
Module Catalogue

**Exchange Studies Faculty of
Applied Computer Science**

Faculty of Applied Computer Science

You can see the other use cases of the modules in Digicampus.

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* = At least one course for this module is offered in the current semester

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* = At least one course for this module is offered in the current semester

Module GEO-1023: Practical Methods 1 <i>Praktische Arbeitsmethoden 1</i>		5 ECTS/LP
Version 3.0.0 (since WS22/23) Person responsible for module: Prof. Dr. Wolfgang Buermann		
Contents: The range of exercises includes, among other things, empirical surveys, qualitative methods of human geography, computer-aided data analysis and modelling, measurement methods, field practicals, laboratory analyses, applications of remote sensing, simulations and geodata analysis and visualization with geographic information systems.		
Learning Outcomes / Competences: This module enables students to acquire basic geographical working methods. After attending this module, the students are able to describe a specific working method in geography (depending on the course chosen), to use this method independently in the right context and to evaluate the results and classify their use. The focus here is on learning and practicing the specific method(s).		
Workload: Total: 150 h		
Conditions: Depending on the content of the course, special technical requirements may be necessary. In principle, the contents of all basic modules are recommended. None for exchange students. None for exchange students.		Credit Requirements: Pass the module exam
Frequency: each semester	Recommended Semester:	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Praktische Arbeitsmethoden GEO-1023 Mode of Instruction: exercise course Language: German / English Frequency: each semester Contact Hours: 2,00
Examination GEO-1023 Praktische Arbeitsmethoden (5 LP) practical exam, Protokoll, kurze Hausarbeit, not graded Test Frequency: each semester Description: protocol, short scientific term

Module GEO-2026: Advanced Module 1 - Human Geography <i>Aufbaumodul 1 - Humangeographie</i>		6 ECTS/LP
Version 3.0.0 (since WS22/23) Person responsible for module: Dr. Niklas Völkening		
Contents: Thematic and regional deepening of a human-geographical topics, e.g. global change, humans and the environment in the Anthropocene, environmental geography, renewable energies, natural resource management, rural areas, geography of foods, geographic development research.		
Learning Outcomes / Competences: The students can explain in-depth knowledge on a specific topic of human geography and present the current state of research. The students can analyse, assess and critically assess the most important principles, theories and methods on the respective topic. In addition, the students can set up theses on selected topics and propose possible solutions. The students can organize and moderate a scientific discussion and develop and defend their own arguments.		
Workload: Total: 180 h		
Conditions: none		Credit Requirements: Pass the module exam
Frequency: each semester	Recommended Semester:	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Spezialvorlesung Humangeographie GEO-2026 Language: German / English Frequency: each semester Contact Hours: 2,00 ECTS Credits: 3.0		
Part of the Module: Begleitseminar zur Spezialvorlesung Humangeographie GEO-2026 Language: German / English Frequency: each semester Contact Hours: 2,00 ECTS Credits: 3.0		
Examination Aufbaumodul 1 - Humangeographie lecture + accompanying seminar, mündl. Prüfung (15 Min.) oder Klausur oder Portfolioprfung, graded Description: Module exam, Oral exam 15 minutes, written exam or portfolio		

Module GEO-2027: Advanced Module 1 - Physical Geography <i>Aufbaumodul 1 - Physische Geographie</i>		6 ECTS/LP
Version 3.0.0 (since WS22/23) Person responsible for module: Prof. Dr. Wolfgang Buermann		
Contents: Thematic and regional deepening of a physical-geographical topic, e.g. global change, environmental protection, urban ecology, landscape balance, vegetation history, biochemical cycles, extreme events; Africa, India, Mediterranean Basin, Alps.		
Learning Outcomes / Competences: The students can explain in-depth knowledge on a specific topic of physical geography and present the current state of research. The students can analyse, assess and critically assess the most important principles, theories and methods on the respective topic. In addition, the students can set up theses on selected topics and propose possible solutions. The students can organize and moderate a scientific discussion and develop and defend their own arguments.		
Workload: Total: 180 h		
Conditions: none		Credit Requirements: Pass the module exam
Frequency: each semester	Recommended Semester:	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Spezialvorlesung Physische Geographie GEO-2027 Mode of Instruction: lecture Language: German / English Frequency: each semester Contact Hours: 2,00		
Part of the Module: Begleitseminar zur Spezialvorlesung Physische Geographie GEO-2027 Mode of Instruction: seminar Language: German / English Frequency: annually Contact Hours: 2,00		
Examination Aufbaumodul 1 - Physische Geographie module exam, mündl. Prüfung (15 Min.) oder Klausur oder Portfolioprfung, graded Description: Oral exam (15 min.) or written exam		

Module GEO-2065: Practical Methods 2 <i>Praktische Arbeitsmethoden 2</i>		5 ECTS/LP
Version 3.0.0 (since WS22/23) Person responsible for module: Prof. Dr. Wolfgang Buermann		
Contents: The range of exercises includes, among other things, empirical surveys, qualitative methods of human geography, computer-aided data analysis and modelling, measurement methods, field practicals, laboratory analyses, applications of remote sensing, simulations and geodata analysis and visualization with geographic information systems.		
Learning Outcomes / Competences: This module enables students to acquire basic geographical working methods. After attending this module, the students are able to describe a specific working method in geography (depending on the course chosen), to use this method independently in the right context and to evaluate the results and classify their use. The focus here is on learning and practicing the specific method(s).		
Workload: Total: 150 h		
Conditions: Depending on the content of the course, special technical requirements may be necessary. In principle, the contents of all basic modules are recommended.		Credit Requirements: Pass the module exam
Frequency: each semester	Recommended Semester: 3. - 6.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Praktische Arbeitsmethoden GEO-2065 Mode of Instruction: exercise course Language: German / English Frequency: each semester Contact Hours: 2,00		
Examination GEO-2065 Praktische Arbeitsmethoden 2 practical exam, Protokoll, kurze Hausarbeit, not graded Test Frequency: each semester		

Module GEO-3082: Advanced Module 2 - Human Geography <i>Aufbaumodul 2 - Humangeographie</i>		6 ECTS/LP
Version 3.0.0 (since WS22/23) Person responsible for module: Dr. Niklas Völkening		
Contents: Thematic and regional deepening of a human-geographical topic, e.g. global change, humans and the environment in the Anthropocene, environmental geography, renewable energies, natural resource management, rural areas, geography of foods, geographic development research.		
Learning Outcomes / Competences: The students can explain in-depth knowledge on a specific topic of human geography and present the current state of research. The students can analyse, assess and critically assess the most important principles, theories and methods on the respective topic. In addition, the students can set up theses on selected topics and propose possible solutions. The students can organize and moderate a scientific discussion and develop and defend their own arguments.		
Workload: Total: 180 h		
Conditions: none		Credit Requirements: Pass the module exam
Frequency: each semester	Recommended Semester: 5. - 8.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Spezialvorlesung Humangeographie GEO-3082 Mode of Instruction: lecture Language: German / English Frequency: each semester Contact Hours: 2,00 ECTS Credits: 3.0
Part of the Module: Begleitseminar zur Spezialvorlesung Humangeographie GEO-3082 Mode of Instruction: seminar Language: German / English Frequency: each semester Contact Hours: 2,00 ECTS Credits: 3.0
Examination Aufbaumodul 2 - Humangeographie lecture + accompanying seminar, mündliche Prüfung (15 Min.), Klausur oder Portfolio, graded Description: Module exam, Oral exam 15 minutes, written exam or portfolio

Module GEO-3083: Advanced Module 2 - Physical Geography <i>Aufbaumodul 2 - Physische Geographie</i>		6 ECTS/LP
Version 3.0.0 (since WS22/23) Person responsible for module: Prof. Dr. Wolfgang Buermann		
Contents: Thematic and regional deepening of a physical-geographical topic, e.g. global change, environmental protection, urban ecology, landscape balance, vegetation history, biochemical cycles, extreme events; Africa, India, Mediterranean Basin, Alps.		
Learning Outcomes / Competences: The students can explain in-depth knowledge on a specific topic of physical geography and present the current state of research. The students can analyse, assess and critically assess the most important principles, theories and methods on the respective topic. In addition, the students can set up theses on selected topics and propose possible solutions. The students can organize and moderate a scientific discussion and develop and defend their own arguments.		
Workload: Total: 180 h		
Conditions: none		Credit Requirements: Pass the module exam
Frequency: each semester	Recommended Semester: 5. - 8.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Spezialvorlesung Physische Geographie GEO-3083 Mode of Instruction: lecture Language: German / English Frequency: each semester Contact Hours: 2,00		
Part of the Module: Begleitseminar zur Spezialvorlesung Physische Geographie GEO-3083 Mode of Instruction: seminar Language: German / English Frequency: each semester Contact Hours: 2,00		
Examination Aufbaumodul 2 - Physische Geographie module exam, mündl. Prüfung (15 Min.) oder Klausur oder Portfolioprüfung, graded Test Frequency: when a course is offered Description: Oral exam (15 min.) or written exam		

Module GEO-3098: Advanced Seminar <i>Hauptseminar</i>		5 ECTS/LP
Version 2.1.0 (since WS22/23) Person responsible for module: Dr. Stephan Bosch		
Contents: In this module, content from the basic courses is deepened and new developments in the subject of geography are dealt with. Advanced seminars are offered on sub-areas of geography, regional focal points and/or special subject areas of geography (such as global change, cultural landscapes, etc.).		
Learning Outcomes / Competences: After completing this module, the students are able to present an in-depth topic of geography in the form of a written work and an oral presentation. For this purpose, the relevant specialist content from the scientific literature is summarized, combined and critically examined. In addition, the moderation and discussion skills of the students are further developed.		
Workload: Total: 150 h 100 h preparation of written term papers (self-study) 20 h preparation of presentations (self-study) 30 h (attendance)		
Conditions: Basic knowledge of scientific work is required. Confident handling of English specialist literature is expected.		Credit Requirements: Pass the module exam
Frequency: each semester	Recommended Semester: 5. - 8.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Hauptseminar Mode of Instruction: advanced seminar Language: German / English Frequency: each semester Contact Hours: 2,00 ECTS Credits: 5.0
Examination Hauptseminar Combined written and oral exam / work period for assignment: 6 weeks, graded Test Frequency: each semester Description: Das in der Hausarbeit erarbeitete Thema wird im Hauptseminar präsentiert.

Module INF-0426: Wearable Technology Applications in Healthcare <i>Wearable Technology Applications in Healthcare</i>		8 ECTS/LP
Version 1.0.0 (since WS22/23) Person responsible for module: Prof. Dr. Elisabeth André		
Learning Outcomes / Competences: Students are familiar with methods and techniques of interaction design and engineering for health care applications. After successful participation, they will have the necessary knowledge to analyze application scenarios according to the guidelines of the user-centered design process and to design software solutions tailored to the target group. They are able to translate current interaction paradigms and design guidelines into models and programs for novel interaction devices, as well as to independently familiarize themselves with the necessary technologies. Furthermore, they are able to apply practice-relevant evaluation methods to assess the quality of the created software prototype. They are able to plan larger project tasks in small teams, solve them according to a self-developed project plan and discuss the results appropriately in plenary sessions and present them as a team.		
Key qualifications: Skill in confident and persuasive presentation of ideas and concepts; knowledge of the mindset and language of application-relevant disciplines; understanding of team processes; skill in collaborating in teams; skill in leading teams; skill in presenting and documenting results in a comprehensible manner; ability to expand existing knowledge independently; ability to contribute to science; competence in recognizing significant technical developments; quality awareness, meticulousness.		
Workload: Total: 240 h 15 h studying of course content using provided materials (self-study) 15 h studying of course content using literature (self-study) 120 h studying of course content through exercises / case studies (self-study) 30 h lecture (attendance) 60 h exercise course (attendance)		
Conditions: Programming experience		
Frequency: each winter semester	Recommended Semester: from 4.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Practical Module Interaction Design and Engineering for Health Care Applications Mode of Instruction: lecture Language: English Frequency: each summer semester Contact Hours: 2,00		
Contents: The specific assignment for student projects is designed each year.		
Literature: Literature references will be announced at the beginning of the semester depending on the topic.		

Part of the Module: Wearable Technology Applications in Healthcare (Exercise Course)

Mode of Instruction: exercise course

Language: English

Frequency: each winter semester

Contact Hours: 4,00

Examination

Practical Module Interaction Design and Engineering for Health Care Applications

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-0457: Introduction to Natural Language Processing <i>Introduction to Natural Language Processing</i>		5 ECTS/LP
Version 1.2.0 (since SoSe23) Person responsible for module: Prof. Dr. Annemarie Friedrich		
Learning Outcomes / Competences: <p>Natural Language Processing (NLP) aims to enable computers to understand, interpret, and generate human language and is thus an interdisciplinary field at the intersection of linguistics, computer science, and artificial intelligence. Recent advances in NLP have been driven by the availability of large datasets and the development of powerful deep learning models.</p> <p>Upon completing the course, students will have the skills and knowledge to identify the nature of an NLP problem and choose suitable approaches for solving the task with state-of-the-art methods. They will be able to discuss the advantages, disadvantages, limitations, and potential ethical considerations of the solutions.</p> <p>During the course, the participants will improve their skills in logical, analytical, and conceptual thinking. Students will gain the ability to make scientifically meaningful assessments in the field of NLP using appropriate methods. They will also acquire relevant terminology in NLP.</p> <p>Key skills: Formal methods; Knowledge of advantages and disadvantages of different design alternatives; Systematical advancement of design tools; Ability to work in teams; Understanding of team management; Knowledge of workflows and processes; Ability to find solutions for practical problems; Ability to work autonomously; Quality awareness; Scientific working.</p>		
Workload: Total: 150 h 30 h lecture (attendance) 30 h exercise course (attendance) 15 h studying of course content using provided materials (self-study) 15 h studying of course content using literature (self-study) 60 h studying of course content through exercises / case studies (self-study)		
Conditions: Experience in Python Programming		Credit Requirements: Passing the module exam
Frequency: each summer semester	Recommended Semester: from 4.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Introduction to Natural Language Processing (Vorlesung) Mode of Instruction: lecture Language: German / English Frequency: each summer semester Contact Hours: 2,00
Contents: <p>This course covers the core concepts of state-of-the-art deep-learning-based natural language processing (NLP) including basic machine learning concepts, word embeddings, neural networks, transformers, language models, text classification, sequence labeling, machine translation, parsing, and ethics in NLP. The practical part of the course will introduce Python-based NLP and deep learning toolkits (prior knowledge of Python is highly recommended).</p>

Literature:

- Dan Jurafsky and James Martin: Speech and Language Processing, 3rd edition. (Draft: <https://web.stanford.edu/~jurafsky/slp3/>)
- Additional literature will be announced at the beginning of the course.

Part of the Module: Introduction to Natural Language Processing (Übung)

Mode of Instruction: exercise course

Language: English

Frequency: each summer semester

Contact Hours: 2,00

Examination

Introduction to Natural Language Processing

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-0477: Foundations of Autonomous Mobile Robotics <i>Grundlagen der Autonomen Mobilen Robotik</i>		5 ECTS/LP
Version 1.1.0 (since WS23/24) Person responsible for module: Prof. Dr. Jörg-Dieter Stückler		
Learning Outcomes / Competences: Students will understand the following methodological principles of autonomous mobile robotics at a practical but scientific level and will be able to implement appropriate algorithms for fundamental problems: Robot kinematics and sensing and their characteristics, recursive Bayesian filters such as Kalman filters and particle filters, probabilistic localization, mapping, simultaneous localization and mapping, as well as path planning and following, and robot control architectures. Students will understand the advantages and disadvantages of various methods and be able to analyze and select them for applications. Students have developed skills for analyzing and structuring fundamental problems in autonomous mobile robotics and know concepts and approaches for implementing algorithms for these problems. Key qualifications: Skills in logical, analytical and conceptual thinking; selection and confident application of appropriate methods; independent work with textbooks; implementation of technical solution concepts in programs; comprehensible presentation of results; skill of cooperation in teams.		
Workload: Total: 150 h 15 h studying of course content using literature (self-study) 15 h studying of course content using provided materials (self-study) 30 h lecture (attendance) 60 h studying of course content through exercises / case studies (self-study) 30 h exercise course (attendance)		
Conditions: <ul style="list-style-type: none">• Recommended: Basic programming knowledge in Python• Recommended: Basics in artificial intelligence		Credit Requirements: Passing the module exam
Frequency: irregular (usu. winter semester)	Recommended Semester: from 5.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Foundations of Autonomous Mobile Robotics (Lecture) Mode of Instruction: lecture Language: English / German Frequency: irregular (usu. winter semester) Contact Hours: 2,00		

Contents:

This lecture covers basic methods and algorithms for perception and control of autonomous mobile robots, especially for navigation. The lecture provides an introduction to the following topics:

- Sensors
- Mobile robot kinematics
- Probabilistic modeling
- Particle filter
- Kalman filter
- Localization
- Mapping
- Simultaneous localization and mapping
- Path planning and following
- Robot control architectures

Literature:

Lecture slides will be provided. Additional literature will be provided in lecture and exercises.

Recommended textbooks:

- Thrun, Burgard, Fox: "Probabilistic Robotics," MIT Press, 2005.

Assigned Courses:

Foundations of Autonomous Mobile Robotics (Grundlagen der Autonomen Mobilen Robotik) (lecture)

**(in attendance) **

Part of the Module: Foundations of Autonomous Mobile Robotics (Exercise)

Mode of Instruction: exercise course

Language: English / German

Frequency: irregular (usu. winter semester)

Contact Hours: 2,00

Assigned Courses:

Exercises for Foundations of Autonomous Mobile Robotics (Übungen zu Grundlagen der Autonomen Mobilen Robotik) (exercise course)

**(in attendance) **

Examination

Foundations of Autonomous Mobile Robotics

written exam / length of examination: 90 minutes, graded

Test Frequency:

when a course is offered

Module INF-0487: Introduction to Python Programming <i>Introduction to Python Programming</i>		4 ECTS/LP
Version 1.1.0 (since WS23/24) Person responsible for module: Prof. Dr. Annemarie Friedrich		
Learning Outcomes / Competences: Participants understand the concepts and models underlying the programming language used advanced and in-depth design techniques and methods of structured programming and can apply these on practically relevant problems of medium size and complexity. Participants will know how to use development environments and they can independently in program libraries, incorporating specific design patterns. Key skills: Ability to think abstractly, logically, analytically and conceptually; independent work with program libraries; team collaboration skills.		
Remarks: The course will be taught in English. During exercises, German will also be used.		
Workload: Total: 120 h 30 h lecture (attendance) 15 h exercise course (attendance) 5 h studying of course content using literature (self-study) 60 h studying of course content through exercises / case studies (self-study) 10 h studying of course content using provided materials (self-study)		
Conditions: Basic programming skills in C or Java are recommended. Module Computer Science 1 (INF-0097) - recommended		Credit Requirements: Passing the module exam
Frequency: each semester	Recommended Semester: from 3.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 3,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module	
Part of the Module: Introduction to Python Programming (Lecture) Mode of Instruction: lecture Language: English Frequency: each semester Contact Hours: 2,00	
Contents: <p>The Python programming language is highly relevant in today's technology landscape due to its versatility and ease of use. It serves as a powerful language for tasks ranging from web development and data analysis to artificial intelligence and automation, making it an essential tool for both beginners and experienced developers in a wide range of industries and research areas.</p> <p>Basic familiarity with either C or Java programming will make it easier to follow the course. The course covers data types, control structures, object orientation, and algorithms with a focus on the peculiarities of the Python programming language.</p> <p>The number of participants of this course is limited.</p>	
Literature: Mark Lutz. Learning Python. O'Reilly 2013.	

Examination**Introduction to Python Programming**

portfolio exam, graded

Test Frequency:

when a course is offered

Parts of the Module**Part of the Module: Introduction to Python Programming (Exercise)**

Mode of Instruction: exercise course

Language: English / German

Frequency: each semester

Contact Hours: 1,00

Module INF-2023: Introduction to Cyber Security <i>Introduction to Cyber Security</i>		5 ECTS/LP
Version 1.2.0 (since SoSe25) Person responsible for module: Prof. Dr. Frank Breitingner		
Contents: <p>This course provides a comprehensive introduction to cybersecurity, covering both foundational principles and practical applications. Students will explore key security challenges, emerging trends, and the role of human factors in security. Topics include cryptography, authentication, network and infrastructure security, intrusion detection, wireless security, and physical security.</p> <p>The course also examines cyber threats such as malware and social engineering, along with secure software development, disaster recovery, and organizational security policies. Additional topics include cybersecurity law, forensic analysis, and ethical considerations. Through lectures, discussions, and hands-on exercises, students will develop knowledge and skills in a variety of cybersecurity topics.</p>		
Learning Outcomes / Competences: <p>Students understand the principles of the structure of the following processors at an advanced, practical but scientific level: superscalar microprocessors, multi- and manycore processors, signal processors, smartphone processors and GPUs. They also learn current concepts of processor architecture and can assess and evaluate advantages/disadvantages of current and future processors based on their internal structure. They understand how different components of microprocessors work and how they interact. Thus, the students are able to classify the influence of different architecture extensions on the overall system. They will also be able to distinguish when it makes sense to use memory-coupled, message-coupled or data-parallel processors, and differentiate between techniques for energy-efficient or high-performance processors. In the practical exercise, students simulate different processor architectures and jump prediction techniques and evaluate their impact on runtime and energy consumption.</p> <p>Key qualifications: Analytical-methodical competence, consideration of approaches to solutions, presentation of solutions to exercise problems; skill in presenting and documenting results in a comprehensible manner; ability to expand existing knowledge independently; quality awareness, meticulousness; self-reflection; responsible action against a background of inadequacy and conflicting interests; skill in making scientifically meaningful assessments using appropriate methods; competence in recognizing significant technical developments.</p>		
Workload: Total: 150 h 30 h exercise course (attendance) 60 h studying of course content through exercises / case studies (self-study) 30 h lecture (attendance) 15 h studying of course content using literature (self-study) 15 h studying of course content using provided materials (self-study)		
Conditions: none		Credit Requirements: Passing the Module Exam
Frequency: each summer semester	Recommended Semester: 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Introduction to Cyber Security (Lecture) Mode of Instruction: lecture Language: German / English Frequency: each summer semester Contact Hours: 2,00
Contents: <p>The lecture "Processor Architecture" delves into the techniques of superscalar microprocessors and current multicore processors. Pipeline stages are covered in detail, many-core processors and multicores are contrasted, and current example processors are presented. Research on manycores and real-time multicores is also reported.</p>
Literature: <ul style="list-style-type: none"> • Uwe Brinkschulte, Theo Ungerer, Mikrocontroller und Mikroprozessoren, Springer Verlag, Heidelberg, dritte Auflage 2010 • John L. Hennessy, David A. Patterson, Computer Architecture: A Quantitative Approach, Morgan Kaufmann, 5. Auflage, 2011
Part of the Module: Introduction to Cyber Security (Exercise) Mode of Instruction: exercise course Language: German / English Frequency: each summer semester Contact Hours: 2,00
Contents: <p>Topics / assignments will be adjusted every year and thus the list below is only to provide an idea:</p> <ul style="list-style-type: none"> • Security Tools research • Port Scanning • Password Cracking • Digital Signature / encrypted emails • Firewalls • Group policies • System Hardening • File Recovery • System recovery / backup
Examination Introduction to Cyber Security <p>written exam / length of examination: 60 minutes, graded</p> Test Frequency: <p>when a course is offered</p>

Module INF-2811: Deep Learning for Biosignal Analysis - Introduction to Concepts, Architectures and Applications <i>Deep Learning for Biosignal Analysis - Introduction to Concepts, Architectures and Applications</i>		6 ECTS/LP
Version 1.0.0 (since WS24/25) Person responsible for module: Prof. Dr. Sebastian Zaunseder		
Learning Outcomes / Competences: Subject-related competences: After successful participation, students have knowledge and competences with regard to deep learning techniques and its use for biosignal analysis. Students know fundamental ideas of deep learning and basic building blocks of deep networks. They are aware of (general) training and testing strategies. Students are familiar with common network architectures, are able to select appropriate architectures for specific biosignal analysis tasks and can work with them. Methodological competencies: Students are able to deal independently with deep networks and their use for biosignal analysis tasks. They can setup own networks using Python. Finally, students are able to quantitatively evaluate the performance of own networks in multiple biosignal processing tasks. Interdisciplinary Competencies: The students are able to apply the acquired knowledge in any area of study that deals with biosignals or diagnostically relevant data in general. In addition, the module teaches essential problem-solving skills, whereby an abstract way of thinking as well as a structured approach to problem solving are learned. Key skills: Ability to think logically, analytically and conceptually; ability to present and document results in a comprehensible manner; ability to communicate orally and in writing in a way that is appropriate to the situation and specific to the target group; ability to work together in teams; ability to solve problems under practical boundary conditions; ability to expand existing knowledge independently; quality awareness.		
Workload: Total: 180 h 60 h studying of course content using provided materials (self-study) 30 h lecture (attendance) 30 h exercise course (attendance) 60 h studying of course content through exercises / case studies (self-study)		
Conditions: Basic mathematical skills; programming skills		Credit Requirements: Passing the module exam
Frequency: each winter semester	Recommended Semester: from 4.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Deep Learning for Biosignal Analysis - Introduction to Concepts, Architectures and Applications (Lecture) Language: English Frequency: each winter semester Contact Hours: 2,00		

Contents:

The lecture deals with the fundamentals, implementation and application of deep learning techniques in the field of biosignal analysis. The following contents are covered:

- Fundamentals of deep learning
- Overview on common network architectures
- Applications of deep learning considering various examples from the field of biosignal processing (including short introductions into the respective biosignals, medical background and technical details of the implementation)

Literature:

- I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning. MIT Press, 2016.

Assigned Courses:

Deep Learning for Biosignal Analysis - Introduction to Concepts, Architectures and Applications (lecture)

**(online/digital) **

Part of the Module: Deep Learning for Biosignal Analysis - Introduction to Concepts, Architectures and Applications (Exercise)

Language: English

Frequency: each winter semester

Contact Hours: 2,00

Contents:

The exercise conveys practical skills in dealing with deep learning techniques for biosignal analysis. The following contents are covered:

- Reading and understanding biosignal data
- Understanding of provided networks
- Conception and setup of own networks
- Training of own networks
- Quantitative evaluation of own networks

Assigned Courses:

Übung zu Deep Learning for Biosignal Analysis - Introduction to Concepts, Architectures and Applications

(exercise course)

**(online/digital) **

Examination

Deep Learning for Biosignal Analysis - Introduction to Concepts, Architectures and Applications

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-2000: Research Module Computer Science <i>Forschungsmodul für Austauschstudierende</i>		6 ECTS/LP
Version 1.0.0 (since SoSe25) Person responsible for module: All professors at the Institute of Computer Science		
Learning Outcomes / Competences: After participating in the research module, students are able to understand computer science problems of medium complexity. They have detailed and up-to-date knowledge in this field and can actively participate in research projects To this end, they understand advanced concepts, methods, procedures, techniques and technologies and can apply this knowledge in research projects. In addition, students have the teamwork and communication skills, the ability to research literature and the learning and working techniques to discuss problems in the field and to critically evaluate, combine and present interim results. Key skills: Ability to think logically, analytically and conceptually; Independent work with specialist literature; Comprehensible, confident and convincing presentation of ideas, concepts and results; Quality awareness; Communication skills; Ability to work in teams and understand team processes; Principles of good scientific practice		
Remarks: This is an individual module with practical focus, e.g. experiments or code development. Due to the individual character, you are registered in STUDIS by the professor for this module.		
Workload: Total: 180 h 165 h internship / practical course (self-study) 15 h seminar (attendance)		
Conditions: none		Credit Requirements: Passing the Module Exam
Frequency: each semester	Recommended Semester: from 4.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 1,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Research Module Computer Science Mode of Instruction: internship Language: English Frequency: each semester		
Contents: The topic is in the scope of the research projects at the Institute of Computer Science: You contact one of the professors at the Institute of Computer Science who works on a research topic you are interested in. Together you define a topic on which you work individually. During the semester, you meet on a regular basis to get feedback (e.g. each week). Finally, you present your work.		
Literature: Depends on the professor and topic, e.g. manuals, scientific papers		
Assigned Courses: Forschungsmodul Informatik / Research Module Computer Science (internship) <i>*(in attendance) *</i>		

Examination

Research Module Computer Science

practical exam, graded

Test Frequency:

each semester

Module INF-2001: Seminar Computer Science Bachelor <i>Seminar Informatik für Austauschstudierende (Bachelor)</i>		4 ECTS/LP
Version 1.0.0 (since SoSe25) Person responsible for module: All professors at the Institute of Computer Science		
Learning Outcomes / Competences: After attending the seminar, students will be able to independently develop and understand fundamental problems, concepts, methods, procedures, techniques and technologies in computer science. They have the working techniques, communication skills and ability to use appropriate media to present a specific topic clearly and comprehensibly both verbally and in writing and to discuss topics from the aforementioned field critically and argumentatively. In addition, they can recognize the logical structures of thinking and argumentation and apply them in a goal-oriented manner. Participants can formulate clearly and comprehensibly and present specialist content freely. They understand how to structure a presentation in a clear and comprehensible way and how to focus the presentation on key messages and convey these in an understandable way. Students know how to present themselves and handle common presentation media with confidence. They are able to tailor a presentation to a specific target group, motivate the audience and apply various moderation techniques. Key skills: Literature research; Independent work with English-language specialist literature; Analytical-methodical competence; Scientific methodology; Principles of good scientific practice; Ability to present (practical or theoretical) ideas, concepts and results in a comprehensible, confident and convincing (written and oral) manner and to document them; Ability to think logically, abstractly, analytically and conceptually and to argue formally; Quality awareness, meticulousness; Communication skills; Time management		
Remarks: Due to the individual character, you are registered in STUDIS by the professor for this module.		
Workload: Total: 120 h 90 h preparation of written term papers (self-study) 30 h seminar (attendance)		
Conditions: none		Credit Requirements: Passing the Module Exam
Frequency: each semester	Recommended Semester: from 4.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Seminar Computer Science Bachelor Mode of Instruction: seminar Language: English Frequency: each semester Contact Hours: 2,00
Contents: <p>There are several seminars where you can choose from (see list below). Enroll at the Digicampus courses for more details.</p> <p>Most seminars have one meeting in the first week (where topics are introduced) of the lecture period and one presentation meeting in the last week of the lecture period. In the weeks between, you work individually on your thesis / presentation and meet with your supervisor.</p>

Literature:

Depends on chosen topic

Assigned Courses:

Seminar Biomedizinische Datenanalyse und Systemmodellierung (Bachelor) (seminar)

**(in attendance) **

Seminar Cyber Security Bachelor (seminar)

**(in attendance) **

Seminar Datenbanksysteme für Bachelor (seminar)

**(hybrid/mixed) **

Seminar Diagnostische Sensorik (Bachelor) (seminar)

**(hybrid/mixed) **

Seminar Embedded Systems (Bachelor) (seminar)

**(in attendance) **

Seminar Embodied Artificial Intelligence and Computer Vision (seminar)

**(in attendance) **

Seminar Software Engineering for Artificial Intelligence Systems Bachelor (seminar)

**(in attendance) **

Seminar Software Engineering in sicherheitskritischen Systemen (Bachelor) (seminar)

**(in attendance) **

Seminar Software Engineering verteilter Systeme (Bachelor) (seminar)

**(in attendance) **

Examination

Seminar Computer Science Bachelor

written/oral exam, graded

Test Frequency:

each semester

Module GEO-4250: Lecture Integrative Geography <i>Vorlesung Integrative Geographie</i>		5 ECTS/LP
Version 2.0.0 (since WS22/23) Person responsible for module: Prof. Dr. Matthias Schmidt		
Contents: The lecture provides an introduction and an overview of the field of integrative geography (also referred to as the "third pillar" or "human-environmental geography"). Basic topics and current research and questions from physical geography and human geography are treated with a nexus to space, environment and society. Presentation of central problem complexes and their current political and socio-economic relevance, discussion of relevant questions, classification of integrative geography in the history of the discipline and current research landscape. The diverse interactions between space, environment and society are presented in their specific natural and socially regionally differentiated forms using selected current case studies.		
Learning Outcomes / Competences: After successfully completing the module, the students have in-depth knowledge of the various approaches, theories and perspectives of integrative geography. They are able to deal critically with current topics in the field of integrative geography, to assess and interpret them.		
Workload: Total: 150 h		
Conditions: none		Credit Requirements: Pass the module exam
Frequency: each winter semester winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Vorlesung Integrative Geographie / Lecture Integrative Geography Mode of Instruction: lecture Language: German / English		
Examination GEO-4250 Integrative Geographie module exam, module exam, graded		

Module GEO-4251: Discourse Analysis <i>Diskursanalyse</i>		5 ECTS/LP
Version 2.0.0 (since WS22/23) Person responsible for module: Dr. Andreas Benz		
Contents: Theoretical and conceptual foundations of discourse analysis, concrete micro- and macro-analytical procedures and methods of discourse analysis as well as fields of application and case studies of discourse analysis procedures.		
Learning Outcomes / Competences: After successfully completing the module, the students have in-depth knowledge of the theoretical foundations of discourse analysis methods. They know and master different methods of discourse analysis and are able to apply them independently to concrete empirical cases.		
Workload: Total: 150 h		
Conditions: none		Credit Requirements: Pass the module exam
Frequency: annually usually in summer semester	Recommended Semester: 1. - 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: <i>Diskursanalyse / Discourse Analysis</i> Mode of Instruction: lecture, exercise course, seminar, internship Language: German / English Frequency: annually meist im Sommersemester		
Examination GEO-4251 Diskursanalyse module exam, Klausur, mündliche Prüfung, Hausarbeit, Übungsaufgabe oder Bericht, graded Description: written exam, oral exam, scientific term paper, practice assignment or report		

Module GEO-4253: Remote Sensing in Geosciences <i>Geowissenschaftliche Fernerkundung</i>		5 ECTS/LP
Version 2.0.0 (since WS22/23) Person responsible for module: Prof. Dr. Wolfgang Buermann		
Contents: This module offers students the opportunity to master the processes for acquiring, analyzing and interpreting geodata from different sensor platforms using specific software. Remote sensing geodata from various remote sensing platforms and sensors are used.		
Learning Outcomes / Competences: Students are able to describe and categorize data recorded by remote sensing, to distinguish between different sensor concepts and to adequately evaluate sensor data. In particular, they know the typical processing, calibration and validation strategies in the context of remote sensing. You will also, at least in some cases, acquire in-depth knowledge of the necessary software solutions and have used this software in exercises.		
Workload: Total: 150 h		
Conditions: none		Credit Requirements: Pass the module exam
Frequency: annually	Recommended Semester: 1. - 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Geowissenschaftliche Fernerkundung / Remote Sensing in Geosciences Mode of Instruction: lecture, exercise course, seminar, internship Language: German / English		
Examination GEO-4253 Geowissenschaftliche Fernerkundung module exam, Klausur, Hausarbeit, mündliche Prüfung, Übungsaufgabe oder Bericht, graded Description: written exam, scientific term paper, oral exam, practical exercise or report		

Module GEO-4254: Modelling in Geosciences <i>Geowissenschaftliche Modellierung</i>		5 ECTS/LP
Version 2.0.0 (since WS22/23) Person responsible for module: apl. Prof. Andreas Philipp		
Contents: The course includes the programming implementation and efficient application of advanced geoscientific methods for data preparation, analysis and visualization using the "R" programming environment. The exercises are carried out using data sets and content-related questions from various sub-areas of geography and geosciences.		
Learning Outcomes / Competences: After completing the module, the students can also efficiently prepare complex geoscientific data sets independently with the help of advanced programming technology. They are able to independently design problem-related geographic and geoscientific data analyzes and visualizations with the help of R, implement them efficiently in terms of programming and use them appropriately.		
Workload: Total: 150 h		
Conditions: none		Credit Requirements: Pass the module exam
Frequency: annually usually winter and summer semester	Recommended Semester: 1. - 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Geowissenschaftliche Modellierung / Modelling in Geosciences Mode of Instruction: exercise course, internship Language: German / English		
Examination GEO-4254 Geowissenschaftliche Modellierung module exam, mündliche Prüfung, Übungsaufgabe oder Bericht, graded Description: oral exam, exercise or report		

Module GEO-4255: Programming in Geosciences <i>Geowissenschaftliche Programmierung</i>		5 ECTS/LP
Version 2.0.0 (since WS22/23) Person responsible for module: apl. Prof. Christoph Beck		
Contents: The course includes the programming implementation and efficient application of advanced geoscientific methods for data preparation, analysis and visualization using the "R" programming environment. The exercises are carried out using data sets and content-related questions from various sub-areas of geography and geosciences.		
Learning Outcomes / Competences: After completing the module, the students can also efficiently prepare complex geoscientific data sets independently with the help of advanced programming technology. They are able to independently design problem-related geographic and geoscientific data analyzes and visualizations with the help of R, implement them efficiently in terms of programming and use them appropriately.		
Workload: Total: 150 h		
Conditions: none		Credit Requirements: Pass the module exam
Frequency: annually usually winter and summer semester	Recommended Semester: 1. - 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: <i>Geowissenschaftliche Programmierung / Programming in Geosciences</i>		
Mode of Instruction: exercise course, internship		
Language: German / English		
Examination GEO-4255 Geowissenschaftliche Programmierung module exam, mündliche Prüfung, Übungsaufgabe oder Bericht, graded		
Description: oral exam, exercise or report		

Module GEO-5122: Geoinformatics 1 <i>Geoinformatik 1 (10LP)</i>		10 ECTS/LP
Version 2.0.0 (since WS22/23) Person responsible for module: Prof. Dr. Sabine Timpf		
Contents: <p>In GIScience geodata is at the core of many applications. However, geodata can only be interpreted within a specific context where models are needed to produce answers to questions. In fact, the models that are hidden beneath a data collection effort are of as much interest and importance as the models used to derive additional knowledge (such as weather forecast models, models of erosion, models of migration patterns, models of transportation systems or models of wayfinding). Every one of us models every day for everyday purposes. Understanding how this modeling happens and how to make these models better as well as computationally tractable helps to become clearer thinkers and expert modelers in GIScience.</p> <p>This module introduces the theoretical foundations of modeling from different viewpoints. It also shows how modeling of geographic information adds a temporal component, leading towards simulation models. It then goes on to deal with the issue of modeling complex systems using a specific type of simulation with a software called Netlogo. After becoming proficient in modeling and simulating, there is a need to evaluate the validity and interpret the results of these implemented models. Using a combination of ground-truthing in case studies as well as sensitivity analysis, the advantages but also the limitations of this modeling approach in GIScience.</p>		
Learning Outcomes / Competences: <p>The learning objectives of this module are a critical understanding of the issues of modeling and simulation in GIScience, a proficiency in spatio-temporal modeling using a multi-agent simulation framework, the ability to abstract from a concrete problem and implement the best model for the solution of the problem, the expert knowledge of how to validate and evaluate a simulation model.</p>		
Workload: <p>Total: 300 h</p>		
Conditions: <p>none</p>		Credit Requirements: <p>Pass the module exam</p>
Frequency: each winter semester	Recommended Semester: 1. - 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: <p>according to the examination regulations of the study program</p>	

Parts of the Module
Part of the Module: Seminar Modelling and Simulation Mode of Instruction: seminar Language: English Frequency: each winter semester Contact Hours: 2,00 ECTS Credits: 5.0
Part of the Module: Exercises Modelling and Simulation Mode of Instruction: exercise course Language: English Frequency: each winter semester Contact Hours: 2,00 ECTS Credits: 5.0

Examination

Geoinformatik 1: Modelling and Simulation (MScGI)

project work, graded

Module GEO-5129: Geoinformatics 2 <i>Geoinformatik 2</i>		10 ECTS/LP
Version 2.0.0 (since WS22/23) Person responsible for module: Prof. Dr. Jukka Krisp		
Contents: Introduction to visual and computer-aided methods of geographic data analysis. Exercises on the computer under guidance with geodata and mining software.		
Learning Outcomes / Competences: After attending this module, the students have become acquainted with computer-aided methods of geoinformatics for visual geodata analysis. You have acquired the ability to describe processes with the help of functional mechanisms and approaches. You have developed a functional set of tools for the visual analysis and processing of geographic data and can use this in specific cases. You can transfer the results of the assignment to similar problems and evaluate them critically.		
Workload: Total: 300 h		
Conditions: none		Credit Requirements: Pass the module exam
Frequency: each semester part 1 each semester, part 2 in summer semester	Recommended Semester: 2. - 3.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Vorlesung/Seminar zu Geodatenanalyse Mode of Instruction: lecture, seminar Language: German / English Frequency: each semester Contact Hours: 2,00 ECTS Credits: 5.0
Part of the Module: Übung/Seminar zu Geodatenanalyse Mode of Instruction: exercise course, seminar Language: German / English Frequency: each summer semester Contact Hours: 2,00 ECTS Credits: 5.0
Examination Geoinformatik 2: Geodatenanalyse (MScGI) portfolio exam, Module exam, graded

Module GEO-5135: Climate 1 <i>Klima 1</i>		10 ECTS/LP
Version 2.0.0 (since WS22/23) Person responsible for module: apl. Prof. Christoph Beck		
Contents: Basic facts and problem contexts from the subject area of climate system and climate change or from the research areas treated with substantial-supporting reference to this subject area. In the associated accompanying seminar, content from the special lecture will be taken up and treated in addition.		
Learning Outcomes / Competences: Acquiring basic knowledge on research areas that either directly address the topic of the climate system and climate change or contain a substantial connection to it; problem-oriented treatment of associated questions in short presentations and contributions to discussions.		
Remarks: Lecture with accompanying seminar		
Workload: Total: 300 h		
Conditions: none		Credit Requirements: Pass the module exam
Frequency: each winter semester winter term	Recommended Semester: 1. - 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Spezialvorlesung Mode of Instruction: lecture Language: German / English Frequency: each winter semester Contact Hours: 2,00 ECTS Credits: 5.0
Literature: IPCC (Intergovernmental Panel on Climate Change): Climate Change 2013. The Physical Science Basis. Fifth Assessment Report, Contribution of Working Group I.
Part of the Module: Begleitseminar Mode of Instruction: seminar Language: German / English Frequency: each winter semester Contact Hours: 2,00 ECTS Credits: 5.0
Examination Klima 1 written exam / length of examination: 90 minutes, graded

Module INF-0277: Analysing Massive Data Sets <i>Analyzing Massive Data Sets</i>		8 ECTS/LP
Version 1.2.0 (since SoSe18) Person responsible for module: Prof. Dr. Peter Michael Fischer		
Learning Outcomes / Competences: After attending the course, students will be able to understand and evaluate the concepts and methods, procedures, techniques, and technologies for analyzing massively large data sets. Possible content includes: <ul style="list-style-type: none"> • Fundamentals of information retrieval • Similarity search and clustering • Analysis of data streams and temporal data • Web graphs: Link analysis and social networks • Dynamic networks and information diffusion • Recommender systems and online advertising • Computational methods for massive data sets Students will also be able to implement technical solution concepts for analyzing large data sets in programs. Key Skills: Ability to think logically, analytically and conceptually, weigh up approaches to solutions, acquire abstraction skills; subject-specific in-depth knowledge; implement subject-specific solution concepts in programs and models; knowledge of the advantages/disadvantages of design alternatives and evaluation in the respective application context; selection and confident application of suitable methods; ability to make scientifically meaningful evaluations using suitable methods; ability to solve problems under practical boundary conditions; competence in recognizing significant technical developments;		
Workload: Total: 240 h 30 h studying of course content using literature (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using provided materials (self-study) 60 h lecture (attendance) 30 h exercise course (attendance)		
Conditions: Module Database Systems (INF-0073) - recommended Module Discrete structures for computer science (INF-0109) - recommended Module Computer Science 3 (INF-0111) - recommended		
Frequency: Sommersemester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Analyzing Massive Data Sets (Vorlesung) Mode of Instruction: lecture Language: English Frequency: irregular (usu. summer semester) Contact Hours: 4,00		
Contents: The lecture covers basic concepts for the analysis of massively large data sets such as information extraction, similarity search, clustering, link and network analysis as well as their implementation.		

Literature:

- Mining of Massive Datasets. J. Leskovec, A. Rajaraman, J.D. Ullman. Cambridge University Press, 2014
- D. Easley, J. Kleinberg. Networks, Crowds, and Markets: Reasoning About a Highly Connected World. Cambridge University Press, 2010.
- R. Baeza-Yates, B. Ribeiro-Neto: Modern Information Retrieval

Weitere Literatur wird in der Vorlesung bekannt gegeben

Part of the Module: Analyzing Massive Data Sets (Übung)

Mode of Instruction: exercise course

Language: English / German

Frequency: irregular (usu. summer semester)

Contact Hours: 2,00

Examination**Analyzing Massive Data Sets**

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-0293: Advanced Deep Learning <i>Advanced Deep Learning</i>		8 ECTS/LP
Version 1.0.0 (since WS18/19) Person responsible for module: Prof. Dr. Rainer Lienhart		
Learning Outcomes / Competences: After participating in the practical module, students have detailed and up-to-date knowledge in the field of machine learning, can identify significant technical developments and can implement a complete pipeline for multimodal data processing with deep neural networks. They can precisely describe and discuss problems and results in the field and apply learned concepts and methods to similar problems in machine learning. In addition, the students analyse advanced concepts, methods, procedures, techniques and technologies from the field of machine learning to apply them in research projects, transfer them to current industry-related tasks and actively participate in them. The students learn to transfer scientifically challenging topics in the field of machine learning to other research questions and, building on this, to work out a complex project in group work. They also have the teamwork and communication skills to discuss problems in the field, to discuss, describe and present questions and interim results. In addition, students can conduct detailed experiments and assess, compare and check results for plausibility.		
Key qualifications: Advanced mathematical-formal methodology; Translating subject-specific solution concepts into programs and models; Methods for developing larger software systems, construction of abstractions and architectures; Interdisciplinary knowledge; Systematic further development of design methods; Skill of confident and convincing presentation of ideas and concepts; Understanding of team processes; Skill of working in teams; Ability to lead teams; Familiarity with procedures and processes in the application environment of computer science; Skill of solving problems under practical boundary conditions; Self-reflection; Responsible action against the background of inadequacy and conflicting interests; Ability to expand existing knowledge independently; Quality awareness, meticulousness		
Workload: Total: 240 h 30 h studying of course content using provided materials (self-study) 30 h studying of course content using literature (self-study) 120 h studying of course content through exercises / case studies (self-study) 20 h lecture (attendance) 40 h exercise course (attendance)		
Conditions: Fundamental knowledge in computer vision (basic studies lectures "Multimedia Grundlagen 1", "Grundlagen der Signalverarbeitung und des Maschinellen Lernens", "Multimedia Grundlagen 2" as well as master's lectures "Multimedia 2" and "Machine Learning and Computer Vision")		Credit Requirements: Passing the portfolio examination
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Advanced Deep Learning (Lecture) Mode of Instruction: lecture Language: English / German Frequency: each winter semester Contact Hours: 2,00		

Contents:

- Deep Learning in general
- Deep Convolutional Neural Networks
- Transfer Learning
- Recurrent Neural Networks / LSTM Networks
- Natural Language Processing
- Multimodal Fusion (Vision+Language)
- Application: Image Captioning

Assigned Courses:

Advanced Deep Learning (lecture)

**(in attendance) **

Part of the Module: Advanced Deep Learning (Tutorial)

Mode of Instruction: exercise course

Language: English / German

Frequency: each winter semester

Contact Hours: 4,00

Assigned Courses:

Übung zu Advanced Deep Learning (exercise course)

**(in attendance) **

Examination

Advanced Deep Learning

portfolio exam, The final grade is made up of assessed exercise sheets and an assessed team project., graded

Test Frequency:

when a course is offered

Module INF-0307: Model-Based Development and Analysis of Software Systems <i>Modellbasierte Entwicklung und Analyse von Software Systemen</i>		6 ECTS/LP
Version 1.1.0 (since SoSe19) Person responsible for module: Prof. Dr. Bernhard Bauer		
Learning Outcomes / Competences: Model-based development and analysis of software systems deal with increasing software production efficiency through automation and reuse. In the course, participants learn to apply and compare methods for the model-driven development of software systems. They develop in-depth, subject-specific solution concepts for MDSD. They can evaluate current technologies and standards for MDSD and analyze their applicability in practice-relevant tasks. The participants build up skills for analyzing and structuring complex IT problems in the generation of infrastructure code, subsystems, configurations, or entire applications from models. In doing so, they develop logical, analytical, and conceptual thinking skills and can systematically develop and assess solutions to problems. Key qualification: Interdisciplinary knowledge; competence in networking different subject areas; teamwork and communication skills; ability to expand existing knowledge independently; quality awareness; familiarity with procedures and processes in the application environment of computer science; knowing and understanding formal quantitative principles; ability to present and document results in an understandable way.		
Workload: Total: 180 h 23 h studying of course content using literature (self-study) 22 h studying of course content using provided materials (self-study) 30 h exercise course (attendance) 45 h lecture (attendance) 60 h studying of course content through exercises / case studies (self-study)		
Conditions: Due to overlaps, the previous course "Model-Driven Software Development" must not have been taken.		
Frequency: irregular (usu. summer semester)	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 5,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Modellbasierte Entwicklung und Analyse von Software Systemen (Vorlesung) Mode of Instruction: lecture Language: German Frequency: irregular (usu. summer semester) Contact Hours: 3,00		
Contents: Model-based development and analysis of software systems are concerned with increasing software production efficiency through automation and reuse. Infrastructure code, subsystems, configurations, or entire applications are generated from models.		

Literature:

- slides
- Pohl et al. Software Product Line Engineering: Foundations, Principles, and Techniques
- Kleppe et al: MDA explained
- Hitz et al: UML@Work
- Further literature in the lecture

Part of the Module: Modellbasierte Entwicklung und Analyse von Software Systemen (Übung)

Mode of Instruction: exercise course

Language: German

Frequency: irregular (usu. summer semester)

Contact Hours: 2,00

Examination

Modellbasierte Entwicklung und Analyse von Software Systemen

oral exam / length of examination: 30 minutes, graded

Test Frequency:

when a course is offered

Module INF-0308: Software-Intensive Systems <i>Software-intensive Systeme</i>		6 ECTS/LP
Version 1.2.0 (since SoSe19) Person responsible for module: Prof. Dr. Bernhard Bauer		
Learning Outcomes / Competences: Students can create (K3), evaluate (K6), and document software architectures. For this purpose, they can transfer technical solution concepts into models and know methods for developing such abstractions and architectures. They can describe the advantages and disadvantages of design alternatives (K4) and evaluate them in the respective application context (K6). Problems can be identified independently (K4), and solutions can be designed systematically (K5) and realized (K3). Furthermore, they have developed skills for the analysis and structuring of problems in enterprise architectures and know the concepts and procedures for creating such architectures. The students can name practice-relevant issues in enterprise architectures (K1). They can select and confidently apply suitable methods for architecture creation and evaluation. The students know modeling languages and patterns to create software and enterprise architectures. They have the competence to recognize significant technical developments. Key qualification: Competence to network different subject areas; ability to work in a team and communicate; ability to expand existing knowledge independently; quality awareness; skill to present and document results in an understandable way; practical experience and professional qualification.		
Workload: Total: 180 h 22 h studying of course content using provided materials (self-study) 23 h studying of course content using literature (self-study) 45 h lecture (attendance) 60 h studying of course content through exercises / case studies (self-study) 30 h exercise course (attendance)		
Conditions: The previous course "Software Architectures and Enterprise Architecture Management" and the course "Software-intensive Systems and Medical Devices" must not have been taken due to overlaps.		
Frequency: irregular (usu. summer semester)	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 5,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Software-intensive Systeme (Vorlesung) Mode of Instruction: lecture Language: German Frequency: Sommersemester Contact Hours: 3,00		
Contents: The lecture content includes patterns, modelling techniques and the evaluation of software architectures. Furthermore, the area of enterprise architecture management is addressed.		
Literature: <ul style="list-style-type: none"> • Bass et al: Software Architecture in Practice • Clements et al: Documenting Software Architectures • Clements et al: Evaluation of Software Architectures • Kopetz: Real-Time Systems 		

Part of the Module: Software-intensive Systeme (Übung)

Mode of Instruction: exercise course

Language: German

Frequency: Sommersemester

Contact Hours: 2,00

Examination

Software-intensive Systeme

oral exam / length of examination: 30 minutes, graded

Test Frequency:

when a course is offered

Module INF-0309: Real-Time Systems <i>Echtzeitsysteme</i>		8 ECTS/LP
Version 1.11.0 (since WS19/20) Person responsible for module: Prof. Dr. Sebastian Altmeyer		
Learning Outcomes / Competences: <p>The lecture imparts basic and advanced knowledge of real-time systems as they occur in almost all embedded systems, but especially in the areas of automotive, aerospace and robotics. The theoretical foundations will be based on the current state of research and will enable students to further engage with the topic of embedded real-time systems at a scientific level.</p> <p>The lecture will provide students with the ability to distinguish and classify different embedded systems based on their real-time requirements. Students will learn to apply, compare, and critically analyze current methods for validation of timing behavior with respect to possible certification of timing behavior. This includes the optimization and selection of real-time schedules and their verification. The lecture will also cover different processor types, and will go into more detail about the specifics of single-core and multi-core processors in the real-time domain. Students will be able to classify processors based on their suitability for real-time systems and to investigate the impact of design decisions on real-time behavior and real-time behavior analysis.</p> <p>The course material will be exemplified by case studies from the automotive and aerospace fields and applied by the students using a simple real-time system.</p> <p>Key qualifications: Analytical-methodical competence, consideration of approaches to solutions, presentation of solutions to exercise problems; skill in presenting and documenting results in a comprehensible manner; ability to expand existing knowledge independently; quality awareness, meticulousness; self-reflection; responsible action against a background of inadequacy and conflicting interests.</p>		
Workload: Total: 240 h 30 h studying of course content using literature (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using provided materials (self-study) 60 h lecture (attendance) 30 h exercise course (attendance)		
Conditions: none		
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Echtzeitsysteme (Vorlesung) Mode of Instruction: lecture Language: German / English Frequency: irregular (usu. winter semester) Contact Hours: 4,00		

Contents:

- WCET Analysis
- Scheduling Analysis
- Programming of real-time systems
- Processors for real-time systems
- Real-time operating systems
- Certification of real-time systems

Literature:

- Sanjoy Baruah, Marko Bertogna, Giorgio Buttazzo, Multiprocessor Scheduling for Real-Time Systems, Springer, 2015.
- Giorgio Buttazzo, Hard Real-Time Computing Systems: Predictable Scheduling Algorithms and Applications, Springer, 2011.
- Heinz Wörn, Uwe Brinkschulte, Echtzeitsysteme, Springer Verlag, Berlin/Heidelberg, 2005
- Uwe Brinkschulte, Theo Ungerer, Mikrocontroller und Mikroprozessoren, Springer Verlag, Heidelberg, dritte Auflage 2010

Assigned Courses:**Real-Time Systems** (lecture)

**(in attendance) **

Part of the Module: Echtzeitsysteme (Übung)

Mode of Instruction: exercise course

Language: German

Frequency: irregular (usu. winter semester)

Contact Hours: 2,00

Assigned Courses:**Exercise for Real-Time Systems** (exercise course)

**(in attendance) **

Examination**Echtzeitsysteme**

written exam / length of examination: 90 minutes, graded

Test Frequency:

this semester

Module INF-0316: Machine Learning and Computer Vision <i>Machine Learning and Computer Vision</i>		8 ECTS/LP
Version 1.0.0 (since SoSe19) Person responsible for module: Prof. Dr. Rainer Lienhart		
Learning Outcomes / Competences: After successful participation in this module, students possess advanced knowledge of machine learning (decision trees, neural networks and deep neural networks, hypothesis evaluation, instance-based learning, Bayesian learning, learning theory), data reduction (e.g. principal component analysis), advanced image processing and machine vision and are able to apply them. They can analyse, understand and programmatically implement scientifically complex procedures in the field of multimedia data processing, as well as to appropriately apply the principles learned to new problems. They develop skills in logical, analytical and conceptual thinking in the field of digital signal processing and multimedia data processing.		
Key qualifications: advanced mathematical-formal logic; implementation of subject-specific solution concepts; interdisciplinary knowledge; development and implementation of solution strategies for complex problems; systematic further development of design methods; ability to solve problems under practical boundary conditions.		
Workload: Total: 240 h 30 h exercise course (attendance) 60 h lecture (attendance) 30 h studying of course content using provided materials (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using literature (self-study)		
Conditions: none		Credit Requirements: Passing the Module Exam
Frequency: each summer semester (except for summer term 2026)	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Machine Learning and Computer Vision (Lecture) Mode of Instruction: lecture Language: German Frequency: each summer semester Contact Hours: 4,00		
Contents: The lecture gives a good overview of all aspects of machine learning and machine extraction of information from multimedia data (e.g. "Google Image Search", "Google Goggles"). The learned concepts will be practised, analysed, and evaluated in the exercises using successful examples from practice. At the end of the semester, advanced topics such as object detection and object recognition of faces and people will be covered. The contents of the lecture include: Machine Learning (Decision Tree Learning, Artificial Neural Networks, Bayesian Learning, Discrete Adaboost), Data Reduction (Quantization (K-Means Clustering, Affinity Propagation), Dimensionality Reduction Techniques (PCA, NMF, Random Projection, MDS)) and Image Processing & Computer Vision (Salient Feature Points and Feature Descriptors, Object Detection (Face/Car/People Detection), Object Recognition (Face Recognition), Image Search with pLSA).		

Literature:

Literature references will be announced at the beginning of the semester.

Part of the Module: Machine Learning and Computer Vision (Tutorial)

Mode of Instruction: exercise course

Language: German

Frequency: each summer semester

Contact Hours: 2,00

Examination**Machine Learning and Computer Vision**

written exam / length of examination: 120 minutes, graded

Test Frequency:

each semester

Description:

The examination can be taken every semester during the examination period.

Module INF-0367: Advanced Machine Learning and Computer Vision <i>Advanced Machine Learning and Computer Vision</i>		5 ECTS/LP
Version 1.0.0 (since WS20/21) Person responsible for module: Prof. Dr. Rainer Lienhart		
Learning Outcomes / Competences: After successful participation in this module, students have in-depth advanced knowledge of machine learning (support vector machines and deep neural networks and their basic building blocks) and machine vision (deep neural network architectures and systems) and can apply these. They can analyse, understand and programmatically implement scientifically complex procedures in the field of image, text, video and signal processing, as well as to appropriately apply the principles learned to new problems. They develop skills in logical, analytical and conceptual thinking in the field of machine learning and vision. Key qualifications: advanced mathematical-formal logic; critical reading and analysis of scientific publications; implementation of technical solution concepts; interdisciplinary knowledge; development and implementation of solution strategies of complex problems; systematic further development of design methods; skills in solving problems under practical boundary conditions		
Workload: Total: 150 h 30 h lecture (attendance) 60 h studying of course content through exercises / case studies (self-study) 30 h exercise course (attendance) 15 h studying of course content using literature (self-study) 15 h studying of course content using provided materials (self-study)		
Conditions: Kenntnisse in maschinellern Lernen und maschinellern Sehen (Master-Vorlesung INF-0092 "Multimedia II" bzw. INF-0316 "Machine Learning and Computer Vision")		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Advanced Machine Learning and Computer Vision (Lecture) Mode of Instruction: lecture Language: German Frequency: each winter semester Contact Hours: 2,00
Contents: The lecture gives an in-depth insight into all aspects of machine learning and machine vision. The concepts learned will be practiced, analyzed and evaluated in the exercises using successful real-world examples. The contents of the lecture include: support vector machines, basic building blocks of deep neural networks (layer structures, normalization, attention mechanisms), as well as current reference architectures and systems for image, text, video processing and their combination with further sensor signals.
Literature: Will be announced at the beginning of the semester.

Assigned Courses:

Advanced Machine Learning and Computer Vision (lecture)

**(online/digital) **

Part of the Module: Advanced Machine Learning and Computer Vision (Tutorial)

Mode of Instruction: exercise course

Language: German

Frequency: each winter semester

Contact Hours: 2,00

Assigned Courses:

Übung zu Advanced Machine Learning and Computer Vision (exercise course)

**(in attendance) **

Examination

Advanced Machine Learning and Computer Vision (Examination)

written exam / length of examination: 90 minutes, graded

Test Frequency:

each semester

Description:

The examination can be taken every semester during the examination period.

Module INF-0371: Approximation Algorithms <i>Approximation Algorithms</i>		5 ECTS/LP
Version 1.3.0 (since WS20/21) Person responsible for module: Prof. Dr. Tobias Mömke		
Learning Outcomes / Competences: Developing an understanding of central topics in the field of approximation algorithms; acquiring powerful mathematical tools to analyze algorithms; improve the ability to abstract and systematically solve optimization problems. Key Skills: Ability to build intuitive understanding of mathematical formalisms; ability to identify core properties of optimization problems; deep understanding of powerful mathematical tools		
Workload: Total: 150 h 30 h exercise course (attendance) 30 h lecture (attendance) 60 h studying of course content through exercises / case studies (self-study) 15 h studying of course content using literature (self-study) 15 h studying of course content using provided materials (self-study)		
Conditions: Basic knowledge of Algorithms and Data Structures (e.g., "INF-0111: Informatik 3") and Theoretical Computer Science (e.g., "INF-0110: Einführung in die Theoretische Informatik").		Credit Requirements: Passing the module exam
Frequency: irregular	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Approximation Algorithms (Vorlesung) Mode of Instruction: lecture Language: German / English Frequency: irregular Contact Hours: 2,00		
Contents: Given an NP-hard optimization problem, how well can it be approximated in polynomial time? It is exciting and challenging to understand the approximability of fundamental optimization problems. This course mainly focuses on upper bounds, i.e., designing efficient approximation algorithms. In this course, we will study several classes of problems, such as packing problems, network design, and graph problems. We will cover central algorithmic techniques for designing approximation algorithms, including greedy algorithms, dynamic programming, linear and semi-definite programming, and randomization.		
Literature: <ul style="list-style-type: none"> David P. Williamson and David B. Shmoys, The Design of Approximation Algorithms, Cambridge University Press. Vijay V. Vazirani, Approximation Algorithms, Springer. 		

Part of the Module: Approximation Algorithms (Übung)

Mode of Instruction: exercise course

Language: English / German

Frequency: irregular

Contact Hours: 2,00

Examination

Approximation Algorithms

portfolio exam / length of examination: 120 minutes, graded

Test Frequency:

when a course is offered

Module INF-0383: Algorithms for Big Data <i>Algorithmen für Big Data</i>		5 ECTS/LP
Version 1.1.0 (since SoSe21) Person responsible for module: Prof. Dr. Tobias Mömke		
Learning Outcomes / Competences: Development and understanding of central competences in algorithm design for situations, where there are large amounts of data such that not all of them can be accessed without restrictions; acquisition of knowledge of mathematical tools to analyze algorithms; improvement of competences in abstract thinking and analyzing problems in a systematic manner. Key Qualifications: Ability to develop an intuitive understanding of mathematical formalisms; ability to identify the core properties of algorithmic problems; deep understanding of useful mathematical tools		
Workload: Total: 150 h 30 h exercise course (attendance) 30 h lecture (attendance) 15 h studying of course content using provided materials (self-study) 60 h studying of course content through exercises / case studies (self-study) 15 h studying of course content using literature (self-study)		
Conditions: Basic knowledge in algorithms and data structures (for example Informatik 3 (INF-0111)) and in probability theory (for example Stochastik für Informatiker (MTH-6040)).		Credit Requirements: Bestehen der Modulprüfung
Frequency: irregular	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module	
Part of the Module: Algorithms for Big Data (lecture) Mode of Instruction: lecture Language: German / English Frequency: irregular Contact Hours: 2,00	
Contents: In modern data processing, we increasingly have the problem that there are large quantities of data which can only be stored on cheap and slow mass storage media. Algorithmically, this poses the problem that at each point in time, we can only access a snapshot of the data, for example in a sequential manner. In the course, we study algorithms that despite such limitations provably yield high quality results.	
Literature: Wissenschaftliche Papiere, Surveys, Skripte	
Part of the Module: Algorithms for Big Data (exercise) Mode of Instruction: exercise course Language: English / German Frequency: irregular Contact Hours: 2,00	

Examination

Algorithms for Big Data

portfolio exam / length of examination: 90 minutes, graded

Test Frequency:

when a course is offered

Module INF-0398: Software-intensive Systems and Medical Products <i>Software-intensive Systeme und Medizinprodukte</i>		6 ECTS/LP
Version 1.0.0 (since WS21/22) Person responsible for module: Prof. Dr. Bernhard Bauer		
Learning Outcomes / Competences: Students can create (K3), evaluate (K6), and document software architectures. To this end, they can transfer technical solution concepts into models and know methods for developing such abstractions and architectures. Such abstractions and architectures. They can describe the advantages and disadvantages of design alternatives (K4). (K4) and can evaluate them in the respective application context (K6). Problems can be identified independently (K4), and solutions can be designed systematically (K5) and realized (K3). Furthermore, they have basic knowledge of creating medical software according to the particular requirements for conformity assessment. Based on the European Medical Device Regulation (MDR), students learn how to implement the required software life cycle process according to IEC 62304 and IEC 82304, the requirements for software requirement management, the link between (agile) software development and the documentation obligation, requirements regarding safety and security. Key qualifications: Competence in networking different specialist areas; teamwork and communication skills; ability to expand existing knowledge independently; quality awareness; ability to present and document results in an understandable way; practical experience and professional qualifications.		
Workload: Total: 180 h 23 h studying of course content using literature (self-study) 22 h studying of course content using provided materials (self-study) 60 h studying of course content through exercises / case studies (self-study) 45 h lecture (attendance) 30 h exercise course (attendance)		
Conditions: The previous course "Software Architectures and Enterprise Architecture Management" and the course "Software-intensive Systems" must not have been taken due to overlaps.		
Frequency: Sommersemester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 5,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Software-intensive Systeme und Medizinprodukte (Vorlesung) Mode of Instruction: lecture Language: German Frequency: Sommersemester Contact Hours: 3,00		
Contents: The lecture content includes patterns, modelling techniques and the evaluation of software architectures. Furthermore, the development of medical devices is dealt with.		

Literature:

- Bass et al: Software Architecture in Practice
- Clements et al: Documenting Software Architectures
- Clements et al: Evaluation of Software Architectures
- Richard N. Taylor, Nenad Medvidovic, and Eric M. Dashofy; Software Architecture: Foundations, Theory, and Practice
- BSI Empfehlungen für Medizinprodukte
- ZVE Empfehlungen für Medizinprodukte

Part of the Module: Software-intensive Systeme und Medizinprodukte (Übung)

Mode of Instruction: exercise course

Language: German

Frequency: Sommersemester

Contact Hours: 2,00

Examination

Software-intensive Systeme

oral exam / length of examination: 30 minutes, graded

Test Frequency:

when a course is offered

Module INF-0408: Extremal Combinatorics <i>Extremal Combinatorics</i>		5 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Tobias Mömke		
Learning Outcomes / Competences: Knowledge Developing an understanding of central topics in the field of combinatorics; acquiring powerful mathematical tools to analyze performance of algorithms; improve the ability to abstract and systematically solve counting problems. Methodical Competences The students are able to develop and write mathematical proofs in the context of advance combinatoric problems. They are able to understand complex reasoning and judge the correctness of mathematical arguments. The students are able to develop novel solution approaches, as solutions to relevant questions are usually not unique Key Skills Ability to build intuitive understanding of mathematical formalisms; ability to identify core properties of optimization problems; deep understanding of powerful mathematical tools; Skills of mathematical thinking		
Workload: Total: 150 h 30 h exercise course (attendance) 15 h studying of course content using provided materials (self-study) 15 h studying of course content using literature (self-study) 60 h studying of course content through exercises / case studies (self-study) 30 h lecture (attendance)		
Conditions: Basic knowledge in mathematics, in particular linear algebra is necessary. Basic knowledge in graph theory is recommended.		Credit Requirements: Passing the module exam
Frequency: irregular	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Extremal Combinatorics (Vorlesung) Mode of Instruction: lecture Language: English / alle Sprachen Frequency: irregular Contact Hours: 2,00
Contents: How many people do you need to invite for your party, in order to have 3 strangers or a group of 3 friends? If 10 people have keys to a safe, how many locks are necessary to make sure any 5 of them can open it? What is the dictator paradox, and should you be worried about it? This course provides an introduction to extremal combinatorics, which helps us to find answers to the questions above.
Literature:

Part of the Module: Extremal Combinatorics (Übung)

Mode of Instruction: exercise course

Language: English / alle Sprachen

Frequency: irregular

Contact Hours: 2,00

Examination

Extremal Combinatorics

oral exam / length of examination: 45 minutes, graded

Test Frequency:

when a course is offered

Module INF-0409: Cyber Security <i>Cyber Security</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Bernhard Bauer		
Learning Outcomes / Competences: Students can create (K3), evaluate (K6), and document security aspects in the software development process and software architectures. To this end, they can transfer technical solution concepts into development processes and IT architectures and know methods for developing secure software. They can describe the advantages and disadvantages of security alternatives (K4) and evaluate them in the respective application context (K6). Problems can be identified independently (K4) and solutions systematically designed (K5) and implemented (K3). Furthermore, they have developed skills for analyzing and structuring the problems of security architectures and know the concepts and procedures for creating such architectures. Students can name practice-relevant issues in security architectures and secure software development processes (K1). They can select suitable methods for They can select and safely apply suitable methods for creating and evaluating security architectures. The students know concepts and technologies for developing secure software and security architectures. They have the competence to recognize significant technical developments. Key qualification: Competence to network different subject areas; team and ability to communicate; ability to expand existing knowledge independently; quality awareness; ability to present and document results understandably; practical experience and professional aptitude.		
Workload: Total: 180 h 23 h studying of course content using literature (self-study) 22 h studying of course content using provided materials (self-study) 60 h studying of course content through exercises / case studies (self-study) 45 h lecture (attendance) 30 h exercise course (attendance)		
Conditions: none		Credit Requirements: Passing the module exam
Frequency: each winter semester SoSe 25 danach WiSe 26-27	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 5,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Cyber Security (Vorlesung) Mode of Instruction: lecture Language: German / English Frequency: each summer semester Contact Hours: 3,00		
Contents: The lecture content includes security standards, secure software development lifecycles, as well as security architectures, and their evaluation in respective technology contexts. and the evaluation of security architectures.		
Literature: <ul style="list-style-type: none">• Slides• A. Deane, A. Kraus: The Official (ISC)2 CISSP CBK Reference• Further literature in the lecture on specific topics		

Part of the Module: Cyber Security (Übung)

Mode of Instruction: exercise course

Language: German / English

Frequency: each summer semester

Contact Hours: 2,00

Examination

Cyber Security

oral exam / length of examination: 30 minutes, graded

Test Frequency:

when a course is offered

Module INF-0410: Gesture-Based Communication in Human-Computer Interaction <i>Gesture-Based Communication in Human-Computer Interaction</i>		8 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Elisabeth André		
Learning Outcomes / Competences: After successful participation in this module, students understand the essential concepts of gesture-based communication in human-computer interaction. They are able to translate technical solution concepts into programs and models and master the selection and application of suitable methods. They have the knowledge of the way of thinking and the language of application-relevant disciplines. Within the framework of the lecture, they learn to evaluate learning components in a scientifically meaningful way using suitable methods, to develop the methods and algorithms independently and to implement them technically. Particularly promoted in this framework are also the skills for confident and convincing presentation of ideas and concepts, comprehensible presentation and documentation of results, as well as logical, analytical and conceptual thinking. Key qualifications: Advanced mathematical formal methodology, skill in analyzing and structuring complex computer science problems, skill in developing and implementing solution strategies for complex problems, understanding of team processes, skill in collaborating in teams, self-reflection; acting responsibly in the face of inadequacy and conflicting interests, quality awareness, meticulousness.		
Workload: Total: 240 h 120 h studying of course content through exercises / case studies (self-study) 15 h studying of course content using literature (self-study) 15 h studying of course content using provided materials (self-study) 60 h exercise course (attendance) 30 h lecture (attendance)		
Conditions: none		
Frequency: irregular	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Gesture-Based Communication in Human-Computer Interaction (Lecture) Mode of Instruction: lecture Language: English Frequency: each summer semester Contact Hours: 2,00		
Contents: HCI methods and principles, Interaction design, Nonverbal communication, Gestures, Gesture recognition systems, Collaboration, Applied computer vision, Ubiquitous computing		
Part of the Module: Gesture-Based Communication in Human-Computer Interaction (Exercise Course) Mode of Instruction: exercise course Language: English Frequency: each summer semester Contact Hours: 4,00		

Examination

Gesture-Based Communication in Human-Computer Interaction

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-0427: Deep Ubiquitous and Wearable Computing for Healthcare <i>Deep Ubiquitous and Wearable Computing for Healthcare</i>		8 ECTS/LP
Version 1.0.0 (since WS22/23) Person responsible for module: Prof. Dr. Elisabeth André		
Learning Outcomes / Competences: Students are familiar with methods and techniques of interaction design and engineering for health care applications. After successful participation, they will have the necessary knowledge to analyze application scenarios according to the guidelines of the user-centered design process and to design software solutions tailored to the target group. They are able to translate current interaction paradigms and design guidelines into models and programs for novel interaction devices, as well as to independently familiarize themselves with the necessary technologies. Furthermore, they are able to apply practice-relevant evaluation methods to assess the quality of the created software prototype. They are able to plan larger project tasks in small teams, solve them according to a self-developed project plan and discuss the results appropriately in plenary sessions and present them as a team.		
Key qualifications: Skill in confident and persuasive presentation of ideas and concepts; knowledge of the mindset and language of application-relevant disciplines; understanding of team processes; skill in collaborating in teams; skill in leading teams; skill in presenting and documenting results in a comprehensible manner; ability to expand existing knowledge independently; ability to contribute to science; competence in recognizing significant technical developments; quality awareness, meticulousness.		
Workload: Total: 240 h 15 h studying of course content using provided materials (self-study) 15 h studying of course content using literature (self-study) 120 h studying of course content through exercises / case studies (self-study) 30 h lecture (attendance) 60 h exercise course (attendance)		
Conditions: Programming experience		
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Practical Module Interaction Design and Engineering for Health Care Applications Mode of Instruction: lecture Language: English Frequency: each summer semester Contact Hours: 2,00		
Contents: The specific assignment for student projects is designed each year.		
Literature: Literature references will be announced at the beginning of the semester depending on the topic.		

Part of the Module: Deep Ubiquitous and Wearable Computing for Healthcare (Exercise Course)

Mode of Instruction: exercise course

Language: English

Frequency: each winter semester

Contact Hours: 4,00

Examination

Practical Module Interaction Design and Engineering for Health Care Applications

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-0440: Quantum Algorithms <i>Quantum Algorithms</i>		5 ECTS/LP
Version 1.0.0 (since SoSe23) Person responsible for module: Prof. Dr. Jakob Siegfried Kottmann		
Learning Outcomes / Competences: Die Studierenden erwerben Grundkenntnisse in der Quantenalgorithmmik und sind in der Lage fundamentale Prinzipien zu erklären und Ihre Verwendung in algorithmischen Strukturen zu beschreiben. Sie können etablierte algorithmische Strukturen aus dem Bereich der Quantenalgorithmmik, wie die Suche, Fouriertransform, und Phasenabschätzung, beschreiben und potentielle Anwendungsgebiete bestimmen und vergleichen. Nach Besuch der Veranstaltung sind Sie in der Lage quantenalgorithmmische Ansätze zu konstruieren und in diskrete Operationen auf Qubitsysteme zu übersetzen. Die Studierenden haben fundiertes Basiswissen in grundlegenden quantenalgorithmmische Strukturen und variationellen Heuristiken. Sie sind in der Lage quantenalgorithmmische Elemente in gegenwärtiger Literatur zu identifizieren, zu analysieren und zu bewerten. Schlüsselqualifikationen: Abstraktionsfähigkeit; Sicherer Umgang mit mathematischen Strukturen; Algorithmisches Denken; Eigenständiges Erarbeiten von algorithmischen Lösungsansätzen; Grundlegendes Verständnis für die Funktion von Quantenrechnern; Grundsätze guter wissenschaftlicher Praxis;		
Workload: Total: 150 h 60 h studying of course content through exercises / case studies (self-study) 15 h studying of course content using literature (self-study) 15 h studying of course content using provided materials (self-study) 30 h exercise course (attendance) 30 h lecture (attendance)		
Conditions: Grundkenntnisse in linearer Algebra werden empfohlen.		Credit Requirements: Bestehen der Modulprüfung.
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Quantum Algorithms (Vorlesung) Mode of Instruction: lecture Language: English / German Frequency: each summer semester Contact Hours: 2,00		

Contents:

Foundations of Quantum Information Processing:

- qubits and their representation
- BraKet notation and necessary structures from linear algebra
- operations on qubits: circuits and gates

Quantum Algorithms

- quantum search and amplitude amplification
- quantum fourier transform and it's applications
- quantum simulation
- variational quantum algorithms
- differentiable quantum algorithmic procedures
- quantum heuristics
- usecases from current day research

Literature:

Basics of Quantum Information/Quantum Computation:

- Michal Nielsen; Isaac Chuang: Quantum Computation and Quantum Information

Basics of quantum mechanics:

- Richard P. Feynman; Robert B. Leighton; Matthew Sands: Feynman-Vorlesungen über Physik: Band III, Quantenmechanik
- original scripts are online: <https://www.feynmanlectures.caltech.edu/info/>

Overview over variational quantum algorithms:

- <https://doi.org/10.1103/RevModPhys.94.015004>
- <https://doi.org/10.1038/s42254-021-00348-9>

More on quantum algorithms:

- <http://theory.caltech.edu/~preskill/ph229/> (chapter 5 provides a good summary of the well-known "traditional" quantum algorithms)

Part of the Module: Quantum Algorithms (Übung)

Mode of Instruction: exercise course

Language: English

Frequency: each summer semester

Contact Hours: 2,00

Examination

Quantum Algorithms

oral exam / length of examination: 25 minutes, graded

Test Frequency:

when a course is offered

Module INF-0450: Clinical Research Data Management <i>Klinisches Forschungsdatenmanagement</i>		5 ECTS/LP
Version 1.0.0 (since SoSe23) Person responsible for module: Prof. Dr. Frank Kramer Florian Auer		
Learning Outcomes / Competences: Students acquire a basic understanding of the data loop in clinical research; application understanding of creating patient survey forms; ability to independently design and create a minimal data set and own FHIR- resource for a medical study; practical understanding extraction, transformation and loading processes in providing data for research; evaluation and analysis options of collected data through feasibility queries. They will also enhance their skills in teamwork, communication, and self-organization by completing assignments. Key skills: Skill in logical, analytical and conceptual thinking; independent work with textbooks and scientific literature, configuration and application of provided software tools; problem solving skills.		
Workload: Total: 150 h 30 h lecture (attendance) 30 h exercise course (attendance) 15 h studying of course content using literature (self-study) 60 h studying of course content through exercises / case studies (self-study) 15 h studying of course content using provided materials (self-study)		
Conditions: Module IT Infrastructure in Medical Information Systems (INF-0312) - recommended		Credit Requirements: Passing the module exam
Frequency: irregular	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Clinical Research Data Management (lecture) Mode of Instruction: lecture Language: English / German Frequency: irregular Contact Hours: 2,00
Contents: This lecture covers current topics in the context of research data management. This includes the following content: Introduction to research data management Data management plan The life cycle of research data ETL Data processing, analysis and visualization Metadata Data storage and archiving. Research data repositories Legal foundations

Literature:

- Handbuch der Medizinischen Informatik, Thomas M. Lehmann, 2. Auflage, 2014
- Biomedizinische Ontologie: Wissen strukturieren für den Informatik-Einsatz, Ludger Jamsem, Barry Smith (Hrsg.), 2008

Part of the Module: Clinical Research Data Management (practical)

Mode of Instruction: exercise course

Language: English / German

Frequency: irregular

Contact Hours: 2,00

Examination

Clinical Research Data Management

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-0456: Content Creation for Virtual Environments <i>Content Creation for Virtual Environments</i>		8 ECTS/LP
Version 1.0.0 (since SoSe23) Person responsible for module: Prof. Dr. Elisabeth André		
Learning Outcomes / Competences: After successful completion of this module, students will understand essential concepts and techniques for making and integrating 2D/3D graphics and audio for virtual environments. They have the knowledge of the mindset and language of application-relevant disciplines. Within the framework of the lecture, they learn to create content by hand and generatively with procedural methods and algorithms, taking into account design principles, to integrate the content into applications, to develop algorithms independently and to implement them technically. The skills of confident and convincing presentation of ideas and concepts, comprehensible presentation and documentation of results, as well as creative, aesthetic, musical, logical, analytical and conceptual thinking are also particularly promoted within this framework. Key Qualifications: Aesthetic, design, artistic, and musical fundamentals, design of virtual worlds, selection and confident application of appropriate methods, interdisciplinary knowledge, skill in analyzing and structuring complex computer science problems, skill in developing and implementing solution strategies for complex problems, understanding of team processes, skill in working in teams, self-reflection; acting responsibly in the face of inadequacy and conflicting interests, quality awareness, meticulousness.		
Workload: Total: 240 h 60 h exercise course (attendance) 30 h lecture (attendance) 15 h studying of course content using provided materials (self-study) 120 h studying of course content through exercises / case studies (self-study) 15 h studying of course content using literature (self-study)		
Conditions: none		
Frequency: irregular	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module	
Part of the Module: Content Creation for Virtual Environments (Lecture) Mode of Instruction: lecture Language: German / English Frequency: each summer semester Contact Hours: 2,00	
Part of the Module: Content Creation for Virtual Environments (Exercise Course) Mode of Instruction: exercise course Language: German / English Frequency: each summer semester Contact Hours: 4,00	

Examination

Content Creation for Virtual Environments

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-0462: Embedded Hardware Lab <i>Embedded Hardware Lab</i>		8 ECTS/LP
Version 1.1.0 (since WS23/24) Person responsible for module: Prof. Dr. Sebastian Altmeyer		
Learning Outcomes / Competences: <p>Students acquire competencies in the following areas at an advanced, practical but scientific level: design process for digital circuits, circuit logic and gates, physical principles of electronic components, description of hardware with a hardware description language.</p> <p>First, students learn how to link logic gates and build a half-adder and a full-adder. They understand the digital circuit design process and apply it directly in a practical way by designing their own RISC-V processor. They model and implement it independently using the hardware description language VHDL. They learn the advantages and disadvantages of schematic and textual hardware description and can decide when it makes sense to use which variant. Furthermore, they combine synchronous and asynchronous processes to achieve a good interaction of the components of their self-built microprocessor. Finally, students evaluate the efficiency of their implementation based on the clock frequency achieved and the hardware effort required. In a final project phase, they learn to plan a complex task, to solve it according to a self-developed sound project plan and to discuss and present the results appropriately in a plenary session.</p> <p>Key qualifications: Skill in presenting and documenting ideas, concepts and results in a comprehensible manner; quality awareness, meticulousness; project-bound work and time management; selection and confident use of appropriate methods; ability to expand existing knowledge independently; self-reflection.</p>		
Workload: Total: 240 h 60 h exercise course (attendance) 30 h lecture (attendance) 120 h studying of course content through exercises / case studies (self-study) 15 h studying of course content using literature (self-study) 15 h studying of course content using provided materials (self-study)		
Conditions: Module Foundations of Technical Computer Science (INF-0138) - recommended		
Frequency: irregular (usu. summer semester)	Recommended Semester: 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Embedded Hardware Lab (Lecture) Mode of Instruction: lecture Language: English / German Frequency: irregular Contact Hours: 2,00
Contents: <p>The course "Hardware Design" presents methods of logical design of digital circuits, starting with the abstract description in a hardware description language (like VHDL) up to the physical implementation on transistor level. In the practical part of the course, hardware design is illustrated using the example of a five-stage processor pipeline. The result is an executable processor developed in VHDL for an FPGA prototype board.</p>

Literature:

- Uwe Brinkschulte, Theo Ungerer, Mikrocontroller und Mikroprozessoren, Springer Verlag, Heidelberg, dritte Auflage 2010
- John L. Hennessy, David A. Patterson, Computer Architecture: A Quantitative Approach, Morgan Kaufmann, 5. Auflage, 2011

Part of the Module: Embedded Hardware Lab (Exercise)**Mode of Instruction:** exercise course**Language:** English / German**Frequency:** irregular**Contact Hours:** 4,00**Examination****Embedded Hardware Lab**

practical exam, graded

Test Frequency:

when a course is offered

Description:

Successful participation in the internship, project presentation at the end of the semester

Module INF-0463: Embodied Characters and Interactive Virtual Worlds Lab <i>Embodied Characters and Interactive Virtual Worlds Lab</i>		8 ECTS/LP
Version 1.0.0 (since WS23/24) Person responsible for module: Prof. Dr. Elisabeth André		
Learning Outcomes / Competences: As part of the practical module, students implement interactive multimedia applications in the areas of 2D/3D/Virtual Reality/Serious Games/Simulations/Robotics. Essential concepts and techniques of embodied characters and virtual worlds include planning, making and integrating 2D/3D graphics, animations, user interfaces, storytelling and audio for virtual environments as well as conceptualizing and implementing user interaction. After successful participation, students will have the knowledge of the mindset and language of application-relevant disciplines. During the internship, they learn to create content by hand and generatively with procedural methods and algorithms, taking into account design and musical principles, to integrate the content into applications, to develop algorithms independently and to implement them technically. Particularly encouraged in this context are also the skills of confident and convincing presentation of ideas and concepts, comprehensible presentation and documentation of results, as well as creative, aesthetic, musical, logical, analytical and conceptual thinking.		
Key Qualifications: Aesthetic, design, artistic and musical fundamentals, design of embodied characters and virtual worlds; skill in confident and convincing presentation of ideas and concepts; knowledge of the thinking and language of application-relevant disciplines; understanding of team processes; skill in working in teams; ability to lead teams; skill in comprehensible presentation and documentation of results; ability to expand existing knowledge independently; ability to make contributions to science; competence in recognizing significant technical developments; quality awareness, meticulousness.		
Workload: Total: 240 h 90 h internship / practical course (attendance) 150 h studying of course content through exercises / case studies (self-study)		
Conditions: <ul style="list-style-type: none">• Programming experience• INF-0456 Content Creation for Virtual Environments (recommended)• INF-0179 Einführung in die Spieleprogrammierung (optional)• INF-0183 Praktikum Spieleprogrammierung (optional)		Credit Requirements: Passing the module exam
Frequency: irregular	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Practical Module Embodied Characters and Interactive Virtual Worlds Mode of Instruction: internship Language: German / English Frequency: each winter semester Contact Hours: 6,00		
Contents: The specific task from the field of "Embodied Characters and Interactive Virtual Worlds" is designed anew each semester.		
Literature: Ändert sich jedes Jahr und wird daher in der Veranstaltung bekannt gegeben		

Examination

Practical Module Embodied Characters and Interactive Virtual Worlds

practical exam, graded

Test Frequency:

when a course is offered

Module INF-0465: Machine Learning for Healthcare <i>Machine Learning for Healthcare</i>		8 ECTS/LP
Version 1.0.0 (since WS23/24) Person responsible for module: Prof. Dr. Elisabeth André		
Learning Outcomes / Competences: After successful participation in this course, students will have a grasp of the fundamentals of machine learning for healthcare. This course aims to give students a comprehensive insight into the application of machine learning for healthcare, encompassing numerous health data modalities (such as EHR, imaging, speech, mobile, and wearables) to enhance clinical workflows as machine learning methodologies and tools. We will be delving into a broad range of topics, including statistical machine learning, deep learning, transfer learning, fairness, interpretability, privacy-preserving ML, ethics, graphical models, and time series analysis.		
Key Qualifications: Mathematical-formal basics; competence in networking different subject areas; knowledge of practice-relevant tasks; skill in analyzing and structuring computer science problems; skill in developing and implementing solution strategies; quantitative aspects of computer science; skill in logical, analytical and conceptual thinking; methods for developing larger software systems, construction of abstractions and architectures; skill in working in teams; skill in presenting and documenting results in an understandable way.		
Workload: Total: 240 h 15 h studying of course content using provided materials (self-study) 15 h studying of course content using literature (self-study) 120 h studying of course content through exercises / case studies (self-study) 30 h lecture (attendance) 60 h exercise course (attendance)		
Conditions: Programming experience		Credit Requirements: Passing the module exam
Frequency: irregular	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Machine Learning for Healthcare (Lecture) Mode of Instruction: lecture Language: English Frequency: irregular Contact Hours: 2,00		
Part of the Module: Machine Learning for Healthcare (Exercise) Mode of Instruction: exercise course Language: English Frequency: each winter semester Contact Hours: 4,00		
Examination Machine Learning for Healthcare portfolio exam, graded Test Frequency: when a course is offered		

Module INF-0466: Biophotonics <i>Biophotonics</i>		5 ECTS/LP
Version 1.3.0 (since WS23/24) Person responsible for module: Prof. Dr. Sebastian Zaunseder		
Learning Outcomes / Competences: Subject-related competences: <p>After successful participation, students have knowledge and competences with regard to biophotonic methods for diagnostic applications. Students have basic knowledge from the field of photonics and know basic principles of light-tissue interaction. They are familiar with the functional principles of selected biophotonic methods for diagnostics, are able to work with them or with data from them and to interpret results. Student can also contribute to the (further) development of corresponding methods.</p> Methodological competencies: <p>Students are able to deal independently with the functionality and possible applications of biophotonic processes, to prepare biophotonic measurement data using common script languages such as Matlab or Python, and to document and interpret the application of methods for data preparation appropriately. Students also have basic competencies in the area of modeling/simulation of biophotonic processes.</p> Interdisciplinary Competencies: <p>The students are able to apply the acquired knowledge in any area of study that deals with diagnostically relevant data. In addition, the module teaches essential problem-solving skills, whereby an abstract way of thinking as well as a structured approach to problem solving are learned.</p> Key skills: <p>Ability to think logically, analytically and conceptually; ability to present and document results in a comprehensible manner; ability to communicate orally and in writing in a way that is appropriate to the situation and specific to the target group; ability to work together in teams; ability to solve problems under practical boundary conditions; ability to expand existing knowledge independently; quality awareness.</p>		
Workload: Total: 150 h 30 h exercise course (attendance) 30 h lecture (attendance) 60 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using provided materials (self-study)		
Conditions: basic math skills; basic programming skills		Credit Requirements: Passing the module exam
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module Part of the Module: Biophotonics (Lecture) Mode of Instruction: lecture Language: English / German Frequency: irregular Contact Hours: 2,00		

Contents:

The lecture deals with the fundamentals, implementation and application of biophotonic methods. The following contents are covered:

- Fundamentals of photonics
- Basics of light-tissue interaction
- Selected biophotonic methods in medical diagnostics (e.g. optical coherence tomography, laser speckle imaging, pulse oximetry)
- Introduction to possibilities for modeling and simulation in the context of biophotonics

Literature:

- Bigio, I. J., & Fantini, S. (2016). Quantitative Biomedical Optics. Cambridge University Press. <https://doi.org/10.1017/CBO9781139029797>
- Keiser, G. (2016). Biophotonics. Springer Singapore. <https://doi.org/10.1007/978-981-10-0945-7>
- Boudoux, C (2017). Fundamentals of Biomedical Optics From light interactions with cells to complex imaging systems. Blurb

Assigned Courses:

Biophotonics (lecture)

**(in attendance) **

Part of the Module: Biophotonics (Exercise)

Mode of Instruction: exercise course

Language: English / German

Frequency: irregular

Contact Hours: 2,00

Contents:

The exercise teaches practical skills in the context of biophotonic methods. The focus is on computational aspects of biophotonic methods and solving concrete problems related to diagnostically applicable biophotonic methods.

The following contents are covered:

- Familiarization with and preparation of biophotonic measurement methods and their application
- Handling of biophotonic measurement data
- Modeling and simulation in the context of biophotonic methods

Assigned Courses:

Exercise to Biophotonics (exercise course)

**(in attendance) **

Examination

Biophotonics

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-0472: Management of Communication Networks <i>Management von Kommunikationsnetzen</i>	5 ECTS/LP
Version 1.1.0 (since WS23/24) Person responsible for module: Prof. Dr. Michael Seufert	
<p>Learning Outcomes / Competences:</p> <p>Die Vorlesung vermittelt den Studierenden Kenntnisse und Fähigkeiten im Bereich des Managements von Kommunikationsnetzen. Das Modul behandelt die verschiedenen Aspekte des effizienten und sicheren Betriebs von Kommunikationsnetzen und bereitet die Studierenden darauf vor, komplexe Netzinfrastrukturen erfolgreich zu planen, zu implementieren und zu verwalten.</p> <p>Die Studierenden erwerben ein fundiertes Wissen über die Grundlagen des Netzmanagements, einschließlich der verschiedenen Managementebenen, -protokolle und -werkzeuge. Sie verstehen die Bedeutung des Netzmanagements für die effektive Nutzung von Kommunikationsnetzen.</p> <p>Das Modul vermittelt den Studierenden umfassende Kenntnisse und Fähigkeiten, um Netzelemente effektiv zu verwalten, Management-Systeme einzusetzen, Geräte zu konfigurieren und Fehlerbehebung durchzuführen. Des Weiteren werden Themen wie Messungen in Kommunikationsnetzen, aktives und passives Netzmonitoring, Quality of Service (QoS)/Quality of Experience (QoE), Automatisierung des Netzmanagements, Virtualisierung und Softwarisierung von Kommunikationsnetzen, Netzsicherheit und Netzneutralität behandelt.</p> <p>Die Studierenden erlangen ein tieferes Verständnis für die Zusammenhänge zwischen theoretischen Konzepten des Netzmanagements und deren praktischer Anwendung. Sie können komplexe Managementherausforderungen analysieren und Lösungsansätze entwickeln. Sie können Leistungsdaten von Kommunikationsnetzen interpretieren, potenzielle Engpässe erkennen und Diagnoseverfahren anwenden, um Netzprobleme zu analysieren und zu beheben.</p> <p>Die Studierenden können die Wirksamkeit von Netzmanagementlösungen bewerten und deren Auswirkungen auf die Leistung und Sicherheit von Kommunikationsnetzen analysieren. Sie können verschiedene Ansätze und Technologien vergleichen und bewerten, um fundierte Entscheidungen zu treffen und Empfehlungen für Verbesserungen abzugeben.</p> <p>Die Studierenden werden befähigt, neue Ansätze und Konzepte im Bereich des Netzmanagements zu entwickeln. Sie können innovative Lösungen entwerfen, die über die herkömmlichen Methoden hinausgehen und den aktuellen Herausforderungen des Netzmanagements gerecht werden. Sie sind in der Lage, neue Managementstrategien und -techniken zu erforschen und diese in der Praxis umzusetzen.</p> <p>Die Studierenden sind in der Lage, die Auswirkungen des Netzmanagements auf organisatorische Ziele und Geschäftsprozesse zu bewerten. Sie können den Mehrwert von effektivem Netzmanagement für Unternehmen und Gesellschaft quantifizieren und geeignete Bewertungsmethoden anwenden, um die Kosten, Risiken und Nutzen des Netzmanagements zu analysieren.</p> <p>Die Übung zum Management von Kommunikationsnetzen ergänzt die Vorlesung und bietet den Studierenden die Möglichkeit, ihr erlerntes Wissen in praktischen Szenarien in realen oder simulierten Umgebungen anzuwenden. Die Übung umfasst praktische Übungen, Fallstudien und Projekte, die es den Studierenden ermöglichen, ihre Fähigkeiten im Bereich des Netzmanagements weiterzuentwickeln und ihre Problemlösungskompetenzen zu stärken.</p> <p>Schlüsselqualifikationen: Fachspezifische Vertiefung; Kenntnisse der Denkweise und Sprache anwendungsrelevanter Disziplinen; Kenntnisse des Einsatzgebiets sowie der Vor-/Nachteile von alternativen Technologien und Bewertung im jeweiligen Anwendungszusammenhang; Kompetenz zum Erkennen von bedeutenden technischen Entwicklungen; Auswahl und sichere Anwendung geeigneter Konzepte und Methoden; Umsetzen fachlicher Lösungskonzepte; Fertigkeit zur Lösung von Problemen unter praxisnahen Randbedingungen; Fähigkeit zur verständlichen Darstellung und Dokumentation von Ergebnissen; Fertigkeit der Zusammenarbeit in Teams</p>	
<p>Workload:</p> <p>Total: 150 h</p> <p>30 h lecture (attendance)</p> <p>30 h exercise course (attendance)</p> <p>15 h studying of course content using literature (self-study)</p>	

60 h studying of course content through exercises / case studies (self-study) 15 h studying of course content using provided materials (self-study)		
Conditions: Kommunikationssysteme (empfohlen)		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester ab dem SoSe 2024	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module**Part of the Module: Management von Kommunikationsnetzen (Vorlesung)****Mode of Instruction:** lecture**Language:** English / German**Frequency:** irregular**Contact Hours:** 2,00**Contents:**

- Definitionen und Modelle für Netzmanagement
- Netzelemente und Managementsysteme
- Konfiguration von Netzelementen und Troubleshooting
- Aktive und passive Netzmessungen
- Quality of Service (QoS)
- Datenmodelle für und Automatisierung von Netzmanagement
- Virtualisierung und Softwarisierung von Kommunikationsnetzen
- Netzsicherheit
- Quality of Experience (QoE)
- Netzneutralität

Literature:

- Clemm A.: Network Management Fundamentals, Cisco Press, 2006
- Claise B., Wolter R.: Network Management: Accounting and Performance Strategies, Cisco Press, 2007
- Edelman J, Lowe S. S., Oswalt M.: Network Programmability and Automation, O'Reilly, 2018
- Capobianco J. W.: Automate Your Network, 2019
- Garrett J.: Data Analytics for IT Networks, Cisco Press, 2019
- Claise B., Clarke J., Lindblad J.: Network Programmability with YANG, Addison-Wesley, 2019
- Chou E.: Mastering Python Networking, Packt, 2020
- Kurose J.W., Ross K.W.: Computer Networking - A Top-Down Approach, 7th edition, Pearson, 2016
- Göransson P., Black C., Culver T.: Software Defined Networks: A Comprehensive Approach, 2nd edition, Morgan Kaufmann, 2017

Part of the Module: Management von Kommunikationsnetzen (Übung)**Mode of Instruction:** exercise course**Language:** English / German**Frequency:** irregular**Contact Hours:** 2,00**Examination****Management von Kommunikationsnetzen**

portfolio exam / length of examination: 30 minutes, graded

Test Frequency:

when a course is offered

Module INF-0476: Computer Vision for Intelligent Systems <i>Computer Vision für Intelligente Systeme</i>		5 ECTS/LP
Version 1.1.0 (since WS23/24) Person responsible for module: Prof. Dr. Jörg-Dieter Stückler		
Learning Outcomes / Competences: Students will understand the following methodological foundations of computer vision for intelligent systems at an in-depth scientific level and will be able to implement appropriate algorithms for advanced problems: Image formation, two-view geometry, deep learning basics for images and point clouds, image motion estimation and optical flow, keypoints and point correspondences, factor graphs and probabilistic state estimation, visual odometry and visual simultaneous localization and mapping, 3D object detection, 3D mapping. Participants understand the advantages and disadvantages of different methods and can analyze and select them for applications and apply them to new problems. Students have developed skills for analyzing and structuring machine vision problems for intelligent systems and know concepts and approaches for implementing algorithms for these problems. In addition, they have the competence to recognize significant technical developments. Key qualifications: Ability to think logically, analytically and conceptually; selection and confident application of appropriate methods; independent work with textbooks; implementation of technical solution concepts in programs and models; knowledge of the advantages/disadvantages of design alternatives, evaluation in the respective application context; ability to make scientifically meaningful assessments using appropriate methods. Comprehensible presentation of results; ability to work in teams.		
Workload: Total: 150 h 15 h studying of course content using provided materials (self-study) 15 h studying of course content using literature (self-study) 60 h studying of course content through exercises / case studies (self-study) 30 h lecture (attendance) 30 h exercise course (attendance)		
Conditions: <ul style="list-style-type: none"> Basic programming knowledge in Python Advantageous: Basic knowledge in Deep Learning 		Credit Requirements: Passing the module exam
Frequency: irregular (usu. winter semester)	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Computer Vision for Intelligent Systems (Lecture) Mode of Instruction: lecture Language: English / German Contact Hours: 2,00		

Contents:

This lecture teaches basic methods and algorithms for computer vision for intelligent systems. The lecture covers the following topics:

- Image formation, geometric primitives and transformations.
- Two-view geometry
- Basics of deep learning for images and point clouds
- Motion estimation in images and optical flow
- Keypoints, descriptors and point correspondences
- Camera motion estimation from images
- Factor graphs and probabilistic state estimation
- Visual simultaneous localization and mapping
- 3D object detection
- 3D mapping

Literature:

Lecture slides will be provided. Additional literature will be provided in lecture and exercises.

Recommended textbooks:

- Yi Ma, Stefano Soatto, Jana Kos Košecká, S. Shankar Sastry. An Invitation to 3-D Vision
- R. Szeliski. Computer vision: algorithms and applications
- K. Murphy. Machine Learning: A Probabilistic Perspective
- Goodfellow, Bengio and Courville. Deep Learning. <https://www.deeplearningbook.org>

Assigned Courses:

Computer Vision for Intelligent Systems (Computer Vision für Intelligente Systeme) (lecture)

**(in attendance) **

Part of the Module: Computer Vision for Intelligent Systems (Exercises)

Mode of Instruction: exercise course

Language: English / German

Contact Hours: 2,00

Assigned Courses:

Exercises for Computer Vision for Intelligent Systems (Übungen zu Computer Vision für Intelligente Systeme)

(exercise course)

**(in attendance) **

Examination

Computer Vision for Intelligent Systems

written exam / length of examination: 90 minutes, graded

Test Frequency:

when a course is offered

Module INF-0499: Foundation Models in Deep Learning <i>Foundation Models in Deep Learning</i>		5 ECTS/LP
Version 1.0.0 (since SoSe24) Person responsible for module: Prof. Dr. Rainer Lienhart		
Learning Outcomes / Competences: After successful participation in this module, participants understand basics and in-depth issues and algorithms of robotics (e.g. recursive state estimation, Gaussian and non-parametric filters, Kalman filters, motion and localisation, perception, mapping, SLAM) from a probabilistic point of view and can apply learned concepts to complex, practice-relevant tasks. Students can analyse and evaluate problems in this context. Participation in this module promotes skills in logical, analytical and conceptual thinking in the field of probabilistic robotics. Students can select suitable methods from the concepts learned in a targeted manner, apply them confidently and transfer them to new problems, including those from other disciplines. The module imparts competencies for recognising current research and significant technological developments in this field.		
Key qualifications: advanced mathematical-formal logic; implementation of subject-specific solution concepts; interdisciplinary knowledge; development and implementation of solution strategies for complex problems; systematic further development of design methods; ability to solve problems under practical boundary conditions.		
Workload: Total: 150 h 30 h exercise course (attendance) 30 h lecture (attendance) 15 h studying of course content using provided materials (self-study) 60 h studying of course content through exercises / case studies (self-study) 15 h studying of course content using literature (self-study)		
Conditions: Kenntnisse in maschinellem Lernen und maschinellem Sehen (MasterVorlesung INF-0092 "Multimedia II" bzw. INF-0316 "Machine Learning and Computer Vision"). Knowledge in machine learning and machine vision (Master lecture INF-0092 "Multimedia II" or INF-0316 "Machine Learning and Computer Vision")		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Probabilistic Robotics (Lecture) Mode of Instruction: lecture Language: German Frequency: each summer semester Contact Hours: 2,00		

Contents:

1. Introduction to Probabilistic Robotics
2. Recursive State Estimation
3. Gaussian Filters
4. Nonparametric Filters
5. Robot Motion
6. Robot Perception
7. Mobile Robot Localization: Markow and Gaussian
8. Mobile Robot Localization: Grid and MonteCarlo
9. Occupancy Grid Mapping
10. SLAM

Literature:

References will be announced at the beginning of the semester.

Part of the Module: Probabilistic Robotics (Tutorial)

Mode of Instruction: exercise course

Language: German

Frequency: each summer semester

Contact Hours: 2,00

Examination**Probabilistic Robotics (Examination)**

oral exam / length of examination: 30 minutes, graded

Test Frequency:

each semester

Description:

The examination can be taken every semester during the examination period.

Module INF-0504: Medical Monitoring and Advanced Sensor Data Processing <i>Medical Monitoring and Advanced Sensor Data Processing</i>		8 ECTS/LP
Version 1.3.0 (since SoSe24) Person responsible for module: Prof. Dr. Sebastian Zaunseder		
Learning Outcomes / Competences: Subject-related competences: After successful participation, students have knowledge and competences with regard to the field of medical monitoring. Students have basic knowledge on the background of medical monitoring and common technical solutions for clinical and out-of-hospital use. They are familiar with the functional principles of various methods relevant to medical monitoring and their interpretation. Students can also contribute to the (further) development of monitoring applications. Methodological competencies: Students are able to deal independently with solutions to medical monitoring. In particular, they are able to process medical data using common script languages such as Python, to document their solutions and to interpret processing results appropriately. In addition, Students have basic competencies in the handling of monitoring data and devices for monitoring. Interdisciplinary Competencies: The students are able to apply the acquired knowledge in any area of study that deals with (medical) data. In addition, the module teaches essential problem-solving skills, whereby an abstract way of thinking as well as a structured approach to problem solving are learned. Key skills: Ability to think logically, analytically and conceptually; ability to present and document results in a comprehensible manner; ability to communicate orally and in writing in a way that is appropriate to the situation and specific to the target group; ability to work together in teams; ability to solve problems under practical boundary conditions; ability to expand existing knowledge independently; quality awareness.		
Workload: Total: 150 h 60 h studying of course content using provided materials (self-study) 60 h exercise course (attendance) 90 h studying of course content through exercises / case studies (self-study) 30 h lecture (attendance)		
Conditions: basic math skills; basic programming skills; basic knowledge on handling digital signals		Credit Requirements: Passing the module exam
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Medical monitoring and advanced sensor data processing (Lecture) Mode of Instruction: lecture Language: English / German Frequency: irregular Contact Hours: 2,00		

Contents:

The lecture deals with the fundamentals, implementations and applications of medical monitoring. The following topics, all of them elaborate with respect and in close connection to medical monitoring, are covered:

- Fundamentals of medical monitoring (basic ideas, history, current solutions, trends)
- Fundamentals of sensor data fusion
- Preprocessing approaches (e.g. denoising by conventional filters, Kalman filters and autoencoders)
- Dimension reduction and source separation (e.g. principal component analysis and independent component analysis)
- Feature extraction by functional transforms (e.g. time-frequency transforms)
- Basic detection/classification approaches

Literature:

- S. Bernhard, A. Brensing, and K.-H. Witte, *Biosignalverarbeitung*. De Gruyter, 2019. doi: 10.1515/9783110442434.

Part of the Module: Medical Monitoring and Advanced Sensor Data Processing (Exercise)

Mode of Instruction: exercise course

Language: English / German

Frequency: irregular

Contact Hours: 4,00

Contents:

The exercise teaches practical skills with relevance to the field of medical monitoring. The focus is handling and processing data from/for monitoring applications. The following contents are covered:

- Familiarization with techniques of data acquisition and handling data
- Denoising of data of variable origin
- Application of feature extraction and dimension reduction techniques
- Prediction/detection of (patho)physiological states
- Techniques for visualization and interpretation of sensor data

Examination**Medical Monitoring and Advanced Sensor Data Processing**

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-0506: Search Engines and Neural Information Retrieval <i>Search Engines and Neural Information Retrieval</i>		8 ECTS/LP
Version 1.3.0 (since SoSe24) Person responsible for module: Prof. Dr. Annemarie Friedrich		
<p>Learning Outcomes / Competences:</p> <p>Neural Information Retrieval leverages the power of neural networks to enhance the representation, understanding, and retrieval of information, addressing many of the challenges posed by the complexity and variability of natural language. With the recent development in the area of large language models (or more generally, foundation models), novel approaches to interactive information retrieval are developing.</p> <p>After taking part in the course, students are able to explain the concepts and methods, procedures, techniques and technologies related to neural information retrieval. In particular, the course covers:</p> <ul style="list-style-type: none"> • Basics of traditional information retrieval methods • Vector-based document and query representations (topic modeling and neural representations) • Ranking with embeddings • Question answering, entity search, and knowledge graphs • Multimodal retrieval • Interactive information retrieval and personalization <p>Students will be able to recognise important technical developments in the field of information retrieval. They can apply machine learning procedures, such as feature extraction, embedding learning, and pattern recognition, to information retrieval problems. They will be able to perform literature research in the area of information retrieval, and identify gaps in the state-of-the-art. They know how to make scientifically meaningful evaluations of proposed systems. They will further learn how to document and present results and complex ideas in a reasonable and meaningful way. Participants will also deepen their programming skills in Python.</p> <p>Key skills: Formal methods; Knowledge of advantages and disadvantages of different design alternatives; Ability to work in teams; Knowledge of workflows and processes; Ability to find solutions for practical problems; Ability to work autonomously; Quality awareness; Scientific working; Literature research.</p>		
<p>Workload:</p> <p>Total: 240 h</p> <p>30 h exercise course (attendance)</p> <p>60 h lecture (attendance)</p> <p>120 h studying of course content through exercises / case studies (self-study)</p> <p>15 h studying of course content using literature (self-study)</p> <p>15 h studying of course content using provided materials (self-study)</p>		
<p>Conditions:</p> <p>Recommended: linear algebra, basic probability theory, Python programming.</p>		<p>Credit Requirements:</p> <p>Passing the module exam</p>
<p>Frequency: each winter semester</p>	<p>Recommended Semester:</p> <p>from 1.</p>	<p>Minimal Duration of the Module:</p> <p>1 semester[s]</p>
<p>Contact Hours:</p> <p>6,00</p>	<p>Repeat Exams Permitted:</p> <p>according to the examination regulations of the study program</p>	
<p>Parts of the Module</p>		
<p>Part of the Module: Search Engines and Neural Information Retrieval (Lecture)</p> <p>Language: English / German</p> <p>Frequency: each winter semester</p> <p>Contact Hours: 4,00</p>		

Contents:

This first part of this interactive course will cover the basics of traditional search engine technology, topic modeling, query expansion, collaborative filtering, neural networks, word and document embeddings, transformers, text classification, ranking and learning to rank, question answering, and evaluation designs. The second part of the course will dive into the recent literature on neural information retrieval including (for example) multi-modal search, interactive retrieval systems, entity search, personalization, and retrieval-augmented generative artificial intelligence. We will also discuss aspects related to responsible information retrieval such as bias and transparency.

The course design is complementary to INF-0277 Analyzing Massive Datasets, which focuses on compute frameworks and algorithms for processing big data.

Literature:

- Bhaskar Mitra; Nick Craswell, An Introduction to Neural Information Retrieval, 2018. doi: 10.1561/15000000061.
- Tonellotto, Nicola. "Lecture Notes on Neural Information Retrieval." *ArXiv* abs/2207.13443 (2022): <https://arxiv.org/abs/2207.13443>
- Dan Jurafsky and James H. Martin. Speech and Language Processing. 3rd edition draft available here: <https://web.stanford.edu/~jurafsky/slp3/>
- Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, *Introduction to Information Retrieval*, Cambridge University Press. 2008. <https://nlp.stanford.edu/IR-book/information-retrieval-book.html>

Assigned Courses:

Search Engines and Neural Information Retrieval (lecture)

*(in attendance) *

Part of the Module: Search Engines and Neural Information Retrieval (Exercise)

Language: English / German

Frequency: each winter semester

Contact Hours: 2,00

Examination

Search Engines and Neural Information Retrieval

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-0508: Probabilistic Machine Learning <i>Probabilistic Machine Learning</i>		8 ECTS/LP
Version 1.0.0 (since SoSe24) Person responsible for module: Prof. Dr. Jörg-Dieter Stücker		
Learning Outcomes / Competences: Students will understand the following methodological foundations of probabilistic machine learning at an in-depth scientific level and will be able to implement appropriate algorithms for advanced problems: Univariate and multivariate distributions, probabilistic graphical models, maximum likelihood and a-posteriori estimation, Bayesian inference and learning, information theory, expectation maximization, linear and logistic regression, probabilistic deep neural networks, Gaussian and Neural processes, probabilistic dimensionality reduction, deep generative models, and probabilistic state-space models. Participants understand the advantages and disadvantages of different methods and can analyze and select them for applications and apply them to new problems. Students have developed skills for analyzing and structuring probabilistic machine learning problems and know concepts and approaches for implementing algorithms for these problems. In addition, they have the competence to recognize significant scientific and technical developments. Key qualifications: Ability to think logically, analytically and conceptually; selection and confident application of appropriate methods; independent work with textbooks; implementation of technical solution concepts in programs and models; knowledge of the advantages/disadvantages of design alternatives, evaluation in the respective application context; ability to make scientifically meaningful assessments using appropriate methods. Comprehensible presentation of results; ability to work in teams.		
Workload: Total: 240 h 30 h exercise course (attendance) 60 h lecture (attendance) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using provided materials (self-study) 30 h studying of course content using literature (self-study)		
Conditions: <ul style="list-style-type: none"> • Basic programming knowledge in Python • Basic knowledge of probability theory • Recommended: Basic knowledge in deep learning 		Credit Requirements: Passing the module exam
Frequency: irregular (usu. summer semester)	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Probabilistic Machine Learning (Lecture) Mode of Instruction: lecture Language: English Frequency: irregular (usu. summer semester) Contact Hours: 4,00		

Contents:

This lecture teaches basic methods and algorithms for probabilistic machine learning. The lecture includes the following topics:

1. Univariate and multivariate distributions
2. Probabilistic graphical models
3. Maximum likelihood and a-posteriori estimation
4. Bayesian statistics and posterior predictive distribution
5. Bias-Variance tradeoff
6. Information theory
7. Linear and logistic regression
8. Variational inference
9. Expectation maximization and Gaussian mixture models
10. Probabilistic deep neural networks (deep ensembles, variational Bayesian neural networks, Laplace approximation)
11. Probabilistic dimensionality reduction (principal component analysis, variational autoencoders)
12. Deep generative models (probabilistic diffusion models)
13. Gaussian and Neural processes
14. Probabilistic state-space models

Literature:

Lecture slides will be provided. Additional references to literature will be provided in lecture and exercises.

Recommended textbooks:

- C. Bishop. Pattern Recognition and Machine Learning. Springer, 2006
- K. Murphy. Machine Learning: A Probabilistic Perspective. MIT Press, 2012
- K. Murphy. Probabilistic Machine Learning: An Introduction. MIT Press, 2022
- K. Murphy. Probabilistic Machine Learning: Advanced Topics. MIT Press, 2023
- C. Bishop. Deep Learning - Foundations and Concepts. Springer, 2023

Part of the Module: Probabilistic Machine Learning (Exercises)

Mode of Instruction: exercise course

Language: English

Frequency: irregular (usu. summer semester)

Contact Hours: 2,00

Examination**Probabilistic Machine Learning**

written exam / length of examination: 120 minutes, graded

Test Frequency:

when a course is offered

Module INF-0510: Human-Centered Artificial Intelligence for Health Care Lab <i>Human-Centered Artificial Intelligence for Health Care Lab</i>		8 ECTS/LP
Version 1.0.0 (since SoSe24) Person responsible for module: Prof. Dr. Elisabeth André		
Learning Outcomes / Competences: After successful participation in this module, students are familiar with basic concepts of artificial intelligence for the development of health-related applications. They are able to translate technical solution concepts into models and master the selection and safe application of suitable methods. In addition, they will gain an insight into current work in the research field. Furthermore, competencies in the areas of teamwork and communication skills as well as self-organization are taught through the processing of project tasks and their independent project planning. In the context of these project tasks, knowledge of the mindset and language of the research field is fostered through the discussion and presentation of project results. Key qualifications: Conversion of technical solution concepts into programs and models; subject-specific consolidation; interdisciplinary knowledge; ability to make scientifically meaningful evaluations using suitable methods; knowledge of the mindset and language of application-relevant disciplines; ability to work in teams; knowledge of practice-relevant tasks; familiarity with procedures and processes in the application environment of computer science; ability to present and document results in a comprehensible manner; ability to expand existing knowledge independently; competence in recognizing significant technical developments.		
Remarks: Kann nicht belegt werden, wenn "INF-0334: Praktikum Human-Centered Artificial Intelligence for Health Care Applications" bereits belegt wurde.		
Workload: Total: 240 h 60 h exercise course (attendance) 30 h lecture (attendance) 120 h studying of course content through exercises / case studies (self-study) 15 h studying of course content using literature (self-study) 15 h studying of course content using provided materials (self-study)		
Conditions: Programming experience		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 5.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Human-Centered Artificial Intelligence for Health Care Lab (Lecture) Mode of Instruction: lecture Language: German / English Frequency: each summer semester Contact Hours: 2,00
Contents: TODO
Literature: TODO

Part of the Module: Human-Centered Artificial Intelligence for Health Care Lab (Exercise Course)

Mode of Instruction: exercise course

Language: German / English

Frequency: each summer semester

Contact Hours: 4,00

Examination

Human-Centered Artificial Intelligence for Health Care Lab

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-0512: Brain and Movement Lab <i>Brain and Movement Lab</i>		8 ECTS/LP
Version 1.0.0 (since SoSe24) Person responsible for module: Prof. Dr. Muthuraman Muthuraman		
Learning Outcomes / Competences: Students acquire competencies in the following areas at an advanced, practical but scientific level: design process for digital circuits, circuit logic and gates, physical principles of electronic components, description of hardware with a hardware description language. First, students learn how to link logic gates and build a half-adder and a full-adder. They understand the digital circuit design process and apply it directly in a practical way by designing their own RISC-V processor. They model and implement it independently using the hardware description language VHDL. They learn the advantages and disadvantages of schematic and textual hardware description and can decide when it makes sense to use which variant. Furthermore, they combine synchronous and asynchronous processes to achieve a good interaction of the components of their self-built microprocessor. Finally, students evaluate the efficiency of their implementation based on the clock frequency achieved and the hardware effort required. In a final project phase, they learn to plan a complex task, to solve it according to a self-developed sound project plan and to discuss and present the results appropriately in a plenary session. Key qualifications: Skill in presenting and documenting ideas, concepts and results in a comprehensible manner; quality awareness, meticulousness; project-bound work and time management; selection and confident use of appropriate methods; ability to expand existing knowledge independently; self-reflection.		
Workload: Total: 240 h 30 h lecture (attendance) 60 h exercise course (attendance) 15 h studying of course content using literature (self-study) 15 h studying of course content using provided materials (self-study) 120 h studying of course content through exercises / case studies (self-study)		
Conditions: none		Credit Requirements: Passing the module exam
Frequency: each summer semester	Recommended Semester: 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Brain and Movement Lab (Lecture) Mode of Instruction: lecture Language: English Frequency: each summer semester Contact Hours: 2,00
Contents: The course "Hardware Design" presents methods of logical design of digital circuits, starting with the abstract description in a hardware description language (like VHDL) up to the physical implementation on transistor level. In the practical part of the course, hardware design is illustrated using the example of a five-stage processor pipeline. The result is an executable processor developed in VHDL for an FPGA prototype board.

Literature:

- Uwe Brinkschulte, Theo Ungerer, Mikrocontroller und Mikroprozessoren, Springer Verlag, Heidelberg, dritte Auflage 2010
- John L. Hennessy, David A. Patterson, Computer Architecture: A Quantitative Approach, Morgan Kaufmann, 5. Auflage, 2011

Part of the Module: Brain and Movement Lab (Exercise)**Mode of Instruction:** exercise course**Language:** English**Frequency:** each summer semester**Contact Hours:** 4,00**Contents:**

The exercise imparts practical skills in the context of electrophysiological and movement analysis methods. The focus is on the acquisition and analysis of dynamical signals for solving specific problems related to the diagnostics and quantification of brain activity and movement. The following contents are covered:

- Familiarization with and processing of electrophysiological data (EEG, EMG) and its application
- Familiarization with and processing of kinematic data (walking, spiral drawing) and its application
- Handling of measurement data
- Application of basic and advanced analysis techniques (e.g. Spectral analysis, Time-frequency analysis, Source reconstruction, Cross-frequency-coupling, Entropy)

Examination**Brain and Movement Lab**

portfolio exam, graded

Test Frequency:

when a course is offered

Description:

Successful participation in the internship, project presentation at the end of the semester

Module INF-3013: Generative Artificial Intelligence for Human-Computer Interaction Lab <i>Generative Artificial Intelligence for Human-Computer Interaction Lab</i>		8 ECTS/LP
Version 1.0.0 (since WS24/25) Person responsible for module: Prof. Dr. Elisabeth André		
Learning Outcomes / Competences: Students will be familiar with methods and techniques of Generative AI for developing interactive systems. After successful participation, they will have the necessary knowledge to develop and evaluate generative models that can be used in various HCI application scenarios. They will be able to translate current artificial intelligence and machine learning methods into models and programs for novel interactive applications and independently work with the necessary technologies. Furthermore, they can apply practical evaluation methods to assess the quality of the created generative models. They will be capable of planning larger project tasks in small teams, solving them according to a self-developed project plan, and appropriately discussing and presenting the results as a team in the plenary. Key qualifications: Conversion of technical solution concepts into programs and models; subject-specific consolidation; interdisciplinary knowledge; ability to make scientifically meaningful evaluations using suitable methods; knowledge of the mindset and language of application-relevant disciplines; ability to work in teams; knowledge of practice-relevant tasks; familiarity with procedures and processes in the application environment of computer science; ability to present and document results in a comprehensible manner; ability to expand existing knowledge independently; competence in recognizing significant technical developments.		
Workload: Total: 240 h 15 h studying of course content using literature (self-study) 15 h studying of course content using provided materials (self-study) 60 h exercise course (attendance) 30 h lecture (attendance) 120 h studying of course content through exercises / case studies (self-study)		
Conditions: Programming experience		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Generative AI for Human-Computer Interaction Lab (Lecture) Mode of Instruction: lecture Language: English / German Frequency: each winter semester Contact Hours: 2,00
Contents: The specific tasks for student projects are redesigned each year.
Literature: Literature references will be announced at the beginning of the semester depending on the topic.

Part of the Module: Generative AI for Human-Computer Interaction Lab (Exercise Course)

Mode of Instruction: exercise course

Language: English / German

Frequency: each winter semester

Contact Hours: 4,00

Examination

Generative Artificial Intelligence for Human-Computer Interaction Lab

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-3015: Interactive Machine Learning Lab <i>Interactive Machine Learning Lab</i>		8 ECTS/LP
Version 1.0.0 (since WS24/25) Person responsible for module: Prof. Dr. Elisabeth André		
Learning Outcomes / Competences: After successful participation in this module, students are familiar with basic concepts of interactive machine learning. They are able to translate domain-specific solution concepts into models and master the selection and safe application of suitable methods. In addition, they will gain an insight into current work in the research area. Furthermore, competencies in the areas of teamwork and communication skills as well as self-organization are taught through the processing of project tasks and their independent project planning. In the context of these project tasks, knowledge of the mindset and language of the research field is fostered through the discussion and presentation of project results. Key qualifications: Conversion of technical solution concepts into programs and models; subject-specific consolidation; interdisciplinary knowledge; ability to make scientifically meaningful evaluations using suitable methods; knowledge of the mindset and language of application-relevant disciplines; ability to work in teams; knowledge of practice-relevant tasks; familiarity with procedures and processes in the application environment of computer science; ability to present and document results in a comprehensible manner; ability to expand existing knowledge independently; competence in recognizing significant technical developments.		
Remarks: Cannot be taken if "INF-0296: Praktikum Interactive Machine Learning" has already been taken. Cannot be taken at the same time as "Interactive Machine Learning for Healthcare Lab".		
Workload: Total: 240 h 120 h studying of course content through exercises / case studies (self-study) 30 h lecture (attendance) 15 h studying of course content using provided materials (self-study) 15 h studying of course content using literature (self-study) 60 h exercise course (attendance)		
Conditions: Programming experience		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Interactive Machine Learning Lab (Lecture) Mode of Instruction: lecture Language: German / English Frequency: each winter semester Contact Hours: 2,00
Contents: The specific tasks for student projects are redesigned each year.
Literature: Literature references will be announced at the beginning of the semester depending on the topic.

Part of the Module: Interactive Machine Learning Lab (Exercise Course)

Mode of Instruction: exercise course

Language: German / English

Frequency: each winter semester

Contact Hours: 4,00

Examination

Interactive Machine Learning Lab

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-3017: Interactive Machine Learning for Healthcare Lab <i>Interactive Machine Learning for Healthcare Lab</i>		8 ECTS/LP
Version 1.0.0 (since WS24/25) Person responsible for module: Prof. Dr. Elisabeth André		
Learning Outcomes / Competences: In contrast to the "Interactive Machine Learning Lab" event, the focus is on applications in the healthcare sector. After successful participation in this module, students are familiar with basic concepts of interactive machine learning. They are able to translate domain-specific solution concepts into models and master the selection and safe application of suitable methods. In addition, they will gain an insight into current work in the research area. Furthermore, competencies in the areas of teamwork and communication skills as well as self-organization are taught through the processing of project tasks and their independent project planning. In the context of these project tasks, knowledge of the mindset and language of the research field is fostered through the discussion and presentation of project results. Key qualifications: Conversion of technical solution concepts into programs and models; subject-specific consolidation; interdisciplinary knowledge; ability to make scientifically meaningful evaluations using suitable methods; knowledge of the mindset and language of application-relevant disciplines; ability to work in teams; knowledge of practice-relevant tasks; familiarity with procedures and processes in the application environment of computer science; ability to present and document results in a comprehensible manner; ability to expand existing knowledge independently; competence in recognizing significant technical developments.		
Remarks: Cannot be taken if "INF-0296: Praktikum Interactive Machine Learning" has already been taken. Cannot be taken at the same time as "Interactive Machine Learning Lab".		
Workload: Total: 240 h 15 h studying of course content using provided materials (self-study) 15 h studying of course content using literature (self-study) 30 h lecture (attendance) 120 h studying of course content through exercises / case studies (self-study) 60 h exercise course (attendance)		
Conditions: Programming experience		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Interactive Machine Learning for Healthcare Lab (Lecture) Mode of Instruction: lecture Language: English / German Frequency: each winter semester Contact Hours: 2,00		
Contents: The specific tasks for student projects are redesigned each year.		
Literature: Literature references will be announced at the beginning of the semester depending on the topic.		

Assigned Courses:

Interactive Machine Learning for Healthcare Lab (lecture)

**(in attendance) **

Part of the Module: Interactive Machine Learning for Healthcare Lab (Exercise Course)

Mode of Instruction: exercise course

Language: English / German

Frequency: each winter semester

Contact Hours: 4,00

Assigned Courses:

Übung zu Interactive Machine Learning for Healthcare Lab (exercise course)

**(in attendance) **

Examination

Interactive Machine Learning for Healthcare Lab

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-3027: Algorithmic Game Theory <i>Algorithmic Game Theory</i>		8 ECTS/LP
Version 1.0.0 (since WS24/25) Person responsible for module: Prof. Dr. Pascal Lenzner		
Learning Outcomes / Competences: <p>The goal of the lecture is to use suitably chosen examples to give a broad overview over the field of Algorithmic Game Theory. For this, we will encounter classical results from Game Theory along with recent results from Algorithmic Game Theory.</p> <p>The students will learn how to model and analyse the interaction of strategic agents in various settings. They will be able to understand and explain different game-theoretic concepts as well as their application in different domains. They will also be able to compute equilibrium solutions for many game variants and they will be able to understand and apply several practical algorithms for solving allocation problems. For this we will formally analyze the efficiency and other properties of the employed algorithms. Moreover, the students will learn how to evaluate the impact of selfishness in optimization problems and how to prove quality guarantees for game-theoretic settings.</p> <p>Key skills: Advanced mathematical-formal methodology, subject-specific specializations, quantitative aspects of computer science, ability to analyze and structure complex computer science problems, ability to develop and implement solution strategies for complex problems, knowledge of the advantages/disadvantages of design alternatives, evaluation in the respective application context, Ability to think logically, analytically and conceptually, selection and reliable application of suitable methods, ability to work in teams, knowledge of practical tasks, ability to present and document results in a comprehensible manner, ability to expand existing knowledge independently, quality awareness, meticulousness</p>		
Workload: Total: 240 h 60 h lecture (attendance) 30 h exercise course (attendance) 30 h studying of course content using provided materials (self-study) 30 h studying of course content using literature (self-study) 90 h studying of course content through exercises / case studies (self-study)		
Conditions: No fixed prerequisites, but basic knowledge in the design and analysis of algorithms as well in complexity theory from the Bachelor studies will be assumed.		Credit Requirements: Passing the module exam
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module Part of the Module: Algorithmic Game Theory (Lecture) Mode of Instruction: lecture Language: German Frequency: each winter semester Contact Hours: 4,00		

Contents:

Algorithmic Game Theory is a young and thriving research area in the intersection of Mathematics, Algorithmics and Economics. Motivated by the rise of the Internet and its related new kinds of problems, Algorithmic Game Theory was established within the last two decades to tackle classical problems from Game Theory with an algorithmic perspective.

Among others we will discuss the following questions:

- How can we solve assignment problems (e.g. assigning talks/projects to students) such that all participants are happy with their assignment?
- Are there auctions in which all bidders want to bid honestly?
- How does the perfect voting system look like?
- Does every game have an equilibrium, that is, an outcome in which all players are happy?
- Is it easy to find an equilibrium for a specific game?
- How good/bad are equilibria reached via egoistic behavior compared to the best centrally enforced solution?

Answers to the above questions have been awarded with 7 "Nobel Prices" in Economics (most recently, the 2020 Economics Nobel Price!) and some of the most prestigious awards in Mathematics and Computer Science.

Literature:

- Nisan et al.: Algorithmic Game Theory, Cambridge University Press
- Shoham and Leyton-Brown: Multitagent Systems, Cambridge University Press
- Roughgarden: 20 Lectures on Algorithmic Game Theory, Cambridge University Press
- Easley and Kleinberg: Networks, Crowds and Markets, Cambridge University Press
- Brandt et al.: Handbook of Computational Social Choice, Cambridge University Press

Part of the Module: Algorithmic Game Theory (Exercise)

Mode of Instruction: exercise course

Language: German

Frequency: each winter semester

Contact Hours: 2,00

Examination**Algorithmic Game Theory**

oral exam / length of examination: 30 minutes, graded

Test Frequency:

when a course is offered

Module INF-3037: Graph Algorithms <i>Graph Algorithms</i>		8 ECTS/LP
Version 1.0.0 (since SoSe25) Person responsible for module: Prof. Dr. Pascal Lenzner		
Learning Outcomes / Competences: The goal of the lecture is to use suitably chosen examples to give a broad overview over the field of Graph Algorithms. The students will learn how to design and analyse graph algorithms for various settings . They will be able to understand and explain different graph-theoretic concepts as well as their application in different domains. They will also be able to understand and apply several practical algorithms for computing shortest paths, flows, matchings, cuts, and embeddings. For this we will formally analyze the efficiency and other properties of the employed algorithms. Moreover, the students will learn how to evaluate the impact of graph properties on complexity of graph problems. Key skills: Advanced mathematical-formal methodology, subject-specific specializations, quantitative aspects of computer science, ability to analyze and structure complex computer science problems, ability to develop and implement solution strategies for complex problems, knowledge of the advantages/disadvantages of design alternatives, evaluation in the respective application context, Ability to think logically, analytically and conceptually, selection and reliable application of suitable methods, ability to work in teams, knowledge of practical tasks, ability to present and document results in a comprehensible manner, ability to expand existing knowledge independently, quality awareness, meticulousness		
Workload: Total: 240 h 30 h studying of course content using provided materials (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using literature (self-study) 30 h exercise course (attendance) 60 h lecture (attendance)		
Conditions: No fixed prerequisites, but basic knowledge in the design and analysis of algorithms as well in complexity theory from the Bachelor studies will be assumed.		Credit Requirements: Passing the module exam
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module	
Part of the Module: Graph Algorithms (Lecture) Mode of Instruction: lecture Language: English / German Frequency: each winter semester Contact Hours: 4,00	

Contents:

Graphs play a central role in the world of algorithms. For example, navigation devices use an algorithm to compute shortest paths on a graph to answer a route query. Many planning and assignment problems can also be easily modeled as problems on graphs. In principle, it is true that a great many problems can be thought of as graph problems, so designing efficient algorithms for such problems is an important subfield of theoretical computer science.

In this lecture we will enter the world of graph algorithms. On the one hand, we will learn about important algorithmic problem classes on graphs and efficient algorithms to solve them. Among other things, we will look at finding shortest paths, flows, cuts, separators, and matchings in graphs. Algorithms for these problems have a wide variety of applications, making them an important and useful tool for any algorithmicist. On the other hand, we will also study how constraints on the graphs at hand affect the complexity of the problems and their algorithmic solution. For example, many algorithmic problems are more efficiently solvable on trees and planar graphs (i.e., graphs that can be embedded in the plane without intersection) than on general graphs. We will also explore some properties of graphs that we can exploit specifically for designing efficient algorithms. For example, trees and planar graphs have small separators (sets of nodes whose removal causes the graphs to decompose into multiple context components), which helps design efficient divide & conquer algorithms.

The goal of the lecture is the development and training of a structured approach to algorithmic problems on graphs. In doing so, we will jointly develop efficient graph algorithms with appropriate data structures, prove their correctness, and analyze their resource requirements (runtime and memory). In addition, the lecture will highlight special graph classes and other important concepts in graph theory and their impact on the world of algorithms.

Part of the Module: Graph Algorithms (Exercise)

Mode of Instruction: exercise course

Language: English / German

Frequency: each winter semester

Contact Hours: 2,00

Examination**Graph Algorithms**

oral exam / length of examination: 30 minutes, graded

Test Frequency:

when a course is offered

Module INF-3039: Human-Robot Interaction <i>Human-Robot Interaction</i>		8 ECTS/LP
Version 1.0.0 (since SoSe25) Person responsible for module: Prof. Dr. Elisabeth André		
<p>Learning Outcomes / Competences:</p> <p>In this course, the students will learn the core concepts regarding the field of human-robot interaction as well as the latest developments drawing examples from recent literature. After successful participation in this course, the students will gain the skills to design, and evaluate solutions to real-world Human-Robot Interaction (HRI) challenges across diverse scenarios. Within the framework of this lecture, the students will learn where does HRI fit into the increasingly technological world of HCI, the history of social robotics, physical versus social HRI, various dimensions of interactions such as proxemics, verbal, and non-verbal interaction modes and how these modalities interplay. They will further learn about the autonomy spectrum and the various technical methods for perception and generation of human and robot behaviors in HRI. They will also acquire the knowledge about design principles of effective HRI and how a complete HRI design cycle looks like. The students will apply these concepts in real world problems situated in, for example, educational, healthcare, in-home, public, entertainment scenarios through case studies and exercises.</p> <p>Schlüsselqualifikationen: Technical foundation with basics of cognitive systems/AI/ML; interdisciplinary awareness on computer science, multimodal human behavior analysis, psychology, ethics and society, design thinking; practical skills such as analytical thinking and ability to both work independently and in teams; attitudes such as curiosity to create impactful and creative HCI solutions; interest in communicating research ideas and latest technological developments; interdisciplinary knowledge; ability to make scientifically meaningful evaluations using suitable methods; knowledge of the mindset and language of application-relevant disciplines; ability to work in teams; knowledge of practice-relevant tasks; familiarity with procedures and processes in the application environment of computer science; ability to present and document results in a comprehensible manner; ability to expand existing knowledge independently; competence in recognizing significant technical developments.</p>		
<p>Workload:</p> <p>Total: 240 h</p> <p>60 h exercise course (attendance)</p> <p>30 h lecture (attendance)</p> <p>120 h studying of course content through exercises / case studies (self-study)</p> <p>15 h studying of course content using provided materials (self-study)</p> <p>15 h studying of course content using literature (self-study)</p>		
Conditions: none		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
<p>Part of the Module: Human-Robot Interaction (Lecture)</p> <p>Language: English</p> <p>Frequency: each summer semester</p> <p>Contact Hours: 2,00</p>		

Contents:

- Social and physical HRI
- Dimensions of interaction (spacial, verbal, non-verbal)
- Autonomy in interaction
- Technical methods for perception and generation
- Cognitive models of HRI such as mental models, engagement, trust, transparency
- Design principles for effective HRI
- Evaluation in HRI
- HRI design cycle
- Prevalent software and hardware

Literature:

- Bartneck, Christoph, Tony Belpaeme, Friederike Eyssel, Takayuki Kanda, Merel Keijsers, and Selma Šabanović. Human-robot interaction: An introduction. Cambridge University Press, 2020
- Thomaz, Andrea, Guy Hoffman, and Maya Cakmak. "Computational human-robot interaction." Foundations and Trends in Robotics 4, no. 2-3 (2016): 105-223.
- Cynthia Brezeczny: Social robots: beyond tools to partners

Part of the Module: Human-Robot Interaction (Exercise Course)

Language: English

Frequency: each summer semester

Contact Hours: 4,00

Examination**Human-Robot Interaction**

portfolio exam, graded

Test Frequency:

when a course is offered

Module INF-3041: Digital Forensics <i>Digital Forensics</i>		8 ECTS/LP
Version 1.0.0 (since SoSe25) Person responsible for module: Prof. Dr. Frank Breitingner Dr. Janine Schneider		
Contents: <p>Digital forensics deals with the identification, securing and analysis of digital evidence for use in legal proceedings. The starting point in each case is the suspicion of a computer crime or an offense that has been committed with the help of digital devices. The lecture provides a sound introduction to the basic concepts, methods and legal framework of digital forensics.</p> <p>After a brief introduction to forensics and its importance, the focus will be on technical aspects: What types of digital traces are there, how are they created and how can they be classified? Which storage media and file systems are relevant and how can data be forensically secured?</p> <p>A central component of the lecture is the technical analysis of digital evidence. In addition to methods for analyzing file systems, timestamps and other metadata are also considered in detail.</p> <p>Furthermore, the legal framework relevant to digital forensics is considered. The role of the expert witness is also explained, particularly with regard to court-proof documentation and communication of forensic findings.</p> <p>In the exercise, the topics of the lecture are practiced in the context of case studies</p>		
Learning Outcomes / Competences: <p>Students acquire competencies in the following areas at a basic, practical, but scientific level: microcomputer design, microprocessors, pipelining, assembly language programming, parallel programming, and operating systems. They will be able to understand the operation of major components of microprocessors and operating systems. Furthermore, they are able to differentiate between RISC and CISC architectures, to distinguish between in-order and out-of-order architectures, to assess the effects of compiler optimizations on runtime and program size, and to classify the influence of various architecture extensions on the overall system. Furthermore, they acquire programming skills in RISC-V assembler as well as parallel programming through practical exercises. They apply their basic concepts with C + POSIX threads in practice-relevant tasks.</p> <p>Key qualifications: Analytical-methodical competence in the field of systems-related computer science; consideration of approaches to solutions; presentation of solutions to exercise tasks; self-reflection; skill in working in teams; quality awareness, meticulousness.</p>		
Workload: Total: 240 h 30 h studying of course content using literature (self-study) 30 h studying of course content using provided materials (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h lecture (attendance) 60 h exercise course (attendance)		
Conditions: none		Credit Requirements: Passing the Module Exam
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Digital Forensics (Lecture) Mode of Instruction: lecture Language: English Frequency: each summer semester Contact Hours: 2,00
Contents: The first part of the lecture gives an introduction to microprocessor technology. Processor design and microcomputer systems are covered here and an outlook on servers and multiprocessors is given. This area is deepened in the exercises by assembler programming of a RISC processor. The second part of the lecture teaches basics of multicores and parallel programming. The third part deals with basics of operating systems. Topics covered include processes/threads, synchronization, scheduling, and memory management. Exercises on parallel programming and operating system techniques round out the module.
Part of the Module: Digital Forensics (Exercise) Mode of Instruction: exercise course Language: English / German Frequency: each summer semester Contact Hours: 4,00
Contents: In the exercise, the topics of the lecture are practiced in the context of case studies
Examination Digital Forensics written exam / length of examination: 90 minutes, graded Test Frequency: when a course is offered

Module INF-3815: Advanced Biomedical Systems Modeling and Data Science <i>Advanced Biomedical Systems Modeling and Data Science</i>		5 ECTS/LP
Version 1.0.0 (since SoSe25) Person responsible for module: Prof. Dr. Andreas Raue		
Learning Outcomes / Competences: This interdisciplinary course provides advanced-level knowledge of computational techniques in systems modeling and data science applied to complex biomedical challenges. Students will expand their expertise in mathematical modeling, machine learning, and biological data analysis. The course emphasizes both theoretical understanding and practical application through project-based learning. A solid background in biology, mathematics (calculus, linear algebra, differential equations), and programming (Python) is required. The goal of this course is to prepare students for a career path as scientists in biomedical, biotechnology or pharmaceutical industry, or for continuing their academic training and research by acquiring a PhD degree. Objectives: <ul style="list-style-type: none">• Deepen understanding of systems modeling and data science principles.• Develop expertise in handling complex datasets and applying advanced models and methods.• Enhance proficiency in interpreting and presenting biomedical data using advanced models.• Strengthen project design and critical evaluation skills for scientific research.		
Workload: Total: 150 h 15 h studying of course content using literature (self-study) 60 h studying of course content through exercises / case studies (self-study) 15 h studying of course content using provided materials (self-study) 30 h lecture (attendance) 30 h exercise course (attendance)		
Conditions: none		Credit Requirements: Passing the module exam
Frequency: each semester	Recommended Semester: 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Advanced Biomedical Systems Modeling and Data Science (Lecture) Mode of Instruction: lecture Language: English / German Frequency: each semester Contact Hours: 2,00		

Contents:**Part 1: Data Science**

- Statistical Theory & Applications
- Machine Learning Techniques
- Omics Data Integration
- Artificial Ground Truth

Part 2: Systems Modeling

- Dynamical Systems & Modeling Concepts
- Model Development & Analysis
- Experimental Design
- Advanced Model Classes

Note: The syllabus may be adjusted based on class progress and instructor discretion.

Literature:

- "Introduction to System Biology" by Edda Klipp
- "A First Course in Systems Biology" by Eberhard O. Voit
- "Introduction to Machine Learning" by Ethem Alpaydin
- "Machine Learning" by Tom M. Mitchell

For further reading, not a blueprint for this lecture!

Additional research papers and online resources will be provided throughout the course.

Assigned Courses:

Advanced Biomedical Systems Modeling and Data Science (lecture)

**(in attendance) **

Part of the Module: Advanced Biomedical Systems Modeling and Data Science (Computer Exercise)

Mode of Instruction: exercise course

Language: English / German

Frequency: each semester

Contact Hours: 2,00

Contents:

- We will apply the concepts covered in each week's lecture to relevant biomedical data
- Exercises will be posted as Python Jupyter Notebooks that include tasks that need to be completed
- A virtual environment will be provided, but students are also encouraged to use their own setups

Assigned Courses:

Übung zu Advanced Biomedical Systems Modeling and Data Science (exercise course)

**(in attendance) **

Examination

Introduction to Biomedical Systems Modeling and Data Science

portfolio exam, graded

Test Frequency:

when a course is offered

Description:

The portfolio exam will consist of two parts:

- Practice/homework coding tasks: You will be able to largely complete those during the computer practice or at home.
- Written exam: Questions will cover the comprehension of the contents of the lectures.

Module INF-3829: Digital Biomarkers <i>Digital Biomarkers</i>		5 ECTS/LP
Version 1.0.0 (since SoSe25) Person responsible for module: Prof. Dr.-Ing Muthuraman Muthuraman Manuel Bange		
Learning Outcomes / Competences: Fachbezogene Kompetenzen: <p>After attending the lecture, students will gain knowledge about selected digital biomarkers (e.g. bioimaging, kinetics, and kinematics) in medicine. They will acquire fundamental skills for developing and evaluating novel biomarkers based on forceplates and video based pose estimation and will understand the underlying requirements. Students will know the mechanisms of digital techniques for diagnostics and will develop the ability to analyze and interpret the data obtained. Furthermore, they will be equipped to contribute to the advancement and development of these procedures.</p> Methodische Kompetenzen: <p>Students can independently engage with the applications of digital biomarker tools from the domains of imaging, kinetics, and kinematics. They are capable of processing various measurement data using common scripting languages such as Matlab or Python and appropriately documenting and interpreting the application of methods for data analysis.</p> Fachübergreifende Kompetenzen: <p>The students are able to apply the acquired knowledge to any area of their studies that deals with diagnostically relevant data. Moreover, the module imparts essential problem-solving skills, teaching abstract thinking and a structured approach to problem-solving.</p> Key skills: <p>Skills in logical, analytical, and conceptual thinking; ability to present and document results understandably; skill in communicating effectively in writing and verbally in a situation-appropriate and audience-specific manner; ability to collaborate in teams; proficiency in problem-solving under practical conditions; capability to independently expand existing knowledge; awareness of quality.</p>		
Workload: Total: 150 h 20 h studying of course content using literature (self-study) 30 h studying of course content through exercises / case studies (self-study) 40 h preparation of written term papers (self-study) 30 h lecture (attendance) 30 h exercise course (attendance)		
Conditions: none		Credit Requirements: Bestehen der Modulprüfung
Frequency: Sommersemester	Recommended Semester: 1. - 4.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module**Part of the Module: Digital Biomarkers (Lecture)****Language:** English / German**Contact Hours:** 2,00**Contents:**

The lecture deals with the fundamentals, implementation, and application of digital biomarkers. The following contents are covered:

- Basics of imaging
- Basics of kinematic movement analysis
- Basics of kinetic movement analysis
- Selected applications in medicine (including various diseases and medical conditions)
- Introduction to basic and advanced methods for developing and validating Biomarkers

Part of the Module: Digital Biomarkers (Exercise)**Language:** English / German**Contact Hours:** 2,00**Contents:**

The exercise imparts practical skills in the context of the application of digital biomarkers. Furthermore, recent developments and novel biomarkers will be presented and discussed. The focus is on understanding the possible applications and relevant challenges of developing digital biomarkers. The following contents are covered:

- Presentation and discussion of selected applications in medicine (including various diseases and medical conditions)
- Handling of measurement data
- Validating biomarkers

Examination**Digital Biomarkers**

portfolio exam, graded

Test Frequency:

when a course is offered

Module PHM-0291: Quantum Computing <i>Quantum Computing</i>		6 ECTS/LP
Version 1.0.0 (since WS23/24) Person responsible for module: Prof. Dr. Markus Heyl		
Contents: <ul style="list-style-type: none"> • Qbits, quantum gates and quantum circuits • Physical realizations • Quantum noise • Quantum error correction • Quantum algorithms • Digital quantum simulation 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students acquire basic understanding of the principles of quantum computers and their applications. • They have the skills to construct concrete quantum circuits and algorithms. • They have the competence to identify the advantages of quantum information processing as well as to follow the modern developments in the field. • Integrated acquisition of key qualifications: Abstraction skills through the translation of physics problems onto quantum computing language, familiarization with English professional language. 		
Workload: Total: 180 h 40 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 40 h studying of course content using provided materials (self-study) 20 h exam preparation (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Basic knowledge of quantum mechanics such as acquired in lectures PHM-0017 Theoretische Physik II, INF-0437 Grundlagen der Quanteninformationsverarbeitung, or INF-0440 Quantum Algorithms.		Credit Requirements: Bestehen der Modulprüfung
Frequency: every 4th semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module	
Part of the Module: Quantum Computing Mode of Instruction: lecture Language: English / German Contact Hours: 2,00	
Learning Outcome: see module description	
Contents: see module description	
Assigned Courses: Quantum Computing (lecture) <i>*(in attendance) *</i>	

Quantum Computing (lecture) <i>*(in attendance) *</i>
Part of the Module: Quantum Computing (Tutorial) Mode of Instruction: exercise course Language: English / German Contact Hours: 2,00
Learning Outcome: see module description
Contents: see module description
Literature: <ul style="list-style-type: none"> • D. DiVincenzo, Quantum Computation, Science 270, 255-261 (1995) • M. Nielsen and I. Chuang, Quantum Computation and Quantum Information (Cambridge University Press, 2000) • J. Stolze and D. Suter, Quantum Computing (Wiley-VCH, 2004) • E. Grumbling and M. Horowitz, Quantum Computing: Progress and Prospects (The National Academies Press, 2019)
Assigned Courses: Quantum Computing (lecture) <i>*(in attendance) *</i> Quantum Computing (Tutorial) (exercise course) <i>*(in attendance) *</i>
Examination Quantum Computing oral exam / length of examination: 30 minutes, graded

Module INF-3000: Project Module Computer Science <i>Projektmodul für Austauschstudierende</i>		10 ECTS/LP
Version 1.0.0 (since SoSe25) Person responsible for module: All professors at the Institute of Computer Science		
Learning Outcomes / Competences: After participating in the project module, students understand computer science problems of higher complexity and have in-depth specialist knowledge and skills in this area. They will be able to develop concepts, methods, procedures, techniques and technologies in this field in research projects and will be able to apply innovative methods to solve problems. This enables them to tie in with international research and make their own scientific contribution in this field. In addition, students have the teamwork and communication skills, the ability to research literature and the scientific methodology to discuss problems in the field, define intermediate goals, and critically evaluate, classify, combine and present intermediate results and innovative ideas. Key skills: Ability to think logically, analytically and conceptually; Ability to work independently with specialized literature; Ability to present ideas, concepts and results in a clear, confident and convincing manner; Quality awareness; Communication skills; Ability to work in teams and understand team processes; Principles of good scientific practice; Project management skills; Scientific methodology		
Remarks: This is an individual module with practical focus, e.g. experiments or code development. Due to the individual character, you are registered in STUDIS by the professor for this module.		
Workload: Total: 300 h 15 h seminar (attendance) 285 h internship / practical course (self-study)		
Conditions: none		Credit Requirements: Passing the Module Exam
Frequency: each semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 1,00	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Project Module Computer Science Mode of Instruction: internship Language: English Frequency: each semester
Contents: The topic is in the scope of the research projects at the Institute of Computer Science: You contact one of the professors at the Institute of Computer Science who works on a research topic you are interested in. Together you define a topic on which you work individually. During the semester, you meet on a regular basis to get feedback (e.g. each week). Finally, you present your work.
Literature: Depends on the professor and topic, e.g. manuals, scientific papers
Assigned Courses: Projektmodul Informatik / Project Module Computer Science (internship)

**(in attendance) **

Examination

Project Module Computer Science

practical exam, graded

Test Frequency:

each semester

Module INF-3001: Seminar Computer Science Master <i>Seminar Informatik für Austauschstudierende (Master)</i>		4 ECTS/LP
Version 1.0.0 (since SoSe25) Person responsible for module: All professors at the Institute of Computer Science		
Learning Outcomes / Competences: After attending the seminar, students will be able to independently develop and analyze advanced problems, concepts, methods, procedures, techniques and technologies in computer science and evaluate them in relation to the individual seminar topic from the area mentioned. They have the scientific methodology, communication skills and ability to use appropriate media to present a specific topic clearly and comprehensibly in written and spoken form and to discuss and evaluate scientifically demanding topics from the above-mentioned field critically and argumentatively. In addition, they can recognize the logical structures of thinking and argumentation and apply them in a goal-oriented manner. Participants can formulate clearly and comprehensibly and present specialist content freely. They understand how to structure a presentation in a clear and comprehensible manner and how to focus the presentation on key messages and convey these in an understandable way, even in the case of complex content. They can skillfully apply chains of argumentation and solution strategies in the event of disruptions. Students know how to present themselves and confidently handle common presentation media and use them interactively. They are able to tailor a presentation to a specific target group and motivate the audience even during longer presentations and apply various moderation techniques. Key skills: Literature research; Independent work with specialist literature; Analytical-methodical competence; Scientific methodology; Principles of good scientific practice; Ability to present (practical or theoretical) ideas, concepts and results in a comprehensible, confident and convincing (written and oral) manner and to document them; Ability to think logically, abstractly, analytically and conceptually and to argue formally; Quality awareness, meticulousness; Communication skills; Time management; Evaluation of approaches, procedures, techniques and technologies from different points of view		
Remarks: Due to the individual character, you are registered in STUDIS by the professor for this module.		
Workload: Total: 120 h 30 h seminar (attendance) 90 h preparation of written term papers (self-study)		
Conditions: none		Credit Requirements: Passing the Module Exam
Frequency: each semester	Recommended Semester: from 4.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2,00	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Seminar Computer Science Master Mode of Instruction: seminar Language: English Frequency: each semester Contact Hours: 2,00		

Contents:

There are several seminars where you can choose from (see list below). Enroll at the Digicampus courses for more details.

Most seminars have one meeting in the first week (where topics are introduced) of the lecture period and one presentation meeting in the last week of the lecture period. In the weeks between, you work individually on your thesis / presentation and meet with your supervisor.

Literature:

Depends on chosen topic

Assigned Courses:

Seminar Biomedizinische Datenanalyse und Systemmodellierung (Master) (seminar)

**(in attendance) **

Seminar Current Topics in Embodied Artificial Intelligence and Computer Vision (seminar)

**(in attendance) **

Seminar Cyber Security Master (lecture)

**(in attendance) **

Seminar Datenbanksysteme für Geoinformatiker (seminar)

**(online/digital) **

Seminar Datenbanksysteme für Master (seminar)

**(hybrid/mixed) **

Seminar Diagnostische Sensorik (Master) (seminar)

**(hybrid/mixed) **

Seminar Embedded Systems (Master) (seminar)

**(in attendance) **

Seminar Software Engineering for Artificial Intelligence Systems Master (seminar)

**(in attendance) **

Seminar Software Engineering in sicherheitskritischen Systemen (Master) (seminar)

**(in attendance) **

Seminar Software Engineering verteilter Systeme (Master) (seminar)

**(in attendance) **

Examination

Seminar Computer Science Master

written/oral exam, graded

Test Frequency:

each semester