeme II" additional relevant topics such as design processes, HW/SW-Partitioning, High-Level-Synthesis and Hardware discription languages are discussed. The modules Eingebettete Systeme I und II offer cross-references to the module "Rechnerarchitektur", "Realzeitbetriebssysteme" and semantic orientated modules of theoretical computer science. It is possible to enhance the knowledge of embedded systems design by attending the modules "System Level Design" and "Low energy System Design".

**Module level**

- **Type of module**: 1VL + 1Ü
- **Previous knowledge**: - Basics of technical computer science  
  - Computer Engineering
- **Examination**: Examination times  
  - Type of examination
- **Final exam of module**: At the end of the semester  
  - Written or oral exam
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<th>SWS</th>
<th>Frequency</th>
<th>Workload of compulsory attendance</th>
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<td>WiSe</td>
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<td>Exercises</td>
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<td>WiSe</td>
<td>14</td>
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</table>

**Total module attendance time**

56 h
inf204 - Embedded Systems II

Module label: Embedded Systems II
Module abbreviation: inf204
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module:
- Bachelor's Programme Computing Science (Bachelor) > Akzentsetzungsbereich - Wahlbereich Informatik
- Dual-Subject Bachelor’s Programme Computing Science (Bachelor) > Wahlpflicht Technische Informatik (30 KP)
- Master of Education Programme (Gymnasium) Computing Science (Master of Education) > Wahlpflichtmodule (Technische Informatik)
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons:
- Fränzle, Martin Georg (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
No participant requirement

Skills to be acquired in this module:
The module provides an introduction to digital embedded systems design.

Professional competence:
The students:
- name embedded systems architectures
- name specific hardware components and architecture designs, particularly processor designs
- characterise the design spaces and associated embedded systems design techniques
- decompose subcomponents of feedback control systems and implement their tasks in different design spaces
- develop software/hardware components
- describe fault-tolerance architecture principles
- describe real-time and safety requirements analysing techniques
- characterise hardware synthesis

Methodological competence:
The students:
- estimate the consequences of design decisions in terms of energy usage, performance and reliability component allocations, and designs
- implement an embedded hardware/software system according to a given specification
- model hardware with a hardware description languages - analyze Hardware/Software systems using event-bases simulation

Social competence:
The students:
- implement solutions to given problems in teams
- present results of computer science problems to groups
- organize themselves as a team to solve a larger problem using project management methods

Self-competence:
The students:
- acknowledge the limits of their ability to cope with pressure during the implementation process of systems
- deal self responsibly with exercises

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 is the continuation of the module “Eingebettete Systeme I” and deals with different architectures of embedded systems and processors. The module provides system partitioning methods and the synthesis of hardware components. Hands-on exercises with development tools, hardware description languages and simulation support the
module contents.

**Recommended reading**

**Secondary literature:**

**Links**

<table>
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<tr>
<th>Language of instruction</th>
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<tbody>
<tr>
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<td>1 Semester</td>
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<tr>
<td>Module frequency</td>
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<tr>
<td>Module capacity</td>
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<tr>
<td>Reference text</td>
<td>This module is supposed to be a compulsory module for students who are specialising in “Eingebettete Systeme und Mikrorobotik”.</td>
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**Module level**

**Type of module**

- 1VL + 1Ü

**Previous knowledge**

- none

**Examination**

**Examination times**

**Type of examination**

**Final exam of module**

**At the end of the lecture times**

<table>
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<th>Frequency</th>
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<td>SoSe</td>
<td>14</td>
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</table>

| Total module attendance time | 56 h |
inf339 - Industrie 4.0 Digitalization in Industrial Manufacturing

Module label
Industrie 4.0 Digitalization in Industrial Manufacturing

Module abbreviation
inf339

Credit points
6.0 KP

Workload
180 h

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

Responsible persons
- Fränzle, Martin Georg (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
No participant requirements

Skills to be acquired in this module
The module consists of a lecture part and a seminar part, in which special topics of the lecture are prepared and presented by the students on the basis of examples. This gives a clear insight into the different aspects and allows further discussion. The preparation and presenting a presentation with subsequent discussion on the respective topic area offers a deeper understanding.

Professional competence
The student:
- Recognize fundamental relationships of the digitization in industrial manufacturing
- Gain knowledge about key competences of the digitization in industrial manufacturing
- Develop practical knowledge about special topics of the digitization in industrial manufacturing
- Put concrete approaches for discussion

Methodological competence
The student:
- Capture needed information and analyze them
- Prepare the recorded information according to target group
- Form an understanding of the digitization in industrial manufacturing

Social competence
The student:
- present and discuss their own work on a technical level

Self-competence
The student:
- understand their own level of knowledge
- learn how to prepare and present a specific topic

Module contents
The module conveys basic knowledge about the digitization of industrial production (Industrie 4.0). In addition to an overview of economic and technical aspects and opportunities of digitizing production, the module focuses on technologies for data acquisition, communication and control in production plants.

Networked machine tools, Production planning and control, organization, Quality and IT systems for planning and operation, The Gentelligent workpiece, Intelligent tools, Transfer systems, Assembly 4.0, Cyber Security, Convertible modular automation systems, Production transformation strategy, Business models

Recommended reading
- Handbuch Industrie 4.0 – Geschäftsmodelle, Prozesse, Technik*, Gunther Reinhart, 2017
- Handbuch Industrie 4.0 Bd.1 – Produktion*, Birgit Vogel-Heuser, Thomas Bauernhansl, Michael ten Hompel, 2017
- Handbuch Industrie 4.0 Bd.2 – Automatisierung*, Birgit Vogel-Heuser,
<table>
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<tr>
<td>Languages of instruction</td>
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<td>Teaching/Learning method</td>
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<td>Examination</td>
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<tr>
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inf340 - Uncertainty Modeling for Control in Digitalised Energy Systems

Module label: Uncertainty Modeling for Control in Digitalised Energy Systems

Module abbreviation: inf340

Credit points: 6.0 KP

Workload: 180 h

Applicability of the module:
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Technische Informatik
- Master's programme Digitalised Energy Systems (Master) > Digitalised Energy System Design and Assessment
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons:
- Rauh, Andreas (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
Basic knowledge of the control of linear time-continuous and/or time-discrete systems and/or robust control

Skills to be acquired in this module:
The students identify fundamentals of uncertainty modelling in control systems as well as problem-specific methods for the consideration of uncertainty during simulation and observer synthesis.

Professional competences:
The students:
- identify fundamentals of uncertainty modeling in control systems
- characterize problem-specific solution techniques for systems with stochastic and set-based uncertainty
- are aware of software implementations in simulation, control, and state estimation.

Methodological competences:
The students:
- students identify fundamentals of uncertainty modelling in control systems
- characterise problem-specific solution techniques for systems with stochastic and set-based uncertainty
- are aware of software implementations in simulation, control, and state estimation.

Social competences:
The students:
- analyse problems of control-oriented uncertainty modelling
- analyse fundamental solution techniques on a theoretical basis as well as transfer and generalise them independently toward novel research-oriented application scenarios.

Self competences:
The students:
- critically reflect the achieved results of their project work
- acknowledge limitations of various approaches for a control-oriented uncertainty modeling.

Module contents:

1. Mathematical modeling of uncertainty in linear and nonlinear dynamic systems
2. Stochastic modeling approaches
   - Probability distributions
   - Bayesian state estimation for discrete-time systems (linear/nonlinear) and for continuous-time systems (linear)
   - Linear estimation techniques in an extended state-space (Carleman linearization for special system classes)
Monte-Carlo methods
3. Estimation of states, parameters and simulation of uncertain processes
   - Outlook: Markov models
   - Outlook: Bayesian networks
4. Set-based approaches
   - Set-based algorithms: Forward-backward contractor and bisection techniques
   - Interval methods for a verified solution of ordinary differential equations and for a stability proof of uncertain systems
   - Estimation of states and parameters as well as simulation of uncertain processes
5. Outlook: Synthesis of controllers and state observers under an explicit description of uncertainty

Recommended reading

- Rauh, A. Folien/Skript zur Vorlesung „Uncertainty Modelling for Control in DES“.

Links

Language of instruction: English
Duration (semesters): 1 Semester Semester
Module frequency: every winter term
Module capacity: unlimited
Module level:
Type of module: 1VL + 1Ü
Previous knowledge: Basic knowledge of the control of linear time-continuous and/or time-discrete systems and/or robust control

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<th>Type of examination</th>
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<tr>
<td>Final exam of module</td>
<td>Following the event period</td>
<td>Portfolio or written exam</td>
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<td>Project</td>
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Total module attendance time: 4 h
inf341 - Robust Control and State Estimation in Digitalised Energy Systems

<table>
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<tbody>
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<td>Credit points</td>
<td>6.0 KP</td>
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<tr>
<td>Workload</td>
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</table>
| Applicability of the module | • Master’s Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik  
• Master’s Programme Computing Science (Master) > Technische Informatik  
• Master’s programme Digitalised Energy Systems (Master) > Digitalised Energy System Automation, Control and Optimisation  
• Master’s Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction  
• Master’s Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering |
| Responsible persons | • Rauh, Andreas (module responsibility)  
• Lehrenden, Die im Modul (Prüfungsberechtigt) |
| Prerequisites | Basic knowledge of the control of linear continuous-time and/or discrete-time systems or of robust control |
| Skills to be acquired in this module | The students identify fundamentals of robust control and state estimation as well as problem-specific solution techniques and their corresponding software implementation.  
**Professional competences**  
The students  
• identify fundamentals of robust control and state estimation  
• characterize problem-specific solution techniques for different classes of uncertainty  
• are aware of reliable software implementations.  
**Methodological competences**  
The students  
• analyze problems of robust control and state estimation for dynamic systems  
• analyze fundamental solution techniques on a theoretical basis  
• transfer as well as generalize those independently to new fields of applications.  
**Social competences**  
The students  
• develop solution ideas for real-life control problems within an accompanying project in small teams  
• explain the obtained results in short presentations.  
**Self competences**  
The students  
• critically reflect the achieved results of their project work  
• acknowledge limitations of various approaches for robust control and state estimation. |
| Module contents |  
1. Robustness of linear systems/ system analysis  
   • Boundary crossing theorem of Frazer and Duncan  
   • Mikhailov criterion  
   • Khantov criterion  
   • Frequency response approaches  
2. Selected control design techniques/ control synthesis  
   • Parameter-space approach of Ackermann and Kaesbauer  
   • Eigenvalue and eigenvalue domain assignment  
   • H-infinity control  
   • Frequency response approaches (Sensitivity function approaches in the frequency domain) |
3. Robust LMI-based control techniques
   - Lyapunov stability
   - Polytopic uncertainty modeling
   - Optimality of solutions
4. Duality between control and observer synthesis
   - Robust state estimation
   - Sliding mode observers
5. Interval methods: Solution of static and dynamic problems (Enclosing function values, Branch-and-bound techniques, Verification techniques for differential equations)
6. Fundamentals: Fault detection and fault-tolerant control

Recommended reading

- Osterlag, E. Mono- and Multivariable Control and Estimation, Springer-Verlag, 2011
- Rauh, A. Folien/ Skript zur Vorlesung „Robuste Regelung und Zustandsschätzung“.
- Weinmann, A. Uncertain Models and Robust Control, Springer-Verlag, 1991

Links

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inf5122 - Learning-Based Control in Digitalised Energy Systems

Module label: Learning-Based Control in Digitalised Energy Systems

Module abbreviation: inf5122

Credit points: 6.0 KP

Workload: 180 h

Applicability of the module:
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's programme Digitalised Energy Systems (Master) > Digitalised Energy System Design and Assessment
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering

Responsible persons:
- Rauh, Andreas (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites:
Basic knowledge of control of linear continuous-time and/or discrete-timesystems and/or robust control

Skills to be acquired in this module:
The students identify fundamentals of learning-based control for dynamic systems.

Professional competences:
The students:
- identify fundamentals of learning-based control for dynamic systems
- characterise problem- specific learning techniques
- are aware of software implementations for selected test rigs.

Methodological competences:
The students:
- analyse problems of learning-based control
- generalise them independently toward novel research-oriented application scenarios.

Social competences:
The students:
- develop solution ideas for real-life control problems within an accompanying project/lab course in small teams
- explain the obtained results in short presentations.

Self competences:
The students:
- critically reflect the achieved results of their project work
- acknowledge limitations of various approaches for learning-based control design.

Module contents:

1. Iterative learning control (ILC)
   - Grundlegende 2D-Systemstrukturen
   - Stability criteria
   - Ausgewählte Optimierungsansätze
2. Data-driven neural network modelling vs. first-principle modelling
   - Static function approximations
   - NARX-modelling
3. Design of neural network- based controllers
4. Stability of neural network-based controllers

Recommended reading:
- Jian Xin Xu; Ying Tan. Linear and Nonlinear Iterative Learning
- Rauh, A. Folien/ Skript zur Vorlesung „Learning-Based Control in DES“

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**Module level**

**Type of module**

| Teaching/Learning method | 1VL + 1S                  |

**Previous knowledge**

| Basic knowledge of control of linear continuous-time and/or discrete-timesystems and/or robust control |

**Examination**

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**Type of course**

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**Total module attendance time**

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inf535 - Computational Intelligence I

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Applicability of the module
- Master Applied Economics and Data Science (Master) > Data Science
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering
- Master's Programme Environmental Modelling (Master) > Mastermodule

Responsible persons
- Kramer, Oliver (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
- Basics of statistics

Skills to be acquired in this module
After successful completion of the course, students should have acquired the ability to master the presented methods in theory and practice. The students should be able to recognize and model corresponding optimization and data analysis problems themselves and to apply the methods unerringly.

Professional competence
The students:
- recognise optimisation problems
- implement simple algorithms of heuristic optimisation
- critically discuss solutions and selection of methods
- deepen previous knowledge of analysis and linear algebra

Methodological competence
The students:
- deepen programming skills
- apply modelling skills
- learn about the relation between problem class and method selection

Social competence
The students:
- cooperatively implement content introduced in lecture
- evaluate own solutions and compare them with those of their peers

Self-competence
The students:
- evaluate own skills with reference to peers
- realize personal limitations
- adapt own problem solving approaches with reference to required method competences

Module contents
Computational Intelligence comprises intelligent and adaptive methods for optimisation and learning. The module “Computational Intelligence I” concentrates on methods for evolutionary optimisation and heuristic approaches. The exercises introduce and deepen practical aspects of the implementation and algorithmic design, also taking into account application aspects.

Overview of Content:
- foundations of optimisation
- genetic algorithms and evolution strategies
- parameter control and self-adaptation
- runtime analysis
- swarm algorithms
- constrained optimisation
- multi-objective optimisation
Recommended reading


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inf536 - Computational Intelligence II

Module label: Computational Intelligence II
Module abbreviation: inf536
Credit points: 6.0 KP
Workload: 180 h

Applicability of the module
- Master Applied Economics and Data Science (Master) > Data Science
- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering
- Master's Programme Environmental Modelling (Master) > Mastermodule

Responsible persons
- Kramer, Oliver (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites
useful previous knowledge: Linear Algebra, Stochastics

Skills to be acquired in this module

In the lecture "Convolutional Neural Networks" you will learn the basics of Convolutional Neural Networks, from methodological understanding to implementation.

Professional competence
The Students:
- will learn Deep Learning expertise, which are essential qualifications as AI experts and Data Scientists.

Methodological competence
The Students:
- learn the methods mentioned as well as the implementation in Python, NymPy and Keras.

Social competence
The Students:
- are encouraged to discuss the taught content in groups and work together to implement the programming tasks in the exercises

Self-competence
The Students:
- are guided to conduct independent research on advanced methods as the teaching field changes dynamically

Module contents
Students learn the basics of machine learning and in particular the topics of dense layers, cross-entropy, backpropagation, SGD, momentum, Adam, batch normalization, regularization, convolution, pooling, ResNet, DenseNet, and convolutional SOMs

Recommended reading
- Deep Learning by Aaron C. Courville, Ian Goodfellow und Yoshua Bengio

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inf5408 - Applied Deep Learning in PyTorch

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Applicability of the module

- Master's Programme Business Informatics (Master) > Akzentsetzungsmodule der Informatik
- Master's Programme Computing Science (Master) > Angewandte Informatik
- Master's Programme Engineering of Socio-Technical Systems (Master) > Embedded Brain Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Human-Computer Interaction
- Master's Programme Engineering of Socio-Technical Systems (Master) > Systems Engineering
- Master's Programme Environmental Modelling (Master) > Mastermodule

Responsible persons

- Strodthoff, Nils (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

Prerequisites

Knowledge of fundamental theoretical understanding in the field of machine learning and practical programming skills in Python.

Skills to be acquired in this module

Professional competence
The students

- have an overview of the components of deep learning frameworks
- are familiar with application areas of deep learning methods across various data modalities, and common solution strategies and model architectures
- can appropriately adapt deep learning methods to new problems in the respective domains and apply them independently.

Methodological competence
The students

- independently develop theoretical and practical concepts with the help of in-person events, provided materials, and specialized literature.

Social competence
The students

- can present solution approaches for problems in this area to the plenary and defend them in discussions.

Self-competence
The students

- are able to assess their own subject-specific and methodological competence
- take responsibility for their competence development and learning progress and reflect on these independently
- independently work on learning content and can critically reflect on the content.

Module contents

This lecture provides a comprehensive introduction to contemporary Deep Learning methods, with a specific emphasis on their practical application. Concurrently, it serves as a primer for the widely-used PyTorch Deep Learning framework, assuming only a basic familiarity with Python. The course encompasses a wide range of prevalent machine learning tasks across various data types, including tabular, image, text, audio, and graph data. Throughout the course, we delve into the most crucial and up-to-date model architectures within these domains. This encompasses convolutional neural networks, recurrent neural networks,
and transformer models. The lecture is complemented by hands-on exercise sessions, where students will gain practical proficiency with PyTorch. Simultaneously, they will acquire practical insights to effectively apply contemporary deep learning methods within their specific fields of interest.

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inf5452 - Current Topics in Trustworthy Machine Learning

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**Applicability of the module**

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

**Responsible persons**

- Strodthoff, Nils (module responsibility)
- Lehrenden, Die im Modul (Prüfungsberechtigt)

**Prerequisites**

The seminar requires attending a foundational lecture in the field of Machine Learning and/or Deep Learning.

**Skills to be acquired in this module**

**Professional competence**

The students
- gain an exemplary overview of challenges and existing solution approaches in their respective problem domains and can contextualize these within the broader methodological context.

**Methodological competence**

The students
- can independently explore topics using current research literature and critically reflect upon them.

**Social competence**

The students
- can present solution approaches for problems in this area to the plenary and defend them in discussions.

**Self-competence**

The students
- are able to assess their own subject-specific and methodological competence. They take responsibility for their competence development and learning progress and reflect on these independently. In addition, they independently work on learning content and can critically reflect on the content.

**Module contents**

This seminar provides insights into various aspects of trustworthy Machine Learning. Depending on the instantiation of the module, different focuses should be set, such as interpretability/explainability, uncertainty quantification, or robustness.

**Recommended reading**

Links

**Language of instruction**

English

**Duration (semesters)**

1 Semester

**Module frequency**

every winter term

**Module capacity**

unlimited
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| **Frequency** | WiSe |
| **Workload Präsenzzeit** | 28 h |
Abschlussmodul

mam - Master’s Thesis Module

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Applicability of the module
- Master’s Programme Engineering of Socio-Technical Systems (Master) > Abschlussmodul

Responsible persons
- der Informatik, Lehrende (Prüfungsberechtigt)

Prerequisites
- no participant 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 competences
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 competences
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 competences
The students:
- communicate with users and experts convincingly
- take reasonable decisions

Self-competences
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 hypothesis to theories independently
- work in their field independently
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