UNIVERSITÄT ZU LÜBECK

Module Guide for the Study Path

Master Computer Science 2019

Version from 6. October 2023

interdisciplinary competence

Applied computer science

Theoretical computer science

technical computer science

computer science

Module part

Canonical Specialization SSE

Elective

Canonical Specialization Bioinformatics and Systems Biology

Canonical Specialization Data Science and AI

advanced module

CS5840-KP04, CS5840 - Seminar in English (SemiEngl)

Duration:	Turnus of offer:	Credit points:
1 Semester	each semester	4 (Typ B)

Course of study, specific field and term:

- Master Artificial Intelligence 2023 (optional subject), for equivalence check, Arbitrary semester
- Master Computer Science 2019 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Computer Science 2014 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Computer Science 2012 (optional suject), interdisciplinary competence, Arbitrary semester

Classes and lectures:

- Seminar in Englisch (seminar, 2 SWS)

Workload:

- 90 Hours work on an individual topic with written and oral presentation
- 30 Hours in-classroom work

Contents of teaching:

- Familiarization in a demanding scientific topic
- Working on a scientific topic and its answers for problems on their own
- Presentation and discussion of the topic in English

Qualification-goals/Competencies:

- The students can obtain a solid grounding a demanding scientific topic.
- They can review a scientific work.
- They are able to present the results in a written documentation and in a talk in an understandable way.
- The can present and discuss a scientific topic in English.
- They can follow a scientific presentation and assess critically in an open discussion.

Grading through:

- oral presentation
- Written report

Responsible for this module:

- Studiengangsleitung Informatik

Teacher:

- Institutes of the Department of Computer Science/ Engineering
- Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges

Literature:

- is selected individually:

Language:

- offered only in English

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful participation in the seminar incl. elaboration, presentation, contributions to the discussion according to the requirements at the beginning of the semester.

Module exam(s):
CS5840-L1: English Language Seminar, Seminar, 100% of (non-existent) module grade.

Registration and topic assignment in a preliminary meeting at the end of the preceding semester.

EC4001-KP04, EC4001 - General Business Administration (ABWL)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Psychology 2016 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Interdisciplinary Courses (optional subject), Interdisciplinary modules, Arbitrary semester
- Master psychology 2013 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Media Informatics 2014 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Computer Science 2014 (optional subject), interdisciplinary competence, Arbitrary semester

Classes and lectures:

- General Business Administration (lecture, 2 SWS)
- General Business Administration (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Theories in business administration
- Organisational forms
- Legal forms
- Accounting basics
- Theories on leaderhip and motivation

Qualification-goals/Competencies:

- The students get an important and in-depth overview of the single parts of business administration.
- Within this lecture, the students are empowered to identify and classify the different theoretical areas of business administration.
- Furthermore, students will be able to evaluate the different approaches and apply them to specific situations.

Grading through:

- portfolio exam

Responsible for this module:

- Prof. Dr. Christian Scheiner

Teacher:

- Institute for Entrepreneurship and Business Development
- Dr. Stefan Becker

Literature:

- Wöhe: Einführung in die Allgemeine Betriebswirtschaftslehre - Vahlen-Verlag, 24. Auflage, 2010
- Hungenberg, Wulf: Grundlagen der Unternehmensführung - Gabler-Verlag, 4. Auflage, 2011

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- none

Prerequisites for participation in module exam(s):
- none
- Prerequisites for admission to the (written) examination may be scheduled at the beginning of the semester. When prerequisites are defined, they should be completed and positively evaluated before the initial (written) examination.

Module exam(s):
- EC4001-L1: General Business Administration, (online) tests, 100 % of module grade

Students for whom this course is a compulsory module have priority.

Registration takes place at the beginning of the semester via Moodle. Further registration and exam-related questions will be clarified during the first lectures.

(Is equal to EC4001 T-KP04)

EC4008-KP04 - Entrepreneurship & Innovation (EI)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), interdisciplinary competence, 1st or 2nd semester
- Master Computer Science 2014 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Media Informatics 2014 (optional subject), Interdisciplinary modules, Arbitrary semester
- Master Medical Informatics 2014 (optional subject), interdisciplinary competence, 1st or 2nd semester
- Master Interdisciplinary Courses (optional subject), Interdisciplinary modules, Arbitrary semester

Classes and lectures:

- Entrepreneurship and Innovation (lecture, 2 SWS)
- Entrepreneurship and Innovation (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- This course deals with fundamental theories, concepts and tools for the entrepreneurship and innovation management.
- The content is also linked to practical and current topics thus covering relevant applications.
- Individual aspects of the event will be studied on selected case studies.

Qualification-goals/Competencies:

- Students are able to master and apply scientific foundations and develop predominantly fundamental expertise in entrepreneurship and innovation.
- Students are able to structure and solve problems in innovation and technology management predominantly in a familiar be to some extent also even in a new, unfamiliar and multidisciplinary context.
- Students are able to define goals for their own development and reflect their own strengths and weaknesses, plan their own development and reflect the societal impact.
- Students can work cooperatively and responsibly in groups and reflect and enhance their own cooperative behavior in groups critical.

Grading through:

- portfolio exam

Responsible for this module:

- Prof. Dr. Christian Scheiner

Teacher:

- Institute for Entrepreneurship and Business Development
- Prof. Dr. Christian Scheiner

Literature:

- Nichols: Social Entrepreneurship - Oxford University Press 1. Auflage 2008
- Bessant & Tidd: Innovation and Entrepreneurship - Wiley-Verlag 2. Auflage 2013
- Fisch & Roß: Fallstudien zum Innovationsmanagement - Gabler-Verlag 1. Auflage 2009
- Bessant & Tidd: Managing Innovation: Integrating Technological, Market and Organizational Change - Wiley-Verlag: 5. Auflage 2013

Language:

- German and English skills required

Notes:

Prerequisites for attending the module:
- none

Prerequisites for participation in module exam(s):
- none
- Prerequisites for admission to the (written) examination may be scheduled at the beginning of the semester. When prerequisites are defined, they should be completed and positively evaluated before the initial (written) examination.

Module exam(s):
- EC4008-L1: Entrepreneurship and Innovation, portfolio exam, 100% of module grade

The portfolio exam consists of the following:
-Individual written assignment, 15 %
-Group work (Presentation), 45 %
-(Online)exams, 40 %

The commercial rounding is used to determine the overall grade.

Students for whom this course is a compulsory module have priority.

Registration takes place at the beginning of the semester via Moodle. Further registration and exam-related questions will be clarified during the first lectures.

(Is equal to EC4008 T-KP04)
(Replaces PS5830-KP04)

EC4010-KP04, EC4010 - Commercial Law (WirtRecht)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), interdisciplinary competence, 1st or 2nd semester
- Master Interdisciplinary Courses (optional subject), Interdisciplinary modules, Arbitrary semester
- Master MES 2014 (optional subject), no specific field, Arbitrary semester
- Bachelor MES 2014 (optional subject), no specific field, 3rd semester at the earliest
- Master Medical Informatics 2014 (optional subject), interdisciplinary competence, 1st or 2nd semester
- Master Computer Science 2014 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (optional subject), interdisciplinary competence, Arbitrary semester

Classes and lectures:

- Commercial Law (lecture, 2 SWS)
- Commercial Law (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- The importance of legal aspects in entrepreneurship especially in the high-tech sector
- legal acts
- contract law
- technology protection and intellectual property (know how, patents, trademarks, designs, with license rights)
- labor law
- corporate law
- enforcement of legal claims

Qualification-goals/Competencies:

- The objective of the course is to provide students with a basic knowledge of legal subjects relevant for scientists, medical doctors, engineers and computer scientists in technology-driven enterprises or in research at a university.
- Students will gain an understanding of legal reasoning to help them avoid pitfalls and exploit to the fullest extent opportunities in R&D projects and startup companies.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. Christian Scheiner

Teacher:

- Institute for Entrepreneurship and Business Development
- Dr. Carsten Richter

Literature:

- Carsten Richter: Kurshandout - -
- Ann/Hauck/Obergfell: Wirtschaftsrecht kompakt - München 2012
- Meyer: Wirtschaftsprivatrecht - Heidelberg 2012
- -: BGB Bürgerliches Gesetzbuch - Beck-Texte, neuste Auflage
- Schönfelder: Deutsche Gesetze Textsammlung - neuste Auflage

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- none

Prerequisites for participation in module exam(s):
- none
- Prerequisites for admission to the (written) examination may be scheduled at the beginning of the semester. When prerequisites are defined, they should be completed and positively evaluated before the initial (written) examination.

Module exam(s):
- EC4010-L1: Commercial Law, written exam, 60 min, 100 % of module grade

PS5810-KP04, PS5810 - Scientific Teaching and Tutoring (WLehrKP04)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4 (Typ B)

Course of study, specific field and term:

- Bachelor Interdisciplinary Courses for health sciences (optional subject), interdisciplinary competence, Arbitrary semester
- Master Computer Science 2019 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Interdisciplinary Courses (optional subject), Interdisciplinary modules, Arbitrary semester
- Bachelor Interdisciplinary Courses (optional subject), Interdisciplinary modules, Arbitrary semester
- Master CLS 2016 (optional subject), Interdisciplinary modules, 3rd semester
- Master Entrepreneurship in Digital Technologies 2014 (optional subject), interdisciplinary competence, Arbitrary semester
- Master Media Informatics 2014 (optional subject), interdisciplinary competence, Arbitrary semester
- Master MES 2014 (optional subject), no specific field, 1st or 2nd semester
- Bachelor MES 2014 (optional subject), no specific field, Arbitrary semester
- Master Computer Science 2014 (optional subject), interdisciplinary competence, Arbitrary semester
- Master CLS 2010 (optional suject), interdisciplinary competence, 3rd semester
- Master Computer Science 2012 (optional subject), interdisciplinary competence, Arbitrary semester

Classes and lectures:

- Theory and Practice of Good Teaching (seminar, 1 SWS)
- Work as a tutor in a lecture (practical course, 2 SWS)

Workload:

- 60 Hours private studies and exercises
- 45 Hours oral presentation (including preparation)
- 15 Hours in-classroom work

Contents of teaching:

- Organizing and running a scientific lecture
- Basic didactics of scientific teaching
- Practical work in tutorials

Qualification-goals/Competencies:

- The participants are able to lead a student working group and to communicate technical issues to it appropriately.
- Basic pedagogical and didactical skills

Grading through:

- continuous participation in all courses of the module

Responsible for this module:

- Prof. Dr. rer. nat. Nico Bunzeck
- Prof. Dr. rer. nat. Jürgen Prestin

Teacher:

- Institute for Mathematics
- Dr. rer. nat. Jörn Schnieder
- Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges
- Corinna Lütsch

Language:

- depends on the chosen courses

Notes:

The seminar must be attended before working as a tutor. This activity cannot be remunerated.

The course instructor in charge of the respective course will issue a certificate of achievement for the module.

CS4130-KP06, CS4130 - Information Systems (InfoSys)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (compulsory), Canonical Specialization Data Science and AI, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (basic module), technology field computer science, 1st or 2nd semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2019 (basic module), Applied computer science, 1st or 2nd semester
- Master Medical Informatics 2019 (basic module), Applied computer science, 1st or 2nd semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Elective, 1st or 2nd semester
- Master IT-Security 2019 (basic module), Applied computer science, 1st or 2nd semester
- Master Medical Informatics 2014 (basic module), ehealth / infomatics, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (basic module), technology field computer science, 1st or 2nd semester
- Master Computer Science 2014 (optional subject), specialization field software systems engineering, 2nd or 3rd semester
- Master Computer Science 2014 (basic module), Applied computer science, 1st or 2nd semester

Classes and lectures:

- Information Systems (lecture, 2 SWS)
- Information Systems (exercise, 2 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Fundamentals of databases, conceptual modeling languages (ontologies), query languages, processes, and agents
- Ontology based data access (OBDA)
- Ontology evolution and ontology integration
- Data exchange and data integration (schema mappings, duplicate detection, inconsistency handling, integration with relational and ontological constraints as well as with incomplete data)
- Data stream processing (e.g., for sensor networks, robotics, web agents) with OBDA and complex event processing (CEP)
- Non-symbolic data and their symbolic annotations (e.g., for applications in bioinformatics/computational biology and for media interpretation), syntax, semantics, hybrid decision and computation problems and their complexity, (analysis of) algorithms
- Data- and ontology-oriented process analysis (e.g., for biological pathways) and process design (e.g., for non-trivial business processes)

Qualification-goals/Competencies:

- Knowledge: The module aims at introducing the students to the formal basics of databases and ontologies, so that they get an overview of concepts, methods, and theories for understanding, analyzing, and designing information systems in open large contexts, such as the web.
- Skills: The students get a basic understanding of logical and formal methods, which allows them to assess the possibilities and limitations of information systems, be it concrete ones or those that still have to be designed. Assessment parameters are correctness and completeness (Does the system produce what is expected? If so, does it produce all results?) as well as expressiveness (Is it possible to formulate all required queries? What are equivalent query languages?) and, last but not least, performance (How long does it take the system to come up with an answer? How much space does it need?). In addition to these analysis skills, students receive logical modeling skills using real application scenarios from industry (business processing, integration of data resources, processing of time-based and event data), and medicine (sensor networks, genomic ontologies, annotation). Based on these, the student not only acquires the ability to assess which logical model is suitable for which application scenario, but also the ability to construct their own logical models where necessary.
- Social Competence und Independent Work: Students work in groups to solve small exercises and project problems and sketch their solutions in short presentations. Independent work is promoted by exercises with practical ontology and database systems.

Grading through:

- Oral examination

Responsible for this module:

- PD Dr. Özgür Özçep

Teacher:

- Institute of Information Systems

- PD Dr. Özgür Özçep

Literature:

- S. Abiteboul, R. Hull, V. Vianu: Foundations of Databases - Addison-Wesley, 1995
- M. Arenas, P. Barcelo, L. Libkin, and F. Murlak: Foundations of Data Exchange - Cambridge University Press, 2014
- F. Baader, D. Calvanese, D.L. McGuinness, D. Nardi, and P.F. Patel-Schneider (Eds.): The Description Logic Handbook: Theory, Implementation, and Applications - Cambridge University Press, 2010
- S. Chakravarthy, Q. Jiang: Stream Data Processing A Quality of Service Perspective - Springer, 2009
- L. Libkin: Elements Of Finite Model Theory (Texts in Theoretical Computer Science. An Eatcs Series) - SpringerVerlag, 2004

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.

Module Exam(s):
- CS4130-L1: Information Systems, oral exam, 100% of module grade.

Previous name: Web Based Information Systems

Recommended previous modules:
- Algorithm and Data Structures (CS1001)
- Linear Algebra and Discrete Structures I+II (MA1000, MA1500)
- Databases (CS2700)
- Logic (CS1002)
- Bachelor Project Computer Science (CS3701), topic: logic programming
- Nonstandard Database Systems (CS3202)

Prerequisites for the exam:
- Successful completion of homework assignments during the semester.

CS4150-KP06, CS4150SJ14 - Distributed Systems (VertSys14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (compulsory), Canonical Specialization SSE, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (basic module), technology field computer science, 1st or 2nd semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2019 (basic module), Applied computer science, 1st or 2nd semester
- Master Medical Informatics 2019 (basic module), Applied computer science, 1st or 2nd semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Elective, 1st or 2nd semester
- Master IT-Security 2019 (basic module), Applied computer science, 1st or 2nd semester
- Master Medical Informatics 2014 (basic module), ehealth / infomatics, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (basic module), technology field computer science, 1st or 2nd semester
- Master Computer Science 2014 (optional subject), specialization field software systems engineering, 2nd or 3rd semester
- Master Computer Science 2014 (basic module), Applied computer science, 1st or 2nd semester

Classes and lectures:

- Distributed Systems (lecture, 2 SWS)
- Distributed Systems (exercise, 2 SWS)

Workload:

- 60 Hours private studies
- 60 Hours in-classroom work
- 40 Hours e-learning
- 20 Hours exam preparation

Contents of teaching:

- Introduction and motivation
- Protocols and layered models
- Message representations
- Realization of network services
- Communication mechanisms
- Addresses, names and directory services
- Synchronisation
- Replication and consistency
- Fault tolerance
- Distributed transactions
- Security

Qualification-goals/Competencies:

- The participants will accquire a deep understanding for problems to be solved in distributed systems, such as synchronization, error handling, naming etc.
- They know the most important services in distributed systems such as name service, distributed file systems etc.
- They are able to program simple distributed applications and systems themselves.
- They know the most important algorithms in distributed systems, for instance for time synchronization, for leader election, or for mutual exclsuion.
- They have a good feeling for when it makes sense to use distributed instead of centralized systems.
- They have a good feeling for what kind of solutions could best be used for what kind of problems in distributed Internet applications.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics

- Prof. Dr. Stefan Fischer
- Dr. rer. nat. Florian-Lennert Lau

Literature:

- A. Tanenbaum, M. van Steen: Distributed Systems: Principles and Paradigms - Prentice Hall 2006
- G. Coulouris, J. Dollimore, T. Kindberg, G. Blair: Distributed Systems - Concepts and Design - Addison Wesley 2012

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- None

Module Exam(s):
- CS4150-L1 Distributed Systems, written exam, 90min, 100% of module grade.

CS4000-KP06, CS4000SJ14 - Algorithmics (ALG14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (compulsory), Canonical Specialization Data Science and AI, Arbitrary semester
- Master Computer Science 2019 (compulsory), Canonical Specialization Bioinformatics and Systems Biology, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (basic module), Theoretical computer science, 1st or 2nd semester
- Master Medical Informatics 2019 (optional subject), Theoretical computer science, 1st or 2nd semester
- Master IT-Security 2019 (compulsory), Theoretical computer science, 1st or 2nd semester
- Master Medical Informatics 2014 (basic module), computer science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (basic module), technology field computer science, 1st or 2nd semester
- Master Computer Science 2014 (optional subject), specialization field IT security and safety, 2nd or 3rd semester
- Master Computer Science 2014 (basic module), Theoretical computer science, 1st or 2nd semester

Classes and lectures:

- Algorithmics (lecture, 2 SWS)
- Algorithmics (exercise, 2 SWS)

Workload:

- 100 Hours private studies and exercises
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- complexity analysis of algorithmic problems
- discrete optimization problems, linear programming
- satisfiability and constraint satisfaction problems
- randomized algorithms
- approximation algorithms and heuristics
- algorithms for algebraic problems

Qualification-goals/Competencies:

- The students can model real problems in an algorithmic manner.
- They can apply basic algorithmic techniques with full command.
- They can analyze algorithms, in particular with respect to corrrectness and complexity.
- They can design efficient algorithms for complex problems.

Grading through:

- written exam

Requires:

- Theoretical Computer Science (CS2000-KP08, CS2000)
- Algorithm Design (CS3000-KP04, CS3000)

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science

- Prof. Dr. Rüdiger Reischuk
- Prof. Dr. rer. nat. Till Tantau
- Prof. Dr. Maciej Liskiewicz

Literature:

- Aho, Hopcroft, Ullman: Design and Analysis of Computer Algorithms - Addison Wesley, 1978
- Cormen, Leiserson, Rivest, Stein: Introduction to Algorithms - The MIT Press, 2009
- Mitzenmacher, Upfal: Probability and Computing - Cambridge University Press, 2005
- Kreher, Stinson: Combinatorial Algorithms - CRC Press, 1999
- Williamson, Shmoys: The Design of Approximation Algorithms - Cambridge University Press, 2011

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None (the competencies of the modules listed under

CS4020-KP06, CS4020SJ14 - Specification and Modelling (SpezMod14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	6

Course of study, specific field and term:

- Master Media Informatics 2020 (optional subject), computer science, 3rd semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (basic module), Theoretical computer science, 1st or 2nd semester
- Master Medical Informatics 2019 (optional subject), Theoretical computer science, 1st or 2nd semester
- Master IT-Security 2019 (compulsory), Theoretical computer science, 1st or 2nd semester
- Master Medical Informatics 2014 (basic module), computer science, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (basic module), technology field computer science, 1st or 2nd semester
- Master Computer Science 2014 (optional subject), specialization field IT security and safety, 2nd or 3rd semester
- Master Computer Science 2014 (basic module), Theoretical computer science, 1st or 2nd semester

Classes and lectures:

- Specification and Modelling (lecture, 2 SWS)
- Specification and Modelling (exercise, 2 SWS)

Workload:

- 80 Hours private studies and exercises
- 60 Hours in-classroom work
- 20 Hours work on project
- 20 Hours exam preparation

Contents of teaching:

- Introduction to modelling and specification
- Modelling concepts (data, streams, traces, diagrams, tables)
- Modelling software components (state, behaviour, structure, interface)
- Modelling concurrency
- Algebraic specification
- Composing, refining, analysing and transforming specifications and models
- Specification languages and tools for specification and modelling

Qualification-goals/Competencies:

- The students can argue on the importance of specifications and models for software development.
- They can characterize, apply, adapt and extent important specification and modelling techniques.
- They can model and specify simple software/hardware system in an adequate way.
- They can describe a system from different views and on different levels of abstraction.
- They can apply specifications and modelsin software development.
- They can analyse specifications and models.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages
- Dr. Annette Stümpel
- Prof. Dr. Martin Leucker

Literature:

- V.S. Alagar, K. Periyasamy: Specification of Software Systems - Springer 2013
- M. Broy, K. Stølen: Specification and Development of Interactive Systems - Springer 2001
- J. Loeckx, H.-D. Ehrich, M. Wolf: Specification of Abstract Data Types - John Wiley & Sons 1997
- D. Bjorner: Software Enginneering 1-3 - Springer 2006
- U. Kastens, H. Kleine Büning: Modellierung - Grundlagen und formale Methoden - Hanser 2005

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.

Module Examination(s):
- CS4020-L1: Specification and Modeling, written exam, 90min, 100% of the module grade.

CS4160-KP06, CS4160SJ14 - Real-Time Systems (Echtzeit14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	6

Course of study, specific field and term:

- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2019 (basic module), technical computer science, 1st or 2nd semester
- Master Medical Informatics 2019 (optional subject), technical computer science, 1st or 2nd semester
- Master IT-Security 2019 (basic module), technical computer science, 1st or 2nd semester
- Master MES 2014 (optional subject), computer science / electrical engineering, 1st semester
- Master Medical Informatics 2014 (basic module), computer science, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (basic module), technology field computer science, 1st or 2nd semester
- Master Computer Science 2014 (basic module), technical computer science, 1st or 2nd semester

Classes and lectures:

- Real-Time Systems (lecture, 2 SWS)
- Real-Time Systems (exercise, 2 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Real-time processing (definitions, requirements)
- Process automation systems
- Real-time programming
- Process connectivity and networking
- Modelling of discrete event systems (automata, state charts)
- Modelling of continuous systems (differential equations, Laplace transformation)
- Application of design tools (Matlab/Simulink, Stateflow)

Qualification-goals/Competencies:

- The students are able to describe the fundamental problems of real-time processing.
- They are able to explain real-time computer systems for process automation, in particular SPS.
- They are able to program real-time systems in the IEC languages.
- They are able to elucidate process interfaces and real-time bus system.
- They are able to model, analyze and implement event discrete systems, in particular process control systems.
- They are able to model, analyze and implement continuous systems, in particular feedback control systems.
- They are able to make use of design tools for real-time systems.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- R. C. Dorf, R. H. Bishop: Modern Control Systems - Prentice Hall 2010
- L. Litz: Grundlagen der Automatisierungstechnik - Oldenbourg 2012
- M. Seitz: Speicherprogrammierbare Steuerungen - Fachbuchverlag Leipzig 2012
- H. Wörn, U. Brinkschulte: Echtzeitsysteme - Berlin: Springer 2005
- S. Zacher, M. Reuter: Regelungstechnik für Ingenieure - Springer-Vieweg 2014

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS4160-L1: Real-Time Systems, written exam, 90min, 100% of the module grade

CS4170-KP06, CS4170SJ14 - Parallel Computer Systems (ParaRSys14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6

Course of study, specific field and term:

- Certificate in Artificial Intelligence (compulsory), Artificial Intelligence, 1st semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (basic module), technical computer science, 1st or 2nd semester
- Master Medical Informatics 2019 (optional subject), technical computer science, 1st or 2nd semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Elective, 1st or 2nd semester
- Master IT-Security 2019 (basic module), technical computer science, 1st or 2nd semester
- Master Medical Informatics 2014 (basic module), computer science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (basic module), technology field computer science, 1st or 2nd semester
- Master Computer Science 2014 (basic module), technical computer science, 1st or 2nd semester

Classes and lectures:

- Parallel Computer Systems (lecture, 2 SWS)
- Parallel Computer Systems (exercise, 2 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Motivation and limitations for parallel processing
- Parallel computing models
- Taxonomy of parallel computers
- Multi/manycore-systems
- Graphic Processing Units (GPUs)
- OpenCL
- Specification languages
- Hardware architectures
- System management of many-core systems

Qualification-goals/Competencies:

- Students are able to characterize different parallel computing architectures.
- They are able to explain models of parallel computing.
- They are able to make use of common programming interfaces for parallel computing systems.
- They are able to judge which kind of parallel computing system is best suited for a dedicated problem and how many cores should be used.
- They are able to evaluate the pros and cons of different hardware architectures.
- They are able to write programs for parallel computing systems under considerations of the underlying hardware architecture.
- They are able to compare methods for dynamic voltage and frequency scaling (DVFS) for manycore systems.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- G. Bengel, C. Baun, M. Kunze, K. U. Stucky: Masterkurs Parallele und Verteilte Systeme - Vieweg + Teubner, 2008
- M. Dubois, M. Annavaram, P. Stenström: Parallel Computer Organization and Design - University Press 2012
- B. R. Gaster, L. Howes, D. R. Kaeli, P. Mistry, D. Schaa: Heterogeneous Computing with OpenCL - Elsevier/Morgan Kaufman 2013
- B. Wilkinson; M. Allen: Parallel Programming - Englewood Cliffs: Pearson 2005
- J. Jeffers, J. Reinders: Intel Xeon Phi Coprozessor High-Performance Programming - Elsevier/Morgan Kaufman 2013

- D. A. Patterson, J. L. Hennessy: Computer Organization and Design - Morgan Kaufmann, 2013

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS4170-L1: Parallel Computer Systems, oral exam, 100% of the module grade

CS5990-KP30, CS5990 - Master Thesis Computer Science (MasterInf)

Duration:	Turnus of offer:	Credit points:
1 Semester	each semester	30

Course of study, specific field and term:

- Master Computer Science 2019 (compulsory), computer science, 4th semester
- Master Computer Science 2014 (compulsory), computer science, 4th semester
- Master Computer Science 2012 (compulsory), computer science, 4th semester

Classes and lectures:

- Master's Thesis (supervised self studies, 1 SWS)
- Colloquium (colloquium, 1 SWS)

Workload:

- 870 Hours research for and write up of a thesis
- 30 Hours oral presentation and discussion (including preparation)

Contents of teaching:

- individual studies under supervision

Qualification-goals/Competencies:

- The students are able to structure a comprehensive and complex problem from the field of computer sciece or its applications and to solve it within limited time.
- They are able to get acquainted with a problem int he field of computer science in a detailed way, to analyse corresponding literature, to work out a solution and to document the solution in a written thesis.
- They can evaluate their solution critically and present it in a talk and defend it in a scientific discussion.

Grading through:

- oral presentation
- Written report

Responsible for this module:

- Studiengangsleitung Informatik

Teacher:

- Institutes of the Department of Computer Science/ Engineering
- Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges

Literature:

- links will be given by the supervisor:

Language:

- thesis can be written in German or English

Notes:

requirements for starting a master's thesis see Academic Regulations and Procedures for Students, e.g. at least 75 credit points

CS3110 T - Module part: Computer-Aided Design of Digital Circuits (SchaltEnta)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly in the winter semester	4

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester

Classes and lectures:

- Computer-Aided Design of Digital Circuits (lecture, 2 SWS)
- Computer-Aided Design of Digital Circuits (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Abstraction levels in circuit design
- Design cycle and design strategies
- FPGA architectures
- Introduction of the hardware description language VHDL
- Design of standard components in VHDL
- Circuit design at different abstraction levels
- Circuit design for synthesis
- VHDL simulation cycle
- VHDL circuit design for FPGAs
- Designing Testbenches
- High-Level-Synthesis

Qualification-goals/Competencies:

- Based on a non-formal description of a digital system, students are able to design digital circuits using VHDL
- They are able to simulate and test VHDL descriptions
- They are able to explain the internal structures of FPGAs
- They are able to determine which VHDL construct will result in which circuit structure
- They are able to explain the VHDL simulation cycle
- They are able to write synthesizable VHDL code

Grading through:

- exam type depends on main module

Requires:

- Fundamentals of Computer Engineering 2 (CS1202-KP06, CS1202)

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- F. Kesel, R. Bartholomä: Entwurf von digitalen Schaltungen und Systemen mit HDLs und FPGAs - Oldenbour Verlag 2009
- C.Maxfield: The Design Warrior's Guide to FPGAs - Newnes 2004

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None (the competencies of the modules listed under

CS4138 T - Module part: Model Checking (ModelCha14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st semester
- Master Computer Science 2014 (Module part of a compulsory module), Module part, Arbitrary semester

Classes and lectures:

- Model Checking (lecture, 3 SWS)
- Model Checking (exercise, 1 SWS)

Workload:

- 100 Hours private studies and exercises
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Quality aspects of software systems
- Analysis and verification techniques for software systems
- Basic techniques for model checking
- Advanced techniques for model checking

Qualification-goals/Competencies:

- The students can describe and compare analysis and verification techniques.
- They can construct, analyse and evaluate specifications of correctness and safety properties.
- They can characterize different system models and can formally represent sysstems in suitable models.
- They can illustrate different techniques for model checking hardware and software systems and can select and apply suitable techniques.
- They can explain the structure of model checkers and can use model checkers.
- They can evaluate the possibilities and limitations of model checking.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Software Technology and Programming Languages
- Prof. Dr. Martin Leucker

Literature:

- C. Baier, J.-P. Katoen: Principles of Model Checking - MIT Press, 2008

Language:

- English, except in case of only German-speaking participants

Notes:

(Is equal to CS4138SJ14)
(Part of Module CS4507)

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester.

CS4139 T - Module part: Runtime Verification and Testing (RVTestena)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 2nd semester
- Master Computer Science 2014 (Module part of a compulsory module), Module part, Arbitrary semester

Classes and lectures:

- Runtime Verification and Testing (lecture, 3 SWS)
- Runtime Verification and Testnig (exercise, 1 SWS)

Workload:

- 100 Hours private studies and exercises
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Quality aspects of software systems
- Analysis and verification techniques for software systems
- Testing levels
- Testing process
- Kinds of tests
- Test case generation
- Specification of correctness properties
- synthesis of monitors for the observation of software systems
- diagnosis of errors in software systems
- realization of monitoring frameworks

Qualification-goals/Competencies:

- The students can describe and compare analysis and verification techniques.
- They can construct, analyse and evaluate specifications of correctness and safety properties.
- They can illustrate different techniques for testing hardware and software systems and can select and apply suitable techniques.
- They can explain the operation process of test case generation tools and can clasify suitable applications.
- They can describe and apply techniques for the synthesis of monitors.
- With the acquired techniques they can develop software of higher quality.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Software Technology and Programming Languages
- Prof. Dr. Martin Leucker

Literature:

- G.J. Myers: The Art of Software Testing - John Wiley, 1979
- B. Beizer: Software Testing Techniques - Van Nostrand Reinhold, 1999
- M. Broy, B. Jonsson, J.-P. Katoen, M. Leucker, A. Pretschner: Model-Based Testing of Reactive Systems - Springer, 2005
- A. Bauer, M. Leucker, C. Schallhart: Runtime Verification for LTL and TLTL - ACM TOSEM, 2011
- C. Baier, J.-P. Katoen: Principles of Model Checking - MIT Press, 2008
- D. Peled: Software Reliability Methods - Springer, 2001

Language:

- English, except in case of only German-speaking participants

Notes:

(Is equal to CS4139)
(Part of Module CS4507)

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester.

CS4140 T - Module part: Mobile and Distributed Databases (MVDBa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Mobile und verteilte Datenbanken (lecture, 2 SWS)
- Mobile und verteilte Datenbanken (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- The contents of the lecture covers query processing, transactions and replication in
- - centralised database management systems
- - parallel database management systems
- - distributed database management systems
- - mobile database management systems

Qualification-goals/Competencies:

- Students can explain the differences between centralised, parallel, distributed and mobile database management systems.
- They can judge about the practical suitability of different synchronization approaches for distributed and mobile transactions for a given problem.
- They can apply approaches for distributed and mobile query processing.
- They can choose suitable replication approaches for a given application and justify their choices.
- They can recognize and deal with the special difficulties and sources of error in distributed and mobile environments.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Information Systems
- Prof. Dr. Sven Groppe

Literature:

- A. Kemper, A. Eickler: Datenbanksysteme - 2006
- T. Conolly, C. Begg: Database Systems - A Practical Approach to Design, Implementation, and Management - Addison-Wesley 2005
- E. Rahm: Mehrrechner-Datenbanksysteme - Addison-Wesley 1994
- P. Dadam: Verteilte Datenbanken und Client/Server Systeme - Springer 1996
- H. Höpfner, C. Türker, B. König-Ries: Mobile Datenbanken und Informationssysteme - dpunkt.verlag 2005
- B. Mutschler, G. Specht: Mobile Datenbanksysteme - Springer 2004
- V. Kumar: Mobile Database Systems - Wiley-Interscience 2006

Language:

- offered only in German

Notes:

(Is equal to CS4140)
(Is module part of CS4508)

Entry requirements for taking the module:
- None

Admission requirements for taking module examination(s):
- see higher-level module

Module examination(s):
- see superordinate module

CS4151 T - Module part: Architectures for Distributed Applications (SVAa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Architectures for Distributed Applications (lecture, 2 SWS)
- Architectures for Distributed Applications (exercise, 1 SWS)

Workload:

- 45 Hours private studies
- 45 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- Motivation
- Software Architectures
- Basics: HTTP, XML & Co
- N-Tier Applications
- Service-Oriented and Event-Driven Architectures (SOA and EDA)
- Web-Oriented Architectures (Web 2.0)
- Overlay Networks
- Peer-to-Peer
- Grid and Cloud Computing
- Internet of Things

Qualification-goals/Competencies:

- The students are able to name the most important archiectures for distributed systems, explain them, and compare them to each other.
- For each architecture, they know the most prominent and important implementation platforms and basically know how to use them.
- For a given problem, they can analyze which architecture is best suited to solve it, and they can design a plan for the solution's realization.

Grading through:

- exam type depends on main module

Responsible for this module:

- Prof. Dr.-Ing Horst Hellbrück

Teacher:

- Institute of Telematics
- Prof. Dr.-Ing Horst Hellbrück

Literature:

- J. Dunkel, A. Eberhart, S. Fischer, C. Kleiner, A. Koschel: Systemarchitekturen für verteilte Anwendungen - Hanser-Verlag 2008
- I. Melzer et.al.: Service-Orientierte Architekturen mit Web Services - Spektrum-Verlag 2010

Language:

- offered only in German

Notes:

IMPORTANT: No longer takes place as a module part of CS4509. Please now pay attention to the modules CS4151 and CS4517!

(Was module part of CS4509)
(Is equal to CS4151)
(Share of telematics in everything is 100%)

Entry requirements for taking the module:
- None

Admission requirements for taking module examination(s):
- see higher-level module

Module examination(s):
- see superordinate module

CS4220 T - Module part: Pattern Recognition (MEa)

Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Computer Science 2014 (module part), advanced curriculum, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st semester
- Master Computer Science 2014 (Module part of a compulsory module), specialization field robotics and automation, Arbitrary semester

Classes and lectures:

- Pattern Recognition (lecture, 2 SWS)
- Pattern Recognition (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Introduction to probability theory
- Principles of feature extraction and pattern recognition
- Bayes decision theory
- Discriminance functions
- Neyman-Pearson test
- Receiver Operating Characteristic
- Parametric and nonparametric density estimation
- kNN classifiers
- Linear classifiers
- Support vector machines and kernel trick
- Random Forest
- Neural Nets
- Feature reduction and feature transforms
- Validation of classifiers
- Selected application scenarios: acoustic scene classification for the selection of hearing-aid algorithms, acoustic event recognition, attention classification based on EEG data, speaker and emotion recognition

Qualification-goals/Competencies:

- Students are able to describe the main elements of feature extraction and pattern recognition.
- They are able to explain the basic elements of statistical modeling.
- They are able to use feature extraction, feature reduction and pattern classification techniques in practice.

Grading through:

- exam type depends on main module

Responsible for this module:

- Prof. Dr.-Ing. Alfred Mertins

Teacher:

- Institute for Signal Processing
- Prof. Dr.-Ing. Alfred Mertins

Literature:

- R. O. Duda, P. E. Hart, D. G. Storck: Pattern Classification - New York: Wiley

Language:

- offered only in German

Notes:

Admission requirements for the module:
- None

Admission requirements for the examination:
- Successful completion of the exercises during the semester (at least 50% of the achievable points).

Module Exam:
- CS4220-L1: Pattern Recognition, written exam, 90 min, 100% of module grade.

(Is equal to CS4220SJ14)
(Is module part of CS4510, CS4290, CS5274-KP08)

CS4405 T - Module part: NeuroInformatics (NeuroInfa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Biophysics 2023 (module part), advanced curriculum, 2nd semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Medical Informatics 2019 (module part), Module part, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 2nd semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Medical Informatics 2014 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 2nd semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- NeuroInformatics (lecture, 2 SWS)
- NeuroInformatics (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- The human brain and abstract neuron models
- Learning with a single neuron:* Perceptrons* Max-Margin Classification* LDA and logistic Regression
- Network architectures:* Hopfield-Networks* Multilayer-Perceptrons* Deep Learning
- Unxupervised Learning:* k-means, Neural Gas and SOMs* PCA & ICA* Sparse Coding

Qualification-goals/Competencies:

- The students are able to understand the principle function of a single neuron and the brain as a whole.
- They know abstract neuronal models and they are able to name practical applications for the different variants.
- They are able to derive a learning rule from a given error function.
- They are able to apply (and implement) the proposed learning rules and approaches to solve unknown practical problems.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Neuro- and Bioinformatics
- Prof. Dr. rer. nat. Thomas Martinetz

Literature:

- S. Haykin: Neural Networks - London: Prentice Hall, 1999
- J. Hertz, A. Krogh, R. Palmer: Introduction to the Theory of Neural Computation - Addison Wesley, 1991
- T. Kohonen: Self-Organizing Maps - Berlin: Springer, 1995
- H. Ritter, T. Martinetz, K. Schulten: Neuronale Netze: Eine Einführung in die Neuroinformatik selbstorganisierender Netzwerke - Bonn: Addison Wesley, 1991

Language:

- offered only in German

Notes:

Examination prerequisites can be defined at the beginning of the semester. If prerequisite courses are defined, they must have been completed and positively evaluated before the first examination.

(Is module part of CS4410, CS4511)
(Is equal to CS4405)

Admission requirements for the module:
- None

Admission requirements for the examination:
- Successful completion of exercises during the semester.

Translated with www.DeepL.com/Translator (free version)

CS4440 T - Module part: Molecular Bioinformatics (MolBioInfa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Biophysics 2023 (module part), advanced curriculum, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, Arbitrary semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Medical Informatics 2019 (module part), Module part, Arbitrary semester
- Master MLS 2009 (Module part of a compulsory module), interdisciplinary competence, 1st semester
- Master Medical Informatics 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Molecular Bioinformatics (lecture, 2 SWS)
- Molecular Bioinformatics (exercise, 1 SWS)

Workload:

- 45 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Methods for fast genome comparison
- Analysis of data describing gene expression profiles and sequence variation
- Advanced usage of biological databases (for sequences, motifs, structures, gene regulation and interactions)

Qualification-goals/Competencies:

- The students can apply indexing based software to Next Generation sequence data.
- They can use and design databases for molecularbiological research.
- They are able to detect statistically significant changes in Microarray data.

Grading through:

- exam type depends on main module

Requires:

- Introduction to Bioinformatics (CS1400-KP04, CS1400)

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Neuro- and Bioinformatics
- Prof. Dr. Bernhard Haubold
- Prof. Dr. rer. nat. Thomas Martinetz
- Prof. Lars Bertram
- MitarbeiterInnen des Instituts

Literature:

- M. S. Waterman: Introduction to Computational Biology - London: Chapman and Hall 1995
- B. Haubold, T. Wiehe: Introduction to Computational Biology - Birkhäuser 2007
- R. Durbin, S. Eddy, A. Krogh, G. Mitchison: Biological sequence analysis. Probabilistic models - Cambridge, MA: Cambridge University Press
- J. Setubal, J. Meidanis: Introduction to computational molecular - Pacific Grove: PWS Publishing Company
- D. M. Mount: Bioinformatics - Sequence and Genome - New York: Cold Spring Harbor Press

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None (The competences of the required modules are required for this module, but the modules are not a prerequisite for admission.)

Prerequisites for the exam:
- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the initial examination.

This modul is for Master MLS the Modulpart B of Modul LS4060 with 5 credit points.

CS4670 T - Module part: Ambient Computing (AmbCompa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Ambient Computing (lecture, 3 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Current paradigms in computer technology
- Smart components
- Software architectures
- Context-sensitive systems
- Ambient Intelligence
- Interactive ambient media systems
- Ambient Computing Applications (AAL)
- Ethical, Legal and Social Implications (ELSI).

Qualification-goals/Competencies:

- The students are able to evaluate possibilities, concepts and challenges of Ambient Systems
- They have an overview about current technologies and systems for developing Ambient Systems
- They are able to follow and judge state-of-the-art research in the area of Ambient Computing

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Telematics
- Prof. Dr.-Ing. Andreas Schrader

Literature:

- John Krumm: Ubiquitous Computing Fundamentals - CRC Press, 2009
- Stefan Poslad: Ubiquitous Computing: Smart Devices, Environments and Interactions - Wiley, 2009
- Uwe Hansman et al: Pervasive Computing - Springer, 2003

Language:

- English, except in case of only German-speaking participants

Notes:

(Is part of the module CS4503-KP12)

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- see higher-level module

Module examination(s):
- see superordinate module

CS5131 T - Module part: Web-Mining Agents (WebMininga)

Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	8

Course of study, specific field and term:

- Certificate in Artificial Intelligence (Module part of a compulsory module), Module part, 1st semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Web-Mining Agents (lecture, 4 SWS)
- Web-Mining Agents (exercise, 1 SWS)
- Web-Mining Agents (practical course, 1 SWS)

Workload:

- 120 Hours private studies
- 90 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- Probabilities and generative models for discrete data
- Gaussian models, Bayesian and frequentist statistics, regression,
- Probabilistic graphical models (e.g., Bayesian networks), learning parameters and structures of probabilistic graphical models (BME, MAP, ML, EM algorithm), probabilistic classification, probabilistic relational models
- Probabilistic reasoning over time (dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, hidden Markov models, Kalman filters, exact inferences and approximations, learning dynamic Bayesian networks)
- Structural Causal Networks (Intervention, instrumental Variables, counterfactuals)
- Mixture models, latent linear models (LDA, LSI, PCA), sparse linear models,
- Decision making under uncertainty (utility theory, decision networks, value of information, sequential decision problems, value iteration, policy iteration, MDPs, decision-theoretic agents, POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks)
- Game theory, decisions with multiple agents (Nash equilibrium, Bayes-Nash equilibrium), social choice (voting, preferences, paradoxes, Arrow's Theorem, mechanism design (controlled autonomy), rules of encounter
- Building and exchanging symbolic annotations for web data (from named entity recognition to discourse representations)
- Building and exchanging symbolic annotations for web data (from named entity recognition to discourse representations)
- Information association, retrieval, query answering and recommendation

Qualification-goals/Competencies:

- Knowledge:Students can explain the agent abstraction, define web mining of rational behavior, and give details about the design of mining agents (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperation can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in real-world scenarios, students can summarize how Bayesian networks can be employed as a knowledge representation and reasoning formalism in static and dynamic settings. In addition, students can define decision making procedures in simple and sequential settings, with and with complete access to the state of the environment. In this context, students can describe techniques for solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information. Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of different types of equilibria, social choice functions, voting protocol, and mechanism design techniques.Students can explain the difference between instance-based and model-based learning approaches, and they can enumerate basic machine learning technique for each of the two basic approaches, either on the basis of static data, or on the basis of incrementally incoming data . For dealing with uncertainty, students can describe suitable representation formalisms, and they explain how axioms, features, parameters, or structures used in these formalisms can be learned automatically with different algorithms. Students are also able to sketch different clustering techniques. They depict how the performance of learned classifiers can be improved by ensemble learning, and they can summarize how this influences computational learning theory. Algorithms for reinforcement learning can also be explained by students.
- Skills:Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesian networks/dynamic Bayesian networks and apply Bayesian reasoning for simple queries. Students can also name and apply different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute the best action or policies for concrete settings. In multi-agent situations students will apply techniques for finding different equilibria states, e.g., Nash

equilibria. For multi-agent decision making students will apply different voting protocols and compare and explain the results.Students derive decision trees and, in turn, propositional rule sets from static data as well and temporal or streaming data. Students present and apply the basic idea of first-order inductive leaning. They apply the BME, MAP, ML, and EM algorithms for learning parameters of Bayesian networks and compare the different algorithms. They also know how to carry out Gaussian mixture learning. Students can describe basic clustering techniques and explain the basic components of those techniques. Students compare related machine learning techniques, e.g., k-means clustering and nearest neighbor classification. They can distinguish various ensemble learning techniques and compare the different goals of those techniques.

- Social competence: Students work in groups in order to solve small exercise and project assignments and present them in short talks in the plenum. In the associated project lab the students the develop a larger project using up-to-date programing languages and software tools for data science applications.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Information Systems
- Prof. Dr. rer. nat. habil. Ralf Möller
- PD Dr. Özgür Özçep

Literature:

- M. Hall, I. Witten and E. Frank: Data Mining: Practical Machine Learning Tools and Techniques - Morgan Kaufmann, 2011
- D. Koller, N. Friedman: Probabilistic Graphical Models: Principles and Techniques - MIT Press, 2009
- K. Murphy: Machine Learning: A Probabilistic Perspective - MIT Press, 2012
- S. Russel, P. Norvig: Artificial Intelligence: A Modern Approach - Pearson Education, 2010
- Y. Shoham, K. Leyton-Brown: Multiagent-Systems: Algorithmic, Game-Theoretic, and Logical Foundations - Cambridge University Press, 2009
- : References to journal articles on special themes are given in the lecture

Language:

- offered only in English

Notes:

Admission requirements for the module:
- None

Admission requirements for the examination:
- Examination prerequisites may be defined at the beginning of the semester. If prerequisites are defined, they must have been completed and positively evaluated prior to the initial examination.

The competencies of the following modules are required for this module (no hard admission requirement):
- Algorithms and Data Structures (CS1001).
- Linear Algebra and Discrete Structures I + II (MA1000, MA1500)
- Databases (CS2700)
- Stochastics 1 (MA2510) or Fundamentals of Statistics (PY1800)
- Introduction to Logic (CS1002)
- Artificial Intelligence 1 (CS3204)
- Information Systems (CS4130)

(Equals CS5131)
(Is module part of CS4513, CS4514-KP12)

CS5140 T - Module part: Semantic Web (SemWeba)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Semantic Web (lecture, 2 SWS)
- Semantic Web (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Introduction with overview of the W3C Semantic Web family of languages
- Data management for Semantic Web data, in particular indexing approaches
- Query processing for Semantic Web queries (central, parallel, and distributed, in particular in the cloud)
- Processing strategies for Semantic Web rules and ontologies

Qualification-goals/Competencies:

- Students can judge about the possibilities and limits of the Semantic Web.
- They can evaluate the consequences of the Semantic Web approach for data modelling, adminstration and processing, and finally for applications.
- They can develop Semantic Web applications.
- They can explain and apply specialized approaches for Semantic Web databases.
- They can discuss about open research questions in the area of the Semantic Web.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Information Systems
- Prof. Dr. Sven Groppe

Literature:

- P. Hitzler, M. Krötzsch, S. Rudolph: Foundations of Semantic Web Technologies - Chapman & Hall / CRC, 2009
- T. Segaran, J. Taylor, C. Evans: Programming the Semantic Web - O'Reilly, 2009
- F. Bry, J. Maluszynski: Semantic Techniques for the Web - Springer, 2009
- J. T. Pollock: Semantic Web for Dummies - Wiley, 2009
- J. Hebeler, M. Fisher, R. Blace, A. Perez-Lopez, M. Dean: Semantic Web Programming - Wiley, 2009
- G. Antoniou, F. van Harmelen: A Semantic Web Primer - MIT Press, 2008
- V. Kashyap, C. Bussler, M. Moran: The Semantic Web - Springer, 2008
- S. Groppe: Data Management and Query Processing in Semantic Web Databases - Springer, 2011

Language:

- offered only in German

Notes:

(Is equal to CS5140)
(Is module part of CS4508)

Entry requirements for taking the module:
- None

Admission requirements for taking module examination(s):
- see higher-level module

Module examination(s):
- see superordinate module

CS5150 T - Module part: Organic Computing (OrganicCoa)

Duration:	Turnus of offer:	Credit points:
1 Semester	normally each year in the winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (Module part of a compulsory module), Module part, Arbitrary semester

Classes and lectures:

- Organic Computing (lecture, 2 SWS)
- Organic Computing (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Basic principles of Organic Computing
- Self-organization and emergence
- Architecture and design of Organic Computing systems
- Organic Computing for distributed systems
- Organic Computing in Neuro- and Bionformatics
- Organic Grid
- Autonomous Systems

Qualification-goals/Competencies:

- Students are able to utilize the principles of organic computing on exemplary designs.
- They are able to explain the principles of Organic Computing.
- They are able to analyze emergence behavior in Organic Computing systems.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Computer Engineering
- Dr. rer. nat. Javad Ghofrani

Literature:

- C. Müller-Schloer, H. Schmeck, T. Ungerer: Organic Computing A Paradigm Shift for Complex Systems - Birkhäuser, 2011
- R. P. Würtz: Organic Computing - Springer, 2008
- C. Klüver, J. Kluever, J. Schmidt: Modellierung komplexer Prozesse durch naturanaloge Verfahren - Springer Vieweg 2012

Language:

- offered only in German

Notes:

(Part of Module CS4290, CS4504-KP12)

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS5150-L1: Organic Computing, oral exam, 100% of the module grade

CS5153 T - Module part: Wireless Sensor Networks (DlSensorNa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Computer Science 2014 (Module part of a compulsory module), specialization field robotics and automation, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), advanced curriculum, Arbitrary semester

Classes and lectures:

- Wireless Sensor Networks (lecture, 2 SWS)
- Wireless Sensor Networks (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Basics of Sensor Networks
- Architecture of Sensor Nodes and Sensor Networks
- Identities and addressing
- Wireless communication
- Data management and topology control
- Localization
- Energy harvesting
- Applications

Qualification-goals/Competencies:

- The students are able to present the potential, benefits and limitations of sensor networks.
- They are able to cope with analysis, design, and evaluation of protocols in sensor networks.
- They are able to interpret and pursue current research activities for sensor networks.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Computer Engineering
- Dr. rer. nat. Javad Ghofrani

Literature:

- H. Karl, A. Willig: Protocols and Architectures of Wireless Sensor Networks, - Wiley, 2005
- F. Zhao, L. Guibas: Wireless Sensor Networks - Morgan Kaufmann, 2004
- B.-C. Renner: Sustained Operation of Sensor Nodes with Energy Harvesters and Supercapacitors - Books on Demand 2013

Language:

- German and English skills required

Notes:

(Part of Modules CS4504-KP12)
(Is equal to CS5153)

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS5153-L1: Wireless Sensor Networks, oral exam, 100% of the module grade

CS5158 T - Module part: Advanced Internet Technologies (AdInternea)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Advanced Internet Technologies (lecture, 2 SWS)
- Advanced Internet Technologies (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Introduction and fundamentals
- Fundamental Internet design principles
- Problems of today's Internet architecture
- Backbone Technologies
- Mobile Internet
- IPv6 und related topics
- Delay Tolerant Networks (DTN)
- Internet of Services / Internet of Things
- Peer-To-Peer networks
- Big Data
- Goals, architectures, algorithms, and protocols for the future Internet

Qualification-goals/Competencies:

- Understand the fundamental design decisions that have led to today's Internet architecture
- Understand the original design goals of the Internet and realize the implications that the emphasis on certain of them has on today's networks
- Learn about essential, universally valid criteria for the design of networks and applications (e.g., end-to-end argument, fate sharing, etc.)
- Know technological as well as societal developments that have led to massive changes in the Internet's infrastructure (growth, innovations, mobile communications,)
- Identify problems of the Internet's architecture and understand potential solutions by comparing different approaches
- Become acquainted with the Future Internet research field and learn about novel approaches to research and shape the Internet of the future

Grading through:

- exam type depends on main module

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics
- Dr. Mohamed Hail

Literature:

- Olivier Hersent, David Boswarthick, Omar Elloumi: The Internet of Things: Key Applications and Protocols - Wiley, 2012
- Athanasios V. Vasilakos, Yan Zhang, Thrasyvoulos Spyropoulos: Delay Tolerant Networks: Protocols and Applications - CRC Press, 2012
- E. Pacitti, R. Akbarinia, M. El-Dick: P2P Techniques for Decentralized Applications - Morgan & Claypool Publishers

Language:

- German and English skills required

Notes:

IMPORTANT: No longer takes place as a module part of CS4509. Please now pay attention to the modules CS5158 and CS4518!

(Was module part of CS4509)
(Is equal to CS5158)

Entry requirements to take the module:
- None

Admission requirements for participation in module examination(s):
- See higher-level module

Module examination(s):
- see superordinate module

CS5170 T - Module part: Hardware/Software Co-Design (HWSWCoda)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Hardware/Software Co-Design (lecture, 2 SWS)
- Hardware/Software Co-Design (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- System design flow
- Basic architectures for HW/SW systems
- System design and modelling
- System synthesis
- Algorithms for scheduling
- System partitioning
- Algorithms for system partitioning
- Design systems
- Performance analysis
- System design and specification with SystemC
- Application examples

Qualification-goals/Competencies:

- Students are able to determine a suitable hardware/software architecture for a given system description
- They are able to determine and describe the pros and cons of implementation alternatives
- They are able to apply methods for system partitioning
- They are able to translate non-formal system descriptions into formal models
- They are able to explain the different steps in system synthesis
- They are able to estimate the quality of system designs
- They are able to create system descriptions in SystemC

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Computer Engineering
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- F. Kesel: Modellierung von digitalen Systemen mit SystemC - Oldenbourg Verlag 2012
- Teich, J., Haubelt, C.: Digital Hardware/Software-Systeme. Synthese und Optimierung - Berlin: Springer 2007

Language:

- offered only in German

Notes:

(Is module part of CS4290, CS4505)
(Is equal to CS5170)

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS5170-L1: Hardware/Software Co-Design, oral exam, 100% of the module grade

CS5194 T - Module part: Practical Project in Signal and Image Processing (PrSigBildv)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second semester	4 (Typ B)

Course of study, specific field and term:

- Master Biophysics 2023 (module part), advanced curriculum, 1st or 2nd semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 1st or 2nd semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- iRoom (practical course, 3 SWS)

Workload:

- 60 Hours group work
- 40 Hours private studies
- 20 Hours written report

Contents of teaching:

- Planning and realization of typical signal processing applications in a team

Qualification-goals/Competencies:

- Students will have comprehensive knowledge of using signal and image processing algorithms in practice.
- They are able to realize signal processing systems in teamwork and in a self-directed manner.
- They have the communication competency to document and present project results.

Grading through:

- exam type depends on main module

Requires:

- Signal processing (CS3100-KP04)
- Image processing (CS3203)

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Signal Processing
- Prof. Dr.-Ing. Alfred Mertins
- MitarbeiterInnen des Instituts

Language:

- offered only in German

Notes:

(Part of Module CS4510)

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- The project must be completed in order to take the exam in the module CS4510

Modul Exam:
- CS4510-L1: Signal Analysis, oral exam consisting out of Pattern Recognition, Selected Topics of Signal Analysis and Enhancement and

this project, 100% of module grade

CS5220 T - Module parte: Static Analysis (StatAnaa)

Duration:	Turnus of offer:	Credit points:
1 Semester	normally each year in the winter semester	6

Course of study, specific field and term:

- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester

Classes and lectures:

- Static Analysis (lecture, 3 SWS)
- Static Analysis (exercise, 1 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Definitions, capabilities, differentiation
- Program analysis
- Data flow analysis
- Abstract Interpretation
- Symbolic Execution
- SMT/SAT Solvers
- Hoare logic, wp calculus
- Software metrics
- Bytecode analysis
- Manual code inspection

Qualification-goals/Competencies:

- The students can illustrate the capabilities of static analysis.
- They can explain and classify the techniques for automatic static source code analysis.
- They can select appropriate analysis methods, and employ and combine them.
- They can relate, compare and evaluate various static methods in order to increase software quality.
- They can describe approaches for bytecode analysis.
- They can select and apply common tools for static analysis.
- They can organize and execute manual code inspections.

Grading through:

- exam type depends on main module

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages
- Prof. Dr. Martin Leucker

Literature:

- F. Nielson, H.R. Nielson, C. Hankin: Principles of Program Analysis - Springer, 2010
- H. Seidl, R. Wilhelm, S. Hack: Übersetzerbau Band 3: Analyse und Transformation - Springer 2010

Language:

- English, except in case of only German-speaking participants

Notes:

(Part of Module CS4507-KP12)

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester

CS5260SJ14 T - Module part: Speech and Audio Signal Processing (SprachA14a)

Duration:	Turnus of offer:	Credit points:
1 Semester	normally each year in the summer semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Biophysics 2023 (module part), advanced curriculum, 1st and 2nd semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 1st or 2nd semester
- Master IT-Security 2019 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (Module part of a compulsory module), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st or 2nd semester

Classes and lectures:

- Speech and Audio Signal Processing (lecture, 2 SWS)
- Speech and Audio Signal Processing (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Speech production and human hearing
- Physical models of the auditory System
- Dynamic compression
- Spectral analysis: Spectrum and Cepstrum
- Spectral perception and masking
- Vocal tract models
- Linear prediction
- Coding in time and frequency domains
- Speech synthesis
- Noise reduction and echo compensation
- Source localization and spatial reproduction
- Basics of automatic speech recognition

Qualification-goals/Competencies:

- Students are able to describe the basics of human speech production and the corresponding mathematical models.
- They are able to describe the process of human auditory perception and the corresponding signal processing tools for mimicing auditory perception.
- They are able to present basic knowledge of statistical speech modeling and automatic speech recognition.
- They can describe and use signal processing methods for source separation and room-acoustic measurements.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Signal Processing
- Prof. Dr.-Ing. Alfred Mertins

Literature:

- L. Rabiner, B.-H. Juang: Fundamentals of Speech Recognition - Upper Saddle River: Prentice Hall 1993
- J. O. Heller, J. L. Hansen, J. G. Proakis: Discrete-Time Processing of Speech Signals - IEEE Press

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of assignments during the semester.

Module examination(s):
- see superordinate module

(Is modul part of CS4290, CS4510, RO4290-KP04)
(Is the same as CS5260SJ14)

CS5275 T - Module part: Selected Topics of Signal Analysis and Enhancement (AMSAVa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Robotics and Autonomous Systems 2019 (module part), Module part Current Issues Robotics and Automation, 1st and/or 2nd semester
- Master Biophysics 2023 (module part), advanced curriculum, 2nd semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 2nd semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st or 2nd semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Selected Topics of Signal Analysis and Enhancement (lecture, 2 SWS)
- Selected Topics of Signal Analysis and Enhancement (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Introduction to statistical signal analysis
- Autocorrelation and spectral estimation
- Linear estimators
- Linear optimal filters
- Adaptive filters
- Multichannel signal processing, beamforming, and source separation
- Compressed sensing
- Basic concepts of multirate signal processing
- Nonlinear signal processing algorithms
- Application scenarios in auditory technology, enhancement, and restauration of one- and higher-dimensional signals, Sound-field measurement, noise reduction, deconvolution (listening-room compensation), inpainting

Qualification-goals/Competencies:

- Students are able to explain the basic elements of stochastic signal processing and optimum filtering.
- They are able to describe and apply linear estimation theory.
- Students are able to describe the concepts of adaptive signal processing.
- They are able to describe and apply the concepts of multichannel signal processing.
- They are able to describe the concept of compressed sensing.
- They are able to analyze and design multirate systems.
- Students are able to explain various applications of nonlinear and adaptive signal processing.
- They are able to create and implement linear optimum filters and nonlinear signal enhancement techniques on their own.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Signal Processing
- Prof. Dr.-Ing. Alfred Mertins

Literature:

- A. Mertins: Signaltheorie: Grundlagen der Signalbeschreibung, Filterbänke, Wavelets, Zeit-Frequenz-Analyse, Parameter- und

Signalschätzung - Springer-Vieweg, 3. Auflage, 2013
- S. Haykin: Adaptive Filter Theory - Prentice Hall, 1995

Language:
- offered only in German

Notes:

(Part of modules CS4290, CS4510, CS5400, RO4290-KP04, CS5274-KP08)
(Is equal to CS5275)

For Details see main module.

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester (at least 50%).

Modul exam in Main module:
- CS5275-L1: Selected Topics of Signal Analysis and Enhancement, written or oral exam, 100% of modul grade

CS5410 T - Module part: Artificial Life (ArtiLifea)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Artificial Life (lecture, 2 SWS)
- Artificial Life (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Properties, flavors and kinds of (artificial) life
- Artificial chemistry and self-replicating code
- Introduction to information theory
- Introduction to statistical mechanics and thermodynamics
- Complex networks and NK models
- Evolutionary algorithms
- Emergence
- Cellular automata
- Game of life
- Tierra
- Ant algorithms

Qualification-goals/Competencies:

- Students are able to classify models of artificial life, artificial chemistry and self-replicating code.
- Students have the competence to explain the mathematical concepts of information theory.
- Students are able to implement and mathematically analyze cellular automata and complex networks.
- Students can formulate mutualistic interactions through Boolean networks and game-theoretic models and can relate them to biological or socioeconomic systems.
- Students have the methodological competence to design evolutionary algorithms and to review them in the context of statistical mechanics and thermodynamics.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Neuro- and Bioinformatics
- Prof. Dr. rer. nat. Thomas Martinetz
- PD Dr. rer. nat. Jens Christian Claussen

Literature:

- Christoph Adami: Introduction to Artificial Life - Springer Verlag, 1998

Language:

- English, except in case of only German-speaking participants

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework and project assignments during the semester.

CS5430 T - module part: Seminar Machine Learning (SemMaschLa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Biophysics 2023 (module part), advanced curriculum, 2nd semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 2nd semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Seminar Machine Learning (seminar, 2 SWS)

Workload:

- 70 Hours private studies
- 30 Hours in-classroom work
- 20 Hours work on an individual topic with written and oral presentation

Contents of teaching:

- Independent study of a specific field of machine learning

Qualification-goals/Competencies:

- Students can read and understand scientific articles in the field of machine learning.
- Students can present the contents of scientific articles in the field of machine learning in a talk.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Neuro- and Bioinformatics
- Prof. Dr.-Ing. Erhardt Barth
- MitarbeiterInnen des Instituts

Language:

- German and English skills required

Notes:

Admission requirements for the module:
- None

Admission requirements for the examination:
- Examination prerequisites may be defined at the beginning of the semester. If prerequisites are defined, they must have been completed and positively evaluated prior to the initial examination.

(Is part of the module CS4511)

CS5440 T - Module part: Seminar Neuro- and Bioinformatics (SemNeurBia)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Seminar Neuro- and Bioinformatics (seminar, 2 SWS)

Workload:

- 70 Hours private studies
- 30 Hours in-classroom work
- 20 Hours work on an individual topic with written and oral presentation

Contents of teaching:

- Introduce students to a current research topic in Neuro- and Bioinformatics

Qualification-goals/Competencies:

- The students are able to read and understand scientific publications in the field of neuro- uand bioinformatics.
- They are able to present orally and in a written paper the content of scientific publications in the field of neuro- and bioinformatics.
- The students can master basic scientific methodology.
- They can summarize a scientific topic in written form.
- They can give an intelligible and concise oral presentation of a current research topic.
- They have communication competency to discuss a current research topic.

Grading through:

- oral presentation
- term paper
- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Neuro- and Bioinformatics
- Prof. Dr. rer. nat. Thomas Martinetz
- Prof. Dr.-Ing. Erhardt Barth
- MitarbeiterInnen des Instituts

Language:

- English, except in case of only German-speaking participants

Notes:

Prerequisites for attending the module:
- None

CS5450 T - Module part: Machine Learning (MaschLerna)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Biophysics 2023 (module part), advanced curriculum, 1st semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 1st semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st or 2nd semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Machine Learning (lecture, 2 SWS)
- Machine Learning (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Representation learning, including manifold learning
- Statistical learning theory
- VC dimension and support vector machines
- Boosting
- Deep learning
- Limits of induction and importance of data ponderation

Qualification-goals/Competencies:

- Students can understand and explain various machine-learning problems.
- They can explain and apply different machine learning methods and algorithms.
- They can chose and then evaluate an appropriate method for a particular learning problem.
- They can understand and explain the limits of automatic data analysis.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Neuro- and Bioinformatics
- Prof. Dr.-Ing. Erhardt Barth
- Prof. Dr. rer. nat. Thomas Martinetz

Literature:

- Chris Bishop: Pattern Recognition and Machine Learning - Springer ISBN 0-387-31073-8
- Vladimir Vapnik: Statistical Learning Theory - Wiley-Interscience, ISBN 0471030031
- Tom Mitchell: Machine Learning - McGraw Hill. ISBN 0-07-042807-7

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester.

Module Exam(s):
- CS5450-L1: Machine Learning, oral exam, 100% of module grade.

(Is part of the module CS4290, CS4511, CS5400, CS4251-KP08)

CS5549 T - Module part: Project Bioinformatics (PrBioinfa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester

Classes and lectures:

- Projektpraktikum Bioinformatik (practical course, 3 SWS)

Workload:

- 45 Hours private studies
- 45 Hours in-classroom work
- 30 Hours group work

Contents of teaching:

- Project for solving a molecular biology problem with computational methods
- Project for implementing biological information principles in technical systems

Qualification-goals/Competencies:

- The students can plan a project and realize in a team and with milestones.
- They can apply bioinformatics software.
- They are able to implement learning algorithms.

Grading through:

- exam type depends on main module
- continuous, successful participation in practical course, >80%

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Martinetz

Teacher:

- Institute for Neuro- and Bioinformatics

- Prof. Dr. rer. nat. Thomas Martinetz
- Prof. Dr.-Ing. Erhardt Barth
- Prof. Dr. Bernhard Haubold
- MitarbeiterInnen des Instituts

Language:

- German and English skills required

EW4170 T - module part: System Biology (SystBioT)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester

Classes and lectures:

- Introduction to classic and translational system biology (lecture, 2 SWS)
- Introduction to classic and translational system biology (exercise, 2 SWS)

Workload:

- 60 Hours in-classroom work
- 50 Hours private studies
- 10 Hours exam preparation

Contents of teaching:

- Introduction to the genome and proteome of cellular systems
- Networks: cellular, genetic, gene-regulatory networks, interactomes
- Analysis of dynamical systems: fixed points, bifurcations and feedback
- Bioinformatic analysis of Omics data
- Introduction to public databases: e.g. STRING, Gene Expression Omnibus, TCGA, KEGG, Reactome, MSigDB
- Exercises: computer lab for analysis of dynamical systems and cellular pathways in R
- Usage, analysis and visualization of high-dimensional data in R
- Exercises for the analysis of protein interaction networks
-

Qualification-goals/Competencies:

- The students can explain the principles of signal transduction in the cell
- The students can relate to the genome, transcriptome, interactome and proteome
- They can analyse and characterize dynamical systems
- They know common methods to analyse high-throughput data
- Lab work will enable the students to continue studying this subject on their own

Grading through:

- Exercises
- written exam

Responsible for this module:

- Prof. Dr. Hauke Busch

Teacher:

- LIED | Lübecker Institut für experimentelle Dermatologie (Lübeck Institute of Experimental Dermatology)
- Prof. Dr. Hauke Busch
- Dr. Axel Künstner
- MitarbeiterInnen des Instituts

Literature:

- Marian Walhout, Marc Vidal, Job Dekker: Handbook of Systems Biology: Concepts and Insights - (Englisch) Gebundene Ausgabe 15. November 2012
- Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald;: Systems Biology: A Textbook - Englisch) Taschenbuch 20. April 2016
- Yoram Vodovotz and Gary: An Translational Systems Biology, Concepts and Practice for the Future of Biomedical Research

Language:

- offered only in English

LS1600 T - Module part: Organic Chemistry (OCMIa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Organic Chemistry (lecture, 3 SWS)

Workload:

- 80 Hours private studies
- 40 Hours in-classroom work

Contents of teaching:

- Introduction
- Alkanes, cycloalkanes
- Alkene and alkynes
- Aromatic compounds
- Stereoisomery
- Substitution and elimination reactions
- Alcohols, phenols and thiols
- Ether and epoxides
- Aldehydes and ketones
- Carboxylic acids and derivates
- Amines and derivates
- Heterocycles
- Lipids
- Carbohydrates
- Amino acids and peptides
- Nucleotides and nucleic acids

Qualification-goals/Competencies:

- Understanding the principles of organic chemistry

Grading through:

- written exam

Requires:

- Basic Chemistry (LS1100-INF)

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Chemistry and Metabolomics
- PD Dr. phil. nat. Thomas Weimar

Literature:

- Hart, H., L. E. Craine, D. J. Hart: Organische Chemie - Wiley-VCH
- Buddrus, J.: Organische Chemie - De Gruyter Verlag

Language:

- offered only in German

Notes:

Knowledge of basic chemistry (such as from LS1100-INF) is required.

Prerequisites for attending the module:
- None

MA2600 T - Module part: Biostatistics 2 (BioStat2a)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Biostatistics 2 (lecture, 2 SWS)
- Biostatistics 2 (exercise, 1 SWS)

Workload:

- 45 Hours in-classroom work
- 35 Hours private studies
- 25 Hours programming
- 15 Hours exam preparation

Contents of teaching:

- Knowledge of model assumptions and mathematical foundation of model assumptions for the linear model
- Knowledge of possible sources of errors in the modelling
- Competence in independent analysis of a study using the linear model
- Competence in correctly interpreting study results
- Competence in parameter interpretation and regression diagnostics
- Knowledge of model assumptions and mathematical foundation of the generalized linear model
- Competence in the independent analysis of a simple study with a dichotomous outcome
- Competence in correctly interpreting study results of a study with a dichotomous outcome

Qualification-goals/Competencies:

- The students are able to enumerate and explain the assumptions of the classical linear model.
- The students are able to describe typical applications of the classical linear model.
- The students are able to list the differences between the linear model and the logistic regression model.
- The students are able to describe possible error sources in modelling the linear model.
- The students are able to calculate the estimators (point and interval estimators, residual) in the linear model by hand.
- The students are able to evaluate the graphics for regression diagnostics in the linear model.
- The students are able to interpret the results of studies, where a linear, a logistic or a Cox regression model was applied.
- The students are able to draw and interpret Kaplan-Meier curves.
- The students are able to perform data transformations.

Grading through:

- exam type depends on main module

Is requisite for:

- Multivariate Statistics (MA4944)
- Interdisciplinary Seminar (MA3300)

Requires:

- Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Medical Biometry and Statistics
- Prof. Dr. rer. biol. hum. Inke König
- Dr. rer. hum. biol. Markus Scheinhardt

Literature:

- Ludwig Fahrmeir, Thomas Kneib, Stefan Lang: Regression: Modelle, Methoden und Anwendungen - ISBN-13 9783540339328
- Dobson, Annette J & Barnett, Adrian: An Introduction to Generalized Linear Models, 3rd ed. - Chapman & Hall/CRC: Boca Raton (FL), 2008

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None (The competences of the required modules are required for this module, but the modules are not a prerequisite for admission.)

Prerequisites for the exam:
- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the initial examination.

MA4020 T - Module part: Stochastics 2 (Stoch2a)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Stochastics 2 (lecture, 2 SWS)
- Stochastics 2 (exercise, 1 SWS)

Workload:

- 65 Hours private studies and exercises
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Lebesgue integral and Riemann integral
- Transformations of measures and integrals
- Product measures and Fubini's theorem
- Moments and dependency measures
- Normally distributed random vectors and distributions closely related to the normal distribution

Qualification-goals/Competencies:

- Studends get insights into basic stochastic structures
- They master techniques of integration being relevant to stochastics
- They master the treatment of (particularly normally distributed) random vectors and their distributions
- They are able to formalize complex stochastic problems

Grading through:

- exam type depends on main module
- Exercises

Is requisite for:

- Modeling Biological Systems (MA4450)
- Stochastic processes and modeling (MA4610-KP04, MA4610)

Requires:

- Stochastics 1 (MA2510-KP04, MA2510)
- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Analysis 2 (MA2500-KP04, MA2500)

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Mathematics
- Nachfolge von Prof. Dr. rer. nat. Karsten Keller

Literature:

- J. Elstrodt: Maß- und Integrationstheorie - Springer
- M. Fisz: Wahrscheinlichkeitsrechnung und mathematische Statistik - Deutscher Verlag der Wissenschaften

Language:

- offered only in German

Notes:

The lecture is identical to that in module MA4020-MML.

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester.

MA4400 T - Module part: Chaos and Complexity of Biological Systems (CKBSa)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Chaos and Complexity of Biological Systems (lecture, 2 SWS)
- Chaos and Complexity of Biological Systems (exercise, 1 SWS)

Workload:

- 65 Hours private studies and exercises
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Time-discrete dynamical systems and stochastic processes
- Nonlinearity and chaos
- Ergodicity
- Lyapunov exponents and fractal dimensions
- Symbolic dynamics
- Information-theoretic complexity measures
- Biological and medical applications, in particular EEG analysis

Qualification-goals/Competencies:

- Students get insights into basic ideas of nonlinear dynamics
- They have skills in analyzing and modeling complex data and time series
- They have competencies in simulating and illustrating nonlinear dynamic phenomena

Grading through:

- exam type depends on main module

Requires:

- Stochastics 1 (MA2510-KP04, MA2510)
- Analysis 1 (MA2000-KP08, MA2000)

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Mathematics
- Nachfolge von Prof. Dr. rer. nat. Karsten Keller

Literature:

- M. Brin, G. Stuck: Introduction to Dynamical Systems - Cambridge University Press 2002
- J. M. Amigó: Permutation Complexity in Dynamical Systems - Springer 2010
- R. L. Devaney: An Introduction to Chaotic Dynamical Systems - Westview Press 2003

Language:

- depends on the chosen courses

Notes:

Lecture and tutorial in English (in German only if desired by all students),
lecture notes in English,
exam can be taken either in English or German language

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester

MA4450 T-INF - Module part: Modeling Biological Systems (MoBSa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Medical Informatics 2019 (module part), Module part, Arbitrary semester
- Master Medical Informatics 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Modeling Biological Systems (lecture, 2 SWS)
- Modeling Biological Systems (exercise, 1 SWS)

Workload:

- 65 Hours private studies and exercises
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Elementary time-discrete deterministic models
- Structured time-discrete population dynamics
- Generating functions, Galton-Watson-processes
- Modeling of data and data analysis

Qualification-goals/Competencies:

- Students have knowledge of elementary time-discrete models for modeling biological processes
- They develop skills in connecting ideas from different fields of mathematics
- They have competencies in data analysis and modelling
- They develop competencies in interdisciplinary work

Grading through:

- Exercises
- exam type depends on main module

Requires:

- Stochastics 1 (MA2510-KP04, MA2510)
- Analysis 2 (MA2500-KP04, MA2500)
- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)

Responsible for this module:

- Nachfolge von Prof. Dr. rer. nat. Karsten Keller

Teacher:

- Institute for Mathematics
- Nachfolge von Prof. Dr. rer. nat. Karsten Keller

Literature:

- F. Braer, C. Castillo-Chavez: Mathematical Models in Population Biology and Epidemiology - New York: Springer 2000
- H. Caswell: Matrix Population Modells - Sunderland: Sinauer Associates 2001
- S. N. Elaydi: An Introduction to Difference Equations - New York: Springer 1999
- B. Huppert: Angewandte Lineare Algebra - Berlin: de Gruyter 1990
- U. Krengel: Einführung in die Wahrscheinlichkeitstheorie und Statistik - Wiesbaden: Vieweg 2002
- E. Seneta: Non-negative Matrices and Markov Chains - New York: Springer 1981

Language:

- offered only in German

Notes:

Is part of CS4441.
The lecture is identical to that in module MA4450-MML.

Prerequisites for attending the module:
- None (The competences of the required modules are required for this module, but the modules are not a prerequisite for admission.)

Prerequisites for the exam:
- Preliminary examinations can be determined at the beginning of the semester. If preliminary work has been defined, it must have been completed and positively assessed before the initial examination.

CS4212-KP04, CS4212 - Current Topics SSE (SSEaktuell)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Computer Science 2019 (compulsory), Canonical Specialization SSE, Arbitrary semester
- Master Computer Science 2014 (compulsory), specialization field software systems engineering, 2nd or 3rd semester
- Master Artificial Intelligence 2023 (optional subject), for equivalence check, Arbitrary semester

Classes and lectures:

- Current Topics SSE (lecture, 2 SWS)
- Current Topics SSE (seminar, 1 SWS)

Workload:

- 60 Hours private studies and exercises
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Model based development
- Quality assurance
- Development of web and mobile applications

Qualification-goals/Competencies:

- The students can apply modern software engineering technologies in practice.
- They can classify and evaluate current trends in software systems engineering.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages
- Prof. Dr. Martin Leucker

Literature:

- Aktuelle Forschungsartikel werden in der Veranstaltung bekanntgegeben.:

Language:

- German and English skills required

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester

CS4507-KP12, CS4507 - Software Verification (SoftVeri)

Duration:	Turnus of offer:	Credit points:
2 Semester	each year, can be started in winter or summer semester	12

Course of study, specific field and term:

- Master Computer Science 2019 (compulsory), Canonical Specialization SSE, Arbitrary semester
- Master MES 2020 (advanced module), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master Computer Science 2014 (compulsory), specialization field software systems engineering, 1st and 2nd semester
- Master MES 2014 (advanced module), computer science / electrical engineering, 1st and 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field computer science, 2nd and 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and 3rd semester

Classes and lectures:

- CS4138 T: Model Checking (lecture with exercises, 4 SWS)
- CS4139 T: Runtime Verification and Testing (lecture with exercises, 4 SWS)
- CS5220 T: Static Analysis (lecture with exercises, 4 SWS)

Workload:

- 210 Hours private studies
- 120 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- The students can relate different approaches to software verification.
- For further competencies see module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages
- Prof. Dr. Martin Leucker

Literature:

- : see module parts

Language:

- German and English skills required

Notes:

(The module consists of CS4138 T, CS4139 T and CS5220 T)

2 of the 3 module parts must be chosen.

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- depending on the module parts

CS5170-KP04, CS5170 - Hardware/Software Co-Design (HWSWCod)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (compulsory), Canonical Specialization SSE, Arbitrary semester
- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Elective, 1st or 2nd semester
- Master Computer Science 2014 (compulsory), specialization field software systems engineering, 1st or 2nd semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 1st or 3rd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2012 (optional subject), specialization field robotics and automation, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), advanced curriculum parallel and distributed system architecutres, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), advanced curriculum intelligent embedded systems, 2nd or 3rd semester
- Master Computer Science 2012 (compulsory), specialization field software systems engineering, 2nd semester

Classes and lectures:

- Hardware/Software Co-Design (lecture, 2 SWS)
- Hardware/Software Co-Design (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- System design flow
- Basic architectures for HW/SW systems
- System design and modelling
- System synthesis
- Algorithms for scheduling
- System partitioning
- Algorithms for system partitioning
- Design systems
- Performance analysis
- System design and specification with SystemC
- Application examples

Qualification-goals/Competencies:

- Students are able to determine a suitable hardware/software architecture for a given system description
- They are able to determine and describe the pros and cons of implementation alternatives
- They are able to apply methods for system partitioning
- They are able to translate non-formal system descriptions into formal models
- They are able to explain the different steps in system synthesis
- They are able to estimate the quality of system designs
- They are able to create system descriptions in SystemC

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- F. Kesel: Modellierung von digitalen Systemen mit SystemC - Oldenbourg Verlag 2012
- Teich, J., Haubelt, C.: Digital Hardware/Software-Systeme. Synthese und Optimierung - Berlin: Springer 2007

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS5170-L1: Hardware/Software Co-Design, oral exam, 100% of the module grade

CS5490-KP06, CS5490SJ14 - Lab Software Systems Engineering (PrSSE14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6 (Typ B)

Course of study, specific field and term:

- Master Artificial Intelligence 2023 (optional subject), for equivalence check, Arbitrary semester
- Master Computer Science 2019 (compulsory), Canonical Specialization SSE, Arbitrary semester
- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Computer Science 2014 (compulsory), specialization field software systems engineering, 2nd or 3rd semester

Classes and lectures:

- Lab Software Systems Engineering (programming project, 4 SWS)

Workload:

- 60 Hours group work
- 60 Hours in-classroom work
- 40 Hours private studies
- 20 Hours oral presentation and discussion (including preparation)

Contents of teaching:

- Design and implementation of an advanced component-based software/hardware system in team work

Qualification-goals/Competencies:

- The students can realize complex software/hardware systems with the acquired techniques.
- They can derive a system design from a requirements specification.
- They can construct a component-based architecture meeting the system design.
- They can implement, test, and integrate components.
- They can document, present, evaluate and improve the implemented system.
- They can cooperate within a teamfor a successful project.

Grading through:

- continuous, successful participation in practical course

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute for Theoretical Computer Science
- Institute of Information Systems
- Institute of Telematics
- Institute of Software Technology and Programming Languages

- Prof. Dr. Martin Leucker
- Prof. Dr. rer. nat. habil. Ralf Möller
- Prof. Dr. Stefan Fischer

Literature:

- : Projektspezifische Literatur wird in der Veranstaltung angegeben

Language:

- English, except in case of only German-speaking participants

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful participation in the internship (including successful solution of the project tasks) with presentation and documentation as specified at the beginning of the semester

Module exam(s):
CS5490-L1: Project Internship Software Systems Engineering, ungraded internship, 0% of module grade, must be passed.

CS4250-KP04, CS4250 - Computer Vision (CompVision)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master CLS 2023 (optional subject), computer science, 2nd or 3rd semester
- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Biophysics 2019 (optional subject), Elective, 2nd semester
- Master Biomedical Engineering (optional subject), advanced curriculum, 2nd semester
- Master CLS 2016 (optional subject), computer science, 2nd or 3rd semester
- Master MES 2014 (optional subject), computer science / electrical engineering, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2012 (optional subject), advanced curriculum imaging systems, 2nd or 3rd semester
- Master CLS 2010 (compulsory), computational life science / imaging, 2nd semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 2nd semester
- Master Computer Science 2012 (optional subject), advanced curriculum signal and image processing, 2nd or 3rd semester
- Master Computer Science 2012 (compulsory), specialization field robotics and automation, 2nd semester
- Master Computer Science 2012 (compulsory), specialization field bioinformatics, 2nd semester
- Master Computer Science 2012 (optional subject), advanced curriculum intelligent embedded systems, 2nd semester

Classes and lectures:

- Computer Vision (lecture, 2 SWS)
- Computer Vision (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Introduction to human and computer vision
- Sensors, cameras, optics and projections
- Image features: edges, intrinsic dimension, Hough transform, Fourier descriptors, snakes
- Range imaging and 3-D cameras
- Motion and optical flow
- Object recognition
- Example applications

Qualification-goals/Competencies:

- Students can understand the basics of computer vision.
- They can explain and perform camera choice and calibration.
- They can explain and apply the basic methods for feature extraction, motion estimation, and object recognition.
- They can indicate appropriate methods for different kinds of computer-vision applications.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Erhardt Barth

Teacher:

- Institute for Neuro- and Bioinformatics
- Prof. Dr.-Ing. Erhardt Barth

Literature:

- Richard Szeliski: Computer Vision: Algorithms and Applications - Springer, Boston, 2011
- David Forsyth and Jean Ponce: Computer Vision: A Modern Approach - Prentice Hall, 2003

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Regular participation in the exercises as specified at the beginning of the semester
- Successful completion of exercise slips as specified at the beginning of the semester

Module exam(s):
- CS4250-L1: Computer Vision, oral exam, 100% of module grade

Is identical to module XM2330 of the University of Applied Sciences Lübeck

CS4451-KP06 - Privacy (Privacy)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master IT-Security 2019 (optional subject), IT Security and Privacy, 1st, 2nd, or 3rd semester

Classes and lectures:

- Privacy (lecture, 2 SWS)
- Privacy (exercise, 2 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Private statistics (Differential Privacy)
- Privacy preserving machine learning
- Privacy attacks against machine-learned models
- Privacy-preserving computation in distributed systems.
- Stylometry: de-anonymization via writing style
- Anonymity

Qualification-goals/Competencies:

- Deep understanding for algorithmic and algebraic methods to secure private data
- Skills to analyze complex security requirements

Grading through:

- Oral examination

Requires:

- Trustworthy AI (CS5075-KP06)

Responsible for this module:

- Prof. Dr. Esfandiar Mohammadi

Teacher:

- Institute for IT Security
- Prof. Dr. Esfandiar Mohammadi

Literature:

- C. Dwork, A. Roth: The Algorithmic Foundations of Differential Privacy - Now Publishers Inc, 2014
- Stanford: Encyclopedia of Philosophy on Privacy
- Andrej Bogdanov: Lecture notes by Andrej Bogdanov from Chinese University of Hong Kong
- Journal und Konferenz-Publikationen: wird aktuell benannt

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None (the competencies under

CS4452-KP06 - Reliability Engineering (TechZuv)

Duration:	Turnus of offer:	Credit points:
1 Semester	normally each year in the winter semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master IT-Security 2019 (optional subject), IT Safety and Reliability, 1st, 2nd, or 3rd semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester

Classes and lectures:

- Reliability Engineering (lecture, 2 SWS)
- Reliability Engineering (exercise, 2 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Basic concepts
- Reliability analysis
- Qualification tests
- Maintainability analysis
- Design guidelines for reliability, maintainability and software quality

Qualification-goals/Competencies:

- Students are able to discuss the basic concepts of Reliabilty Engineering
- They are able to analyze the reliability of technical systems by mathematical models
- They are able to select and apply qualification tests
- They are able to perform a maintainability analysis
- They are able to follow design guidelines for reliable and maintainable systems.

Grading through:

- Viva Voce or test

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- A. Birolini: Reliability Engineering: Theory and Practice - Springer 2013
- M. Rausand: Reliability of Safety-Critical Systems - Wiley 2014

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.

Module Exam(s):
- CS4452-L1: Technical Reliability, written exam, 90min, 100% of the module grade.

According to the decision of the examination board of computer science of 15.1.2020 this module can be chosen by students Master Computer Science SGO from 2019 in the area of 5th elective.

CS4703-KP06 - Advanced Cryptology (AdvCrypto)

Duration:	Turnus of offer:	Credit points:
1 Semester	every summer semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester
- Master CLS 2016 (optional subject), computer science, 3rd semester
- Master IT-Security 2019 (optional subject), IT Security and Privacy, Arbitrary semester

Classes and lectures:

- Lecture Advanced Cryptoplogy (lecture, 3 SWS)
- Exercise Advanced Cryptoplogy (seminar-style lectures with exercises, 1 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Concrete security and asymptotic security: comparison of both approaches in relation to modes of operations
- Block-Ciphers: Feistel Networks, Substitution-Permutation Networks, Design Principles, Linear Cryptanalysis, Differential cryptanalysis
- Authenticated Encryption
- Secure multi-party calculations: preprocessing model, protection of algorithms against side-channel attacks, MPC-in-the-Head (for ZK evidence)
- Obfuscation: Nicht-Machbarkeit (BlackBox), Machbarkeit (indistinguishable Obfuscation)

Qualification-goals/Competencies:

- The participants can explain and use basic theoretic cryptographic objects
- They are able to understand current concepts of cryptography
- They show a deep understanding of cryptographic methods
- They understand the basic connection between theoretical and practical aspects of cryptography
- They are able to understand current scientific works about cryptography and explain them

Grading through:

- Written or oral exam as announced by the examiner
- written homework

Requires:

- Cryptology (CS3420-KP04, CS3420)

Responsible for this module:

- Prof. Dr. Thomas Eisenbarth

Teacher:

- Institute for IT Security
- Dr Sebastian Berndt

Literature:

- Katz, Lindell: Introduction to Modern Cryptography - 2nd ed., CRC Press, 2014
- Cramer, Damgård, Nielsen: Secure Multiparty Computation and Secret Sharing - 1st ed., Cambridge University Press, 2015
- Barak: An Intensive Introduction to Cryptography - Lecture Notes

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None (the competencies under

CS4705-KP06 - Cryptographic Engineering (CryEng)

Duration:	Turnus of offer:	Credit points:
1 Semester	every summer semester	6

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester
- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master IT-Security 2019 (optional subject), IT Security and Privacy, 1st, 2nd, or 3rd semester

Classes and lectures:

- Cryptographic Engineering (lecture, 2 SWS)
- Cryptographic Engineering (exercise, 2 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Efficient Implementation of Finite Field Arithmetic for cryptographic Applications.
- Stream Ciphers: Design and hardware Implementation.
- Block Ciphers: Design, hardware Implementation, and Lightweight Encryption Algorithms.
- Hash Functions: Design and hardware Implementation.
- Public-Key Cryptography over GF(2m): Design and Implementation.
- True and Pseudo Random Number Generators (TRNG): Design, test, and hardware Implementation.
- Physical Unclonable Functions (PUFs): Design Challenges and Hardware- Architectures.

Qualification-goals/Competencies:

- Students will become familiar with the concept of cryptographic engineering and the associated topics with it.
- They can expand and enhance their knowledge about a cryptography and applied cryptography.
- They can become more familiar with the concepts of hardware-security.
- They can learn efficient implementation of Finite Field Arithmetic in hardware and its applications in cryptography.
- They can learn the techniques for hardware-implementation of cryptographic algorithms
- They can demonstrate a deep understanding of several structures and designs of stream and block ciphers
- They can take an advanced step towards hardware and physical security such as TRNG, PUFs.

Grading through:

- written exam

Requires:

- Cryptology (CS3420-KP04, CS3420)

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Dr.-Ing. Saleh Mulhem

Literature:

- Ferguson, Niels, Bruce Schneier, and Tadayoshi Kohno: Cryptography Engineering: Design Principles and Practical Applications - 2012
- Koç Ç.K.: Cryptographic Engineering - Springer, Boston, MA, (2009)
- Wachsmann, Christian, and Ahmad-Reza Sadeghi: Physically unclonable functions (PUFs): Applications, models, and future directions - Morgan & Claypool Publishers, 2014
- Johnston, David: Random Number Generators Principles and Practices: A Guide for Engineers and Programmers - Walter de Gruyter GmbH & Co KG, 2018

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.

Module examination(s):
- CS4705-L1: Cryptographic Technology, written exam, 90min, 100% of module grade.

CS4720-KP06 - Energy Efficiency in Emebedded Systems (EEE)

Duration:	Turnus of offer:	Credit points:
1 Semester	every summer semester	6

Course of study, specific field and term:

- Master Robotics and Autonomous Systems 2019 (module part), Additionally recognized elective module, Arbitrary semester
- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester

Classes and lectures:

- Energy Efficiency in Emebedded Systems (lecture, 2 SWS)
- Energy Efficiency in Emebedded Systems (exercise, 2 SWS)

Workload:

- 85 Hours private studies and exercises
- 70 Hours in-classroom work
- 25 Hours exam preparation

Contents of teaching:

- Motivation and power dissipation on semiconductor level
- Power dissipation of digital circuits, inparticular CMOS
- Power Management in Hard- and Software (Sleep Modes, DVS, FS, Undervolting)
- Energy efficient system design (applications)
- Energy Harvesting and Transiently Powered Computing (TPC)

Qualification-goals/Competencies:

- students will have a deeper understanding of hardware and software mechanisms for evaluating and developing energy-efficient embedded systems
- They have a deeper understanding of the electrotechnical basics of power dissipation in digital systems
- They can analyze the power dissipation of systems at any level and apply appropriate methods to increase efficiency
- They can use a variety of standard techniques to achieve
- They can model and evaluate energy-autonomous systems

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Dr. Ulf Kulau

Literature:

- Ulf Kulau: Course: Energy Efficiency in Embedded Systems A System-Level Perspective for Computer Scientists - EWME, 2018
- David Harris and N. Weste: CMOS VLSI Design ed. - Pearson Education, 2010
- Jan Rabaey: Low Power Design Essentials (Integrated Circuits and Systems) - Springer, 2009

Language:

- English, except in case of only German-speaking participants

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of practice and project assignments during the semester.

CS5020-KP06 - Algorithmic Learning and Causality (ALKI)

Duration:	Turnus of offer:	Credit points:
1 Semester	normally each year in the summer semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Computer Science 2019 (compulsory), Canonical Specialization Data Science and AI, Arbitrary semester

Classes and lectures:

- Algorithmic Learning and Causality (lecture, 4 SWS)
- Algorithmic Learning and Causality (exercise, 1 SWS)

Workload:

- 105 Hours private studies
- 75 Hours in-classroom work

Contents of teaching:

- inductive inferenz
- algorithmic learning strategies, complexity analysis
- causality, structures and effects
- structural learning, linear models counterfactual inference

Qualification-goals/Competencies:

- The students can understand and analyse methods for the generation of knowlege.
- They dan compare statistic and logic approaches.

Grading through:

- Oral examination

Requires:

- Machine Learning (CS5450-KP04, CS5450)

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science
- Prof. Dr. Maciej Liskiewicz
- Prof. Dr. Rüdiger Reischuk

Literature:

- :
- :
- :

Language:

-

Notes:

Prerequisites for attending the module:
- None

CS5070-KP04 - Advanced Topics Data Science and AI (Dataakuell)

Duration:	Turnus of offer:	Credit points:
1 Semester	each semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (compulsory), Canonical Specialization Bioinformatics and Systems Biology, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, 3rd semester
- Master Computer Science 2019 (compulsory), Canonical Specialization Data Science and AI, Arbitrary semester
- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester

Classes and lectures:

- CS5070-V: Advanced Topics Data Science and AI (lecture, 2 SWS)
- CS5070-S: Advanced Topics Data Science and AI (seminar, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Current research results and applications of data science and artificial intelligence techniquesTopics are among:
- Probabilistic Differential Programming
- Automated Planning and Acting
- Quantum Computing
- Stochastic Relational Modeling and Learning

Qualification-goals/Competencies:

- All current techniques taught in the module can be named and defined by the students and their functional proofs can be explained on the basis of applications.
- Students are able to identify advantages and disadvantages of Data Science- and AI-based system development approaches.
- Students are able to identify ethical aspects and assess their implications.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. habil. Ralf Möller

Teacher:

- Institute of Information Systems

- Prof. Dr. rer. nat. habil. Ralf Möller
- PD Dr. Özgür Özçep
- Prof. Dr. Sven Groppe

Literature:

- : Current conference papers for the topics of the course will be announced in lectures

Language:

- German and English skills required

Notes:

Choose 1 out of 2: Students must attend one of the two courses.

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- None

CS5075-KP06 - Trustworthy AI (TrustAI)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master IT-Security 2019 (optional subject), IT Security and Privacy, 1st, 2nd, or 3rd semester

Classes and lectures:

- CS5075-V: Trustworthy AI (lecture, 3 SWS)
- CS5075-Ü: Trustworthy AI (exercise, 1 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Guiding principles of Trustworthy AI: lawful, ethical and robust AI
- Trustworthy Computing Basics: Security, Privacy, Dependability, Safety, Transparency, Explainability, Traceability, Accountability
- De-anonymization methods using machine learning models
- Mathematical notions for privacy-preserving machine learning methods
- Privacy-preserving machine learning methods
- Analyse maschinell gelernter Modellen (Robustness Check, Explainability)
- Verifikation maschinell gelernter Modellen ((Statistical Testing), Model Checking)
- Black-Box methods for extracting machine learning models (for economical reasons, for analysis, and for verification)
- Attacks for manipulating machine learning models (adversarial examples, backdoors)
- Hardening of machine learning methods against manipulation methods
- Robust machine learning methods against manipulation attacksSecure and privacy-preserving distributed learning methods (Privacy-Preserving Federated Learning)

Qualification-goals/Competencies:

- All current techniques taught in the module and described above can be named and defined by the students and their functional proofs can be explained on the basis of applications.
- The formal foundations from the course can be precisely explained
- Students are able to identify advantages and disadvantages of planning and acting approaches
- Understanding about potential vulnerabilities of machine learning methods w.r.t. privacy-violations and manipulation possibilities
- Understanding of hardening methods compared to deanonymization and manipulation methods
- Students can analyze complex security requirements

Grading through:

- Oral examination

Is requisite for:

- Privacy (CS4451-KP06)

Responsible for this module:

- Prof. Dr. Esfandiar Mohammadi

Teacher:

- Institute of Software Technology and Programming Languages
- Institute for IT Security

- Prof. Dr. Thomas Eisenbarth
- Prof. Dr. Martin Leucker
- Prof. Dr. Esfandiar Mohammadi

Literature:

- C. Dwork, A. Roth: The Algorithmic Foundations of Differential Privacy - Now Publishers Inc, 2014
- Andrej Bogdanov: Lecture notes by Andrej Bogdanov from Chinese University of Hong Kong
- : Current conference and journal articles on the topics of the event will be announced at the beginning of the event in the case of the

seminar and at the discussion of the topic in the case of the lecture.

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises and project tasks as specified at the beginning of the semester.

Module Exam(s):
- CS5075-L1: Trustworthy AI, oral examination, 100% of module grade.

According to the decision of the examination board of computer science from 19.1.2022 this module can be chosen for Master SGO from WS 2019 in the area 5. elective.

CS5195-KP04 - Current Topics in IT Security (AktTheITS)

Duration:	Turnus of offer:	Credit points:
1 Semester	each semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master IT-Security 2019 (compulsory), IT-Security, 3rd semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester

Classes and lectures:

- Current Topics IT Security and Reliability (seminar-style lectures, 2 SWS)
- Current Topics IT Security and Reliability (project work, 1 SWS)

Workload:

- 45 Hours work on project
- 45 Hours in-classroom work
- 30 Hours private studies and exercises

Contents of teaching:

- new results in cyber security
- design and implementation of a secure system for a complex application and its security analysis

Qualification-goals/Competencies:

- deeper knowledge of current developments in IT security
- professional experience of constructing and analyzing computer systems and networks with respect to security issues

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Thomas Eisenbarth

Teacher:

- Institute for IT Security
- Institute for Theoretical Computer Science

- Prof. Dr. Maciej Liskiewicz
- Prof. Dr. Rüdiger Reischuk
- Prof. Dr. Thomas Eisenbarth
- Prof. Dr. Esfandiar Mohammadi

Literature:

- papers to be discussed depend on specific topics: -

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- alternates, will be announced at the beginning of the semester

Module Exam(s):
- CS5195-L1: Current Topics in IT Security, oral exam, 100% of module grade.

In the winter semester, the organization and teaching are carried out by ITS, with Professor Thomas Eisenbarth in charge.

In the summer semester, the organization and teaching are carried out by TCS, with Professor Rüdiger Reischuk holding the responsibility.

CS5400-KP08, CS5400 - Current Trends in Bioinformatics (WahlBioInf)

Duration:	Turnus of offer:	Credit points:
1 Semester	each semester	8

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Computer Science 2019 (compulsory), Canonical Specialization Bioinformatics and Systems Biology, 2nd and/or 3rd semester
- Master Computer Science 2014 (compulsory), specialization field bioinformatics, 2nd and/or 3rd semester

Classes and lectures:

- CS5410 T: Artificial Life (lecture with exercises, 3 SWS)
- CS5275 T: Selected Topics of Signal Analysis and Enhancement (lecture with exercises, 3 SWS)
- MA2600 T: Biostatistics 2 (lecture with exercises, 3 SWS)
- MA4400 T: Chaos and Complexity of Biological Systems (lecture with exercises, 3 SWS)
- CS5450 T: Machine Learning (lecture with exercises, 3 SWS)
- CS5440 T: Seminar Neuro- and Bioinformatics (seminar, 2 SWS)
- MA4020 T: Stochastics 2 (lecture with exercises, 3 SWS)
- EW4170: Systems Biology (lecture with exercises, 3 SWS)
- LS1600-MI T: Organic Chemistry (lecture, 3 SWS)
- CS5549 T: Project Bioinformatics (practical course, 3 SWS)

Workload:

- 240 Hours (see module parts)

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- see module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Martinetz

Teacher:

- Institute of Medical Biometry and Statistics
- Institute for Mathematics
- Institute for Robotics and Cognitive Systems
- Institute for Signal Processing
- Institute for Neuro- and Bioinformatics

Literature:

- : see module parts

Language:

- German and English skills required

Notes:

You must pick module parts totaling 8 ECTS.

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- depending on the module parts

LS3151-KP04, LS3151 - Molecular Biology (MolBioINF)

Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	4

Course of study, specific field and term:

- Master Computer Science 2019 (compulsory), Canonical Specialization Bioinformatics and Systems Biology, Arbitrary semester
- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), bioinformatics, 1st or 2nd semester
- Master Computer Science 2014 (compulsory), specialization field bioinformatics, 1st, 2nd, or 3rd semester
- Master Medical Informatics 2014 (optional subject), bioinformatics, 1st or 2nd semester
- Master Computer Science 2012 (compulsory), specialization field bioinformatics, 2nd semester

Classes and lectures:

- Molecular Biology (lecture, 2 SWS)
- Molecular Biology (seminar, 2 SWS)

Workload:

- 60 Hours private studies
- 60 Hours in-classroom work

Contents of teaching:

- Lecture: Molecular basis for processing and analysis of biological data (nucleic acids, genome sequencing, DNA polymorphism, infection biology, host genome and virus infection, stem cell biology)
- Seminar: Scientific article reading and oral presentation
- understanding scientific context
- training in reading English in science

Qualification-goals/Competencies:

- Students are able to present basic molecular biological requirements for processing and analysis of biological data.
- They are able to explain the molecular biological terms genome, transcriptome and proteome.
- They acquire the competence to handle English literature and to present it in a scientific oral presentation.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Norbert Tautz

Teacher:

- Institute of Virology and Cell Biology

- Dr. rer. nat. Olaf Isken
- Prof. Dr. rer. nat. Norbert Tautz

Literature:

- Alberts et al.: Molecular Biology of Cells - Garland Science
- Lodish et al.: Molecular Cell Biology - Freeman

Language:

- offered only in German

Notes:

Seminar-dates by appointment, prior registration is mandatory

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- attendance, >90%

CS4511-KP12, CS4511 - Learning Systems (LernSys)

Duration:	Turnus of offer:	Credit points:
2 Semester	irregularly	12

Course of study, specific field and term:

- Master Biophysics 2023 (advanced module), advanced curriculum, 1st or 2nd semester
- Master Computer Science 2019 (optional subject), Canonical Specialization Bioinformatics and Systems Biology, Arbitrary semester
- Master MES 2020 (advanced module), computer science / electrical engineering, Arbitrary semester
- Master Computer Science 2019 (optional subject), Canonical Specialization Data Science and AI, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master Biophysics 2019 (advanced module), advanced curriculum, 1st and 2nd semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master MES 2014 (advanced module), computer science / electrical engineering, 1st and 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field computer science, 2nd and 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and 3rd semester

Classes and lectures:

- CS4405 T: Neuro Informatics (lecture with exercises, 3 SWS)
- CS5450 T: Machine Learning (lecture with exercises, 3 SWS)
- CS5430 T: Seminar Machine Learning (seminar, 2 SWS)

Workload:

- 180 Hours private studies
- 120 Hours in-classroom work
- 40 Hours exam preparation
- 20 Hours work on an individual topic with written and oral presentation

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- see module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Martinetz

Teacher:

- Institute for Neuro- and Bioinformatics

- Prof. Dr. rer. nat. Thomas Martinetz
- Prof. Dr.-Ing. Erhardt Barth

Literature:

- : see module parts

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises and project tasks as specified at the beginning of the semester.
- Seminar lecture and elaboration according to the requirements at the beginning of the semester.

Module Exam(s):
- CS4511-L1: Learning Systems, oral exam, 100% of module grade.

(Consists of CS4405 T, CS5450 T, CS5430 T)

Only for computer science students with the application subject Bioinformatics, the course CS4405 T Neuroinformatics is replaced by CS5204 T Artificial Intelligence 2, because this group of participants must already complete Neuroinformatics as part of a required module.

CS4516-KP12 - Bioinformatics and System Biology (BioinfVert)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	12

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Canonical Specialization Bioinformatics and Systems Biology, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester

Classes and lectures:

- CS4440 T Molecular Bioinformatics (lecture, 2 SWS)
- CS4440 T Molecular Bioinformatics (exercise, 1 SWS)
- MA4450 T-INF Modeling Biological Systems (lecture, 2 SWS)
- MA4450 T-INF Modeling Biological Systems (exercise, 1 SWS)
- EW4170 T System Biology (lecture, 2 SWS)
- EW4170 T System Biology (exercise, 2 SWS)

Workload:

- 170 Hours private studies
- 150 Hours in-classroom work
- 40 Hours exam preparation

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- see module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Martinetz

Teacher:

- LIED | Lübecker Institut für experimentelle Dermatologie (Lübeck Institute of Experimental Dermatology)
- Institute for Neuro- and Bioinformatics

- Prof. Dr. Hauke Busch
- Prof. Dr. rer. nat. Thomas Martinetz
- Dr. Axel Künstner
- Nachfolge von Prof. Dr. rer. nat. Karsten Keller
- Prof. Dr. Bernhard Haubold
- Dr. rer. nat. Kurt Fellenberg

Literature:

- :

Language:

- German and English skills required

Notes:

(The module consists of CS4440 T, MA4450 T-INF and EW4170 T)
(Is equal to and is replaced by CS4442-KP12)

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- depending on the module parts

CS4514-KP12 - Intelligent Agents (IntAgents)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	12

Course of study, specific field and term:

- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, 1st to 3th semester
- Certificate in Artificial Intelligence (compulsory), Artificial Intelligence, 1st semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (optional subject), Canonical Specialization Data Science and AI, 1st or 2nd semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester

Classes and lectures:

- CS4514-P: Lab course Intelligent Agents (practical course, 2 SWS)
- CS4514-V: Intelligent Agents (lecture with exercises, 6 SWS)

Workload:

- 195 Hours private studies
- 120 Hours in-classroom work
- 45 Hours exam preparation

Contents of teaching:

- Agents, Mechanisms, and Collaboration: Intelligent agents and artificial intelligence / Game theory and social choice / Mechanism design, algorithmic mechanism design / Agent collaboration, rules of encounter / Continuous Space / Epistemic logic / Knowledge and seeing / Knowledge and time / Dynamic epistemic logic / Knowledge-based programs
- Perception (Language and Vision): Information retrieval and web-mining agents / Probabilistic dimension reduction, latent content descriptions, topic models, LDA, LDA-HMM / Representation learning for sequential structures, embedding spaces, word2vec, CBOW, skip-gram, hierarchical softmax, negative sampling / Language models (1d-CNNs. RNNs, LSTMs, ELMo, Transformers, BERT, GPT-3/OPT, and beyond), Natural language inference and query answering / Computer Vision (2D-CNNs, Deep Architectures: AlexNet, ResNet) /Combining language and vision (CLIP (OpenAI) / LIT (Google) / data2vec (Facebook) / Flamingo (DeepMind), DALL-E and beyond) /Knowledge graph embedding with GNNs, combining embedding-based KG completion with probabilistic graphical models(ExpressGNN, pLogicNet), MLN inference and learning based on embedded knowledge graphs, GMNNs)
- Planning, Causality, and Reinforcement Learning: Planning and acting with deterministic models, temporal models, nondeterministic models, probabilistic models / Standard decision making / Advanced decision making and reinforcement learning / Causal dependencies / Intervention / Instrumental variables / Counterfactuals / Causal planning / Causal reinforcement learning
- In the project lab students use the usual (open source) data science related programming languages and tools in order to transfer the abstractions, concepts and results taught in the lecture into concrete software models and artefacts to be applied on big data.

Qualification-goals/Competencies:

- The students can enumerate central ideas, define the relevant concepts and explain the functioning of algorithms with help of application scenarios for all the items listed in contents of teaching.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. habil. Ralf Möller

Teacher:

- Institute of Information Systems
- Prof. Dr. rer. nat. habil. Ralf Möller
- PD Dr. Özgür Özçep

Literature:

- J. Pearl, C. Glymour, and N.P. Jewell: Causal Inference in Statistics - A Primer - Wiley, 2016
- Y. Shoham, K. Leyton-Brown: Multiagent-Systems: Algorithmic, Game-Theoretic, and Logical Foundations - Cambridge University Press, 2009
- S.J. Russell, P. Norvig: Artificial Intelligence: A Modern Approach - Pearson, 2020
- M. Ghallab, D. Nau, P. Traverso: Automated Planning and Acting - Cambridge University Press, 2016

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- successful completion of the Lab Course Intelligent Agents CS4514-P

Module examination(s):
- CS4514-L1: Intelligent Agents, oral examination, 100% of module grade.

(Replaces CS4513-KP12).

CS4501-KP12, CS4501 - Algorithmics, Logic and Computational Complexity (ALK14)

Duration:	Turnus of offer:	Credit points:
2 Semester	each summer semester	12

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field computer science, 2nd and/or 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and/or 3rd semester

Classes and lectures:

- Algorithmics, Logic and Computational Complexity (lecture, 4 SWS)
- Algorithmics, Logic and Computational Complexity (exercise, 2 SWS)
- Seminar Algorithmics, Logic and Computational Complexity (seminar, 2 SWS)

Workload:

- 160 Hours private studies and exercises
- 120 Hours in-classroom work
- 40 Hours exam preparation
- 40 Hours work on an individual topic with written and oral presentation

Contents of teaching:

- recent results in algorithmics and complexity theory
- communication and circuit complexity
- structural and descriptive complexity theory
- algorithmic game theory
- nonstandard computing models
- understanding logics as a tool

Qualification-goals/Competencies:

- the students can demonstrate a deep knowledge of concepts and methods for algorithm design and complexity analysis.
- They are able to classify algorithmic problems and to select appropriate strategies for their solution
- They are able to model complex problem settings appropriately.
- They can assess and explain the importance of lower bounds for applications.

Grading through:

- Oral examination

Requires:

- Algorithmics (CS4000-KP06, CS4000SJ14)

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science

- Prof. Dr. Rüdiger Reischuk
- Prof. Dr. rer. nat. Till Tantau
- Prof. Dr. Maciej Liskiewicz

Literature:

- R. Reischuk: Einführung in die Komplexitätstheorie - Teubner, 1990
- S. Arora, B. Barak: Computational Complexity - Cambridge UP 2009
- C. Papadimitriou: Computational Complexity - Addison-Wesley, 1994
- M. Huth, M. Ryan: Logic in Computer Science - Cambridge University. Press 2004
- D. Kozen: Theory of Computation - Springer, 2006

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None (the competencies under

CS4503-KP12, CS4503 - Ambient Computing (AmbCompA)

Duration:	Turnus of offer:	Credit points:
2 Semester	normally each year in the summer semester	12

Course of study, specific field and term:

- Master Robotics and Autonomous Systems 2019 (advanced module), advanced curriculum, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field computer science, 2nd and/or 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and/or 3rd semester

Classes and lectures:

- CS4670 T: Ambient Computing (lecture, 3 SWS)
- Seminar Ambient Computing (seminar, 2 SWS)
- Lab Course Ambient Computing (project work, 3 SWS)

Workload:

- 120 Hours in-classroom work
- 120 Hours group work
- 70 Hours private studies
- 30 Hours oral presentation (including preparation)
- 20 Hours exam preparation

Contents of teaching:

- Ambient Computing:
- Current paradigms in computer technology
- Smart components
- Software architectures
- Context-sensitive systems
- Ambient Intelligence
- Interactive ambient media systems
- Ambient Computing Applications (AAL)
- Ethical, Legal and Social Implications (ELSI)

Qualification-goals/Competencies:

- Ambient Computing:
- The students are able to evaluate possibilities, concepts and challenges of Ambient Systems
- They have an overview about current technologies and systems for developing Ambient Systems
- They are able to follow and judge state-of-the-art research in the area of Ambient Computing

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Andreas Schrader

Teacher:

- Institute of Telematics
- Prof. Dr.-Ing. Andreas Schrader

Literature:

- John Krumm: Ubiquitous Computing Fundamentals - CRC Press, 2009
- Stefan Poslad: Ubiquitous Computing: Smart Devices, Environments and Interactions - Wiley, 2009
- Uwe Hansman et al: Pervasive Computing - Springer, 2003

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of the project assignment as specified at the beginning of the semester.
- Seminar lecture with elaboration according to the requirements at the beginning of the semester

Module Exam(s):
- CS4503-L1: Ambient Computing and Applications, oral exam, 100% of module grade.

(Consists of CS4670 T)

CS4504-KP12, CS4504 - Cyber Physical Systems (CPS)

Duration:	Turnus of offer:	Credit points:
2 Semester	each year, can be started in winter or summer semester	12

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (advanced module), advanced curriculum, 1st or 2nd semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field computer science, 2nd and/or 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and/or 3rd semester

Classes and lectures:

- CS5150 T: Organic Computing (lecture with exercises, 3 SWS)
- CS5153 T: Wireless Sensor Networks (lecture with exercises, 3 SWS)
- CS4504-S: Cyber Physical Systems (seminar, 2 SWS)

Workload:

- 220 Hours private studies
- 120 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- basic principles of organic computing / self-x system properties
- from motion to intelligent behavior and system/machine behavior
- design for self-organization, robustness, adaptivity, flexibility, trust
- analyzing, reverse-engineering, debugging machine behavior
- designing experiments and measuring behavior
- modeling system/machine behavior
- complexity, opacity, obscurity, trust of (AI) systems and explainable AI
- architecture of organic computing systems
- applications of self-x systems
- basics of wireless sensor networks
- hardware aspects of sensor nodes
- physics and protocols of wireless communication
- routing in wireless networks
- time synchronization and localization in wireless networks
- data management and data processing in wireless sensor networks
- applications of wireless sensor networks

Qualification-goals/Competencies:

- Students are able to utilize the principles of organic computing/self-x systems on exemplary designs.
- They are able to explain principles of organic computing/self-x systems.
- They are able to analyze system/machine behaviors in a structured, sound approach.
- Students are able to present the pros and cons of sensor networks.
- They are able to cope with analysis, design, and evaluation of protocols in sensor networks.
- They are able to interpret and pursue current research activities for sensor networks.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Dr. rer. nat. Javad Ghofrani

Literature:

- C. Müller-Schloer, S. Tomforde: Organic Computing Technical Systems for Survival in the Real World - Birkhäuser, 2017
- H. Karl, A. Willig: Protocols and Architectures of Wireless Sensor Networks - Wiley, 2005

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.
- Seminar lecture and elaboration according to the requirements at the beginning of the semester

Module Exam(s):
- CS4504-L1: Cyber Physical Systems, oral exam, 100% of the module grade.

(Consists of CS5150 T, CS5153 T)

CS4505-KP12, CS4505 - System Architecture (SysArch)

Duration:	Turnus of offer:	Credit points:
2 Semester	irregularly	12

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field computer science, 2nd and/or 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and/or 3rd semester

Classes and lectures:

- Computer-Aided Design of Digital Circuits (s. CS3110 T) (lecture with exercises, 3 SWS)
- Hardware/Software Co-Design (s. CS5170 T) (lecture with exercises, 3 SWS)
- Lab course System Architecture or Seminar System Architecture (practical course, 3 SWS)

Workload:

- 195 Hours private studies
- 135 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- see module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- :

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.
- Successful completion of the practical tasks according to the requirements at the beginning of the semester.

Module Exam(s):
- CS4505-L1: System Architecture, oral exam, 100% of the module grade.

A seminar can also be offered instead of the internship.

CS4506-KP12, CS4506 - Information and Communication Security (SDK)

Duration:	Turnus of offer:	Credit points:
2 Semester	each year, can be started in winter or summer semester	12

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master Computer Science 2014 (compulsory), specialization field IT security and safety, 1st and 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field computer science, 2nd and 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and 3rd semester

Classes and lectures:

- Cryptographic Protocols (lecture, 3 SWS)
- Cryptographic Protocols (exercise, 1,5 SWS)
- Modeling and Analysing Security (seminar, 3 SWS)
- Modeling and Analysing Security (practical course, 1 SWS)
- Modeling and Analysing Security (exercise, 1 SWS)

Workload:

- 170 Hours private studies
- 150 Hours in-classroom work
- 40 Hours exam preparation

Contents of teaching:

- see module parts CS4211T and CS4210T
-
-
-
-
- Modelling and formalizing protocols and security properties
- Adversaries and models of attacks, security pitfalls
- Symbolic methods and automatic verification of security properties
- Consistency and synchronization

Qualification-goals/Competencies:

- The students can comprehensively explain the security challenges of of digital communication.
- They can reason about cryptographic methods and their application in communication systems.
- The are able to select suitable security primitives for given applications and to implement them.
- The can conduct a security analysis of communication protocols.
- They can designate the weaknesses of real systems and evaluate them.
- The students can comprehensively elaborate on algorithmic basics for IT security.
- They can report on security properties.
- They can recite complex methods for IT security and apply them.
- They are able to specify, analyse and verify protocols and security properties.
- They can describe techniques for automatic verification of security properties.

Grading through:

- Oral examination

Requires:

- Cryptology (CS4016)
- Security in Networks and Distributed Systems (CS4180-KP04, CS4180)

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science

- Prof. Dr. Rüdiger Reischuk
- Prof. Dr. Maciej Liskiewicz

Literature:

- V. Cortier, S. Kremer (Ed.): Formal Models and Techniques for Analyzing Security Protocols - Cryptology and Information Security Series 5, IOS Press, 2011
- C. Pfleeger, S. Pfleeger: Security in Computing - Prentice-Hall 2007
- A. Joux: Algorithmic Cryptanalysis - CRC Press 2009
- J. Katz, Y. Lindell: Introduction to Modern Cryptography - CRC Press 2014
- S. Loepp, W. Wootters: Protecting Information - Cambridge Univ. Press 2006
- Lindell: Tutorials on the Foundations of Cryptography - Springer 2017
- Goldreich: Fundamentals of Cryptography - Cambridge Univ. Press 2004
- I. Cox, M. Miller, J. Bloom, J. Fridrich, T. Kalkerm: Digital Watermarking and Steganography - Morgan Kaufmann 2008
- Dwork, Roth: The Algorithmic Foundations of Differential Privacy - 2014

Language:

- English, except in case of only German-speaking participants

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework and project assignments during the semester

CS4508-KP12, CS4508 - Data Management (DatManag)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	12

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field computer science, 2nd or 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd or 3rd semester

Classes and lectures:

- CS4140 T: Mobile and distributed information systems (lecture with exercises, 3 SWS)
- CS5140 T: Semantic Web (lecture with exercises, 3 SWS)
- Seminar data management (seminar, 2 SWS)

Workload:

- 130 Hours private studies
- 120 Hours in-classroom work
- 90 Hours work on an individual topic with written and oral presentation or group work
- 20 Hours exam preparation

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- see module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Sven Groppe

Teacher:

- Institute of Information Systems
- Prof. Dr. Sven Groppe

Literature:

- : see module parts

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of the project assignment as specified at the beginning of the semester or
- Seminar lecture with elaboration according to the requirements at the beginning of the semester.

Module Exam(s):
- CS4508-L1: Data Management, oral exam, 100% of the module grade.

Instead of the seminar, an internship can also be offered.

(Consists of CS4140 T, CS5140 T)

CS4509-KP12, CS4509 - Internet Structures and Protocols / Internet Technologies (Internet)

Duration:	Turnus of offer:	Credit points:
2 Semester	not available anymore	12

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field computer science, 2nd and 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and 3rd semester

Classes and lectures:

- Architectures for Distributed Applications (lecture with exercises, 3 SWS)
- Advanced Internet Technologies (lecture with exercises, 3 SWS)
- Software Architectures (project work, 3 SWS)

Workload:

- 120 Hours in-classroom work
- 105 Hours private studies
- 45 Hours exam preparation
- 45 Hours group work
- 45 Hours work on project

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- see module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics
- Prof. Dr.-Ing Horst Hellbrück
- Prof. Dr.-Ing. habil. Dennis Pfisterer

Literature:

- : see module parts

Language:

- German and English skills required

Notes:

(Consists of CS5158 T, CS4151 T).

As of winter semester 2019/20, the module has been renamed from Internet Technologies to Internet Structures and Protocols.

As of winter semester 2020/21, the module is no longer offered to new students.

Admission requirements for taking the module:
- None

Admission requirements for taking module examination(s):
- Successful participation in lab

CS4510-KP12, CS4510 - Signal Analysis (SignalAna)

Duration:	Turnus of offer:	Credit points:
2 Semester	each year, can be started in winter or summer semester	12

Course of study, specific field and term:

- Master Biophysics 2023 (advanced module), advanced curriculum, 1st or 2nd semester
- Master MES 2020 (advanced module), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master Biophysics 2019 (advanced module), advanced curriculum, 1st and 2nd semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master MES 2014 (advanced module), computer science / electrical engineering, 1st and/or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field computer science, 2nd and/or 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and/or 3rd semester

Classes and lectures:

- CS5260SJ14 T: Speech and Audio Signal Processing (lecture with exercises, 3 SWS)
- CS5275 T: Selected Topics of Signal Analysis and Enhancement (lecture with exercises, 3 SWS)
- CS5194 T: Lab course (project work, 3 SWS)

Workload:

- 150 Hours private studies
- 90 Hours in-classroom work
- 60 Hours group work
- 40 Hours exam preparation
- 20 Hours written report

Contents of teaching:

- Introduction to statistical signal analysis
- Principles of feature extraction and pattern recognition
- Linear optimum filters
- Adaptive filters
- Spectrum analysis
- Basic concepts of multirate signal processing
- Applications in speech and image processing
- Realization of signal processing tasks for typical application scenarios in teamwork

Qualification-goals/Competencies:

- Students are able to explain the basic elements of stochastic signal processing and optimum filtering.
- They are able to describe and apply linear estimation theory.
- Students are able to describe the concepts of adaptive signal processing.
- They are able to explain theconcepts of feature extraction and pattern recognition.
- They are able to analyze and design multirate systems.
- Students are able to explain various practical applications of signal processing algorithms.
- They are able to create and implement signal processing systems on their own and in teamwork.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Alfred Mertins

Teacher:

- Institute for Signal Processing
- Prof. Dr.-Ing. Alfred Mertins

Literature:

- : See description of module parts

Language:

- German and English skills required

Notes:

Examination prerequisites can be defined at the beginning of the semester. If preliminary work is defined, it must have been completed and positively evaluated before the first examination.

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of the project assignment, seminar presentation and exercise assignments as specified at the beginning of the semester.

Module Exam(s):
- CS4510-L1: Signal Analysis, oral exam, 100% of module grade.

(Consists of CS4220 T, CS5275 T, CS5194 T)

CS4515-KP12 - Computer and System Security (ComSysSec)

Duration:	Turnus of offer:	Credit points:
2 Semester	each year, can be started in winter or summer semester	12

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field computer science, 2nd and 3rd semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester

Classes and lectures:

- Communication and System Security (lecture, 2 SWS)
- Communication and System Security (exercise, 1 SWS)
- Communication and System Security (seminar, 1 SWS)
- Computer Security (lecture, 2 SWS)
- Computer Security (practical course, 3 SWS)

Workload:

- 170 Hours private studies
- 150 Hours in-classroom work
- 40 Hours exam preparation

Contents of teaching:

- Applied cryptography in systems and protocols: Overview of common methods and their applications
- Efficient and secure implementation of common crypto procedures: multiple-precision arithmetic, efficient exponentiation, constant time algorithms etc.
- Physical implementation attacks and countermeasures: Error injection attacks, passive physical attacks such as SPA/DPA and timing attacks, modern inference methods and associated cryptanalysis methods, classes of protective measures
- Virtualization security and microarchitecture attacks: security concepts in the operating system and hypervisor, microarchitecture attacks such as cache attacks, spectre, etc., measures to restore system security
- Trusted Computing and Hardware-Assisted System Security: Functionality TPMs, Secure Elements and Trusted Execution Environments, basics and cryptographic techniques, design basics for secure systems
- Cryptographic procedures and protocols, security analyses
- IT security at system level, security mechanisms
- Security, privacy and trust of special systems like Cloud and IoT
- Operating system security
- Security management, legal framework conditions
- Security problems in IT systems

Qualification-goals/Competencies:

- The students can demonstrate a deep understanding of cryptographic methods and their applications in communication systems.
- They can construct secure and efficient cryptographic primitives and implement them securely in computer systems.
- They can explain methods and algorithms for efficient multiple-precision arithmetic.
- They can perform basic side-channel attacks on systems with physical access or shared systems with code execution rights.
- They can implement protection against specific physical attacks for cryptographic primitives.
- They can evaluate the security of existing primitives.
- Students can explain the basic methods in the field of cybersecurity and apply them to case studies.
- They can demonstrate a deeper understanding of cryptographic methods and their applications in communication systems.
- They can analyze the entire spectrum of the security of a system.
- They can explain modelling techniques and describe experiences with their use.
- They can apply a variety of standard techniques to increase the security of a system.

Grading through:

- Written or oral exam as announced by the examiner
- written homework

Requires:

- Cybersecurity (CS2250-KP04)
- Cryptology (CS3420-KP04, CS3420)

Responsible for this module:

- Prof. Dr. Thomas Eisenbarth

Teacher:

- Institute for IT Security

- Prof. Dr. Thomas Eisenbarth
- Prof. Dr. Rüdiger Reischuk

Literature:

- S. Mangard, E. Oswald & T. Popp: Power analysis attacks: Revealing the secrets of smart cards - Vol. 31, Springer Science & Business Media, 2008
- D. Stinson: Cryptography: Theory and Practice - 4th ed., CRC Press, 2018
- Stallings, Brown: Computer Security: Principles and Practice - 4th ed., Pearson, 2018
- Katz, Lindell: Introduction to Modern Cryptography - 2nd ed., CRC Press, 2014
- : Recent literature

Language:

- English, except in case of only German-speaking participants

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework and project assignments during the semester.

CS4517-KP12 - Architectures for Distributed Communication Systems (ArchVeK)

Duration:	Turnus of offer:	Credit points:
2 Semester	each semester	12

Course of study, specific field and term:

- Master IT-Security 2019 (optional subject), Elective Computer Science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2020 (optional subject), technology field computer science, 2nd or 3rd semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester

Classes and lectures:

- Architectures for distributed communication systems (lecture, 2 SWS)
- Architectures for distributed communication systems (exercise, 1 SWS)
- Mobil communication systems (lecture, 2 SWS)
- Mobil communication systems (exercise, 1 SWS)
- Architectures for distributed communication systems (practical course, 3 SWS)

Workload:

- 120 Hours in-classroom work
- 105 Hours private studies
- 45 Hours group work
- 45 Hours exam preparation
- 45 Hours work on project

Contents of teaching:

- Introduction to Communication Systems and overview of the state-of-the-art technologies
- Wireless Data Link Layer, Network Layer and Technologies (802.15.4, WLAN, GSM, Bluetooth, RFID, LowPowerWANs, Broadcast and Satellite Systems)
- Security in wireless Networks
- Applications of wireless Networks
- Software Architectures
- Basics of communication in distributed networks
- N-Tier Applications
- Architectures of distributed systems (Service-Oriented and Event-Driven Architectures (SOA and EDA), Web-Oriented Architectures (Web 2.0), Overlay Networks, Peer-to-Peer, Grid and Cloud Computing, Internet of Things)

Qualification-goals/Competencies:

- Students can highlight the particularities of wireless mobile communication systems and the challenges and concepts.
- They interpret and follow current research activities and technology trends.
- They can systematically design and evaluate protocols for mobile communication systems and their applications.
- They can design, implement, and operate real-time applications based on wireless communication networks.
- They can analyze technical requirements for mobile radio systems and components and choose solutions.
- They can carry out diagnoses, tests and optimizations of wireless networked mobile communication systems.
- The students are able to name the most important archiectures for distributed systems, explain them, and compare them to each other.
- For each architecture, they know the most prominent and important implementation platforms and basically know how to use them.
- For a given problem, they can analyze which architecture is best suited to solve it, and they can design a plan for the solution's realization.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics
- Prof. Dr.-Ing Horst Hellbrück
- Dr. Mohamed Hail

Literature:

- Jochen Schiller: Mobile Communications - 2nd Edition, Addison-Wesley, 2004, Signature: VK 2650 2005 A 302

- Andrew S. Tanenbaum: Computer Networks - 4th Edition, Prentice-Hall, 2003, Signature: VK 1670 2004 A 823
- Charles E. Perkins: Ad Hoc Networking - 1st Edition, Addison Wesley Professional, December 2000, Signature: VK 1670 2002 A 640
- J. Dunkel, A. Eberhart, S. Fischer, C. Kleiner, A. Koschel: Systemarchitekturen für verteilte Anwendungen - Hanser-Verlag 2008
- I. Melzer et.al.: Service-Orientierte Architekturen mit Web Services - Spektrum-Verlag 2010

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of the project internship

Module Examination(s):
- CS4517-L1: Architectures for Distributed Communication Systems, oral exam, 100% of module grade.

According to the decision of the Examination Board for Computer Science of 17.7.2020, this module can be chosen as a specialization module for Master Computer Science.

CS4518-KP12 - Current and Future Network Technologies (AzuNet)

Duration:	Turnus of offer:	Credit points:
2 Semester	each semester	12

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master IT-Security 2019 (optional subject), Elective Computer Science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2020 (optional subject), technology field computer science, 2nd or 3rd semester

Classes and lectures:

- Advanced Internet Technologies (lecture, 2 SWS)
- Advanced Internet Technologies (exercise, 1 SWS)
- Nano communication networks (lecture, 2 SWS)
- Nano communication networks (project work, 1 SWS)
- Seminar Internet of Things or Seminar Nano communication networks (seminar, 2 SWS)

Workload:

- 165 Hours private studies
- 105 Hours in-classroom work
- 45 Hours exam preparation
- 30 Hours work on an individual topic with written and oral presentation
- 15 Hours work on project

Contents of teaching:

- Fundamental Internet design principles
- Problems of today's Internet architecture
- Backbone Technologies
- Mobile Internet
- IPv6 und related topics
- Delay Tolerant Networks (DTN)
- Internet of Services / Internet of Things
- Peer-To-Peer networks
- Big Data
- Goals, architectures, algorithms, and protocols for the future Internet
- Self-assembly systems
- Reductions and compilation
- Definitions & associations of nanonetworks
- Simulation tools for nanonetworks
- Deployment in medical application scenarios

Qualification-goals/Competencies:

- The students understand the fundamental design decisions that led to the development of the Internet network protocols.
- They know basic, general criteria for designing networks (end-to-end argument, fate sharing, etc.).
- They learn about technological and social developments that have led to massive changes in the Internet infrastructure (growth, innovations such as mobile communication, etc.)
- They recognize the problems of the current internet architecture and can derive potential solutions by comparing them with alternative approaches.
- Sie lernen das Forschungsgebiet des Future Internet kennen und begegnen so einer Reihe aktueller Ansätze, die das Internet der Zukunft erforschen.
- Students know and understand the basic concepts of nanonetworks.
- Students know the basic concepts of nanoscale computational models.
- Students know and understand self-assembly systems and crystal formation.
- Students know and understand the constraints and peculiarities at the nanoscale.
- Students know how to verify or falsify a model using simulation tools.
- Students can transfer basic theoretical concepts to related questions.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics

- Dr. Mohamed Hail
- Dr. rer. nat. Florian-Lennert Lau

Literature:

- Olivier Hersent, David Boswarthick, Omar Elloumi: The Internet of Things: Key Applications and Protocols - Wiley, 2012
- Athanasios V. Vasilakos, Yan Zhang, Thrasyvoulos Spyropoulos: Delay Tolerant Networks: Protocols and Applications - CRC Press, 2012
- E. Pacitti, R. Akbarinia, M. El-Dick: P2P Techniques for Decentralized Applications - Morgan & Claypool Publishers

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful participation in the seminar

Module Exam(s):
- CS4518-L1: Current and Future Network Technologies, oral exam, 100% of module grade.

CS4520-KP12, CS4520 - Case study in professional product development (Fallstudie)

Duration:	Turnus of offer:	Credit points:	Max. group size:
2 Semester	each semester	12	12

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field computer science, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field computer science, 2nd and 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and 3rd semester
- Master Artificial Intelligence 2023 (optional subject), for equivalence check, Arbitrary semester

Classes and lectures:

- Basics for product development (exercise, 2 SWS)
- Product development (practical course, 6 SWS)

Workload:

- 120 Hours group work
- 120 Hours in-classroom work
- 70 Hours private studies
- 30 Hours oral presentation (including preparation)
- 20 Hours exam preparation

Contents of teaching:

- generating ideas for product development
- developing a business plan
- planning and developing a prototype
- techniques for management and planning
- product cycles
- economic studies
- licences

Qualification-goals/Competencies:

- Students can start working in or leading a team for product development in informatics.
- They can organize and conduct the different phases of product development.
- They can assess legal and economic restrictions of product development.
- They are able to play different roles in a developing team.

Grading through:

- Oral examination

Responsible for this module:

- Studiengangsleitung Informatik

Teacher:

- Institutes of the Department of Computer Science/ Engineering
- Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges

Language:

- English, except in case of only German-speaking participants

Notes:

Basics for product development can be taught by various appropriate forms of instruction other than exercises.

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- continuous, successful participation in course
- presentation
- successful addressing of the project goals
- documentation
- grading by the reviewer

CS4521-KP12 - Constructive Cognitive Science (CCS)

Duration:	Turnus of offer:	Credit points:
2 Semester	each semester	12

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, 1st to 3th semester

Classes and lectures:

- Human-Aware AI (lecture, 3 SWS)
- Models for human intelligent Assistance (lecture, 3 SWS)
- Human-Aware AI (Excercises with project, 3 SWS)

Workload:

- 135 Hours in-classroom work
- 105 Hours private studies
- 90 Hours work on project
- 30 Hours exam preparation

Contents of teaching:

- Definition and Examples for Human-Centered and Human-Aware AI systems
- Constructive Cognitive Science, Situation understanding and mental models
- Explainable Human-AI Interaction
- Cognitive Modelling especially cognitive architectures
- Human-Robot Collaboration
- Digital cognitive Twins and Physical Human Models
- Intention recognition and Theory of Mind
- Interactive task learning
- Situated cognitive agents
- Tracing the cognitive state of the human-in-the-loop

Qualification-goals/Competencies:

- The students can enumerate central ideas, define the relevant concepts and explain the functioning of algorithms with help of application scenarios as well as apply the algorithms for all the items listed in contents of teaching.

Grading through:

- exercises and project assignments
- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Nele Rußwinkel

Teacher:

- Institute of Information Systems
- Prof. Dr.-Ing. Nele Rußwinkel

Literature:

- S.J. Russell: Human Compatible: Artificial Intelligence and the Problem of Control - Penguin Books, 2020
- C.S. Nam, J.-Y. Jung, S. Lee (Eds.): Human-Centered Artificial Intelligence: Research and Applications - Elsevier, 2022
- J.R. Anderson: How Can the Human Mind Occur in the Physical Universe? - Oxford University Press, 2007
- B. Sneiderman: Human-Centered AI - Oxford University Press, 2022

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises and project tasks as specified at the beginning of the semester.

Module Exam(s):
- CS4505-L1: Constructive Cognitive Science, oral exam, 100% of the module grade.