UNIVERSITÄT ZU LÜBECK

Module Guide for the Study Path

Master Medical Informatics 2019

Version from 1. April 2025

1st and 2nd semester

1st or 2nd semester

3rd semester

4th semester

Arbitrary semester

MZ4400-KP08, MZ4400 - Clinical Medicine (KM)

Duration:	Turnus of offer:	Credit points:
2 Semester	starts every winter semester	8

Course of study, specific field and term:

- Master MES 2020 (compulsory), medical engineering science, 1st and 2nd semester
- Master Medical Informatics 2019 (compulsory), medical computer science, 1st and 2nd semester
- Master Medical Informatics 2014 (compulsory), medical computer science, 1st and 2nd semester
- Master MES 2014 (compulsory), medical engineering science, 1st and 2nd semester

Classes and lectures:

- Clinical Medicine 1 (lecture, 2 SWS)
- Clinical Medicine 2 (lecture, 2 SWS)
- Clinical Medicine 3 (lecture, 2 SWS)

Workload:

- 110 Hours private studies
- 90 Hours in-classroom work
- 40 Hours exam preparation

Contents of teaching:

- Fundamentals of general, visceral, thoracic and vascular surgery, urology, traumatology, orthopedics and pediatric surgery
- Fundamentals of surgical wound management
- Practical applications of medical technology in the eye, otorhinolaryngology, neurology, neurosurgery
- Fundamentals of cardiac surgery, cardiology, cardiovascular laboratory, pulmonology, nephrology
- Use of medical devices in extracorporeal circulation (eg dialysis / hemofiltration, cardiopulmonary bypass, mechanical circulatory support and ventilation)
- Structure and regulation of the cardiovascular system incl. breathing and fluid homeostasis
- Application of medical procedures and their interaction with the patient
- Implementing medical technology procedures in the clinical processes of diagnosis and therapy

Qualification-goals/Competencies:

- Students know the essential surgical diseases and their treatment principles.
- They have an understanding of surgical complications and their management.
- They know the essential head surgical diseases and their treatment principles.
- They know the basic diseases of the cardiovascular, respiratory and renal system and their treatment principles with a particular focus on monitoring organs and substitution processes.
- They know the interaction between medical procedures and patient-oriented application.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. rer. nat. Thorsten Buzug

Teacher:

- Universitätsklinikum S-H
- N.N.

Literature:

- Müller: Chirurgie für Studium und Praxis 2006/07 - Medizinische Verlags- und Informationsdienste.Breisach
- Helmut Rössler, Wolfgang Rüther, Jörn Steinhagen: Orthopädie und Unfallchirurgie - StudentConsult (Broschiert). Urban & Fischer , 19. aktualis. u. erw. Auflage 2005 .ISBN-10: 343744445X
- Mow, Huiskes: Basic orthopaedic biomechanics & mechano-biology
- Ertan Mayatepek: Lehrbuch Pädiatrie - Urban & Fischer bei Elsevier, 2007
- Hautmann/Huland: Urologie - Springerverlag
- Jocham/Miller: Praxis der Urologie - Thiemeverlag
- Brinckmann, Frobin, Leivseth: Orthopädische Biomechanik
- Berghaus: Duale Reihe HNO
- Theissing: Praktische HNO-Lehre - Thieme-Verlag
- Howaldt/Schmelzeisen: Einführung in die Mund-, Kiefer-, Gesichtschirurgie - Verlag Urban und Fischer
- Schwenzer/Ehrenfeld: Zahn-Mund-Kiefer-Heilkunde - Thieme-Verlag, Stuttgart

- Moskopp/Wassmann: Neurochirurgie - Schattauer-Verlag
- Kampik: Laserjahrbuch der Augenheilkunde - Biermann-Verlag
- Lang: Augenheilkunde verstehen, lernen und anwenden - Thieme-Verlag

Language:

- offered only in German

Notes:

The module MZ4400 Clinical Medicine consists of the lectures Clinical Medicine 1, Clinical Medicine 2 (both winter semester) and Clinical Medicine 3 (summer semester).

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- None

Examination numbers: MZ4400-L1 Clinical Medicine 1, MZ4400-L2 Clinical Medicine 2, MZ4400-L3 Clinical Medicine 3

CS3510-KP04 - Data protection law and information security (DatInfoSec)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (optional subject), interdisciplinary competence, 1st or 2nd semester
- Bachelor Medical Informatics 2019 (optional subject), interdisciplinary competence, 4th to 6th semester
- Master Interdisciplinary Courses (optional subject), interdisciplinary, Arbitrary semester
- Bachelor Interdisciplinary Courses (optional subject), interdisciplinary, Arbitrary semester
- Bachelor Interdisciplinary Courses for health sciences (optional suject), interdisciplinary, Arbitrary semester

Classes and lectures:

- CS3510-V: Data protection law and information security (lecture, 2 SWS)
- CS3510-Ü: Data protection law and information security (exercise, 1 SWS)

Workload:

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

Contents of teaching:

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Qualification-goals/Competencies:

- Students can recognize and apply the legal framework for data protection and information security for persons who are responsible for a data processing system.
- Students can assess what they need to consider legally when developing, implementing and operating data processing systems.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute for IT Security
- externe Referent*innen

Literature:

- :
- :
- :
- :
- :

Language:

- offered only in German

Notes:

Admission requirements for taking the module(s):
- None

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

Module examination:
- CS3510-KP04 Data protection law and information security Written exam, 100 % of the 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), specific, 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), specific, 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 exam preparation
- 20 Hours work on project

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.

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), Applied 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), Applied 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:

- Motivation of knowledge graphs and their relationship to the Semantic Web
- Overview over the W3C Semantic Web family of languages
- Comparison between and the interaction of knowledge graphs and generative artificial intelligence such as large language models
- Graph Neural Networks and their applications for tasks of knowledge graphs

Qualification-goals/Competencies:

- Knowledge: Students acquire an overview of knowledge graphs and the Semantic Web as well as generative artificial intelligence such as large language models and graph neural networks.
- Skills: Students can assess the possibilities and limitations of knowledge graphs and the Semantic Web. They can estimate the consequences of the Semantic Web approach for data modeling, data administration and processing and for applications. They can develop Semantic Web applications. They can use generative artificial intelligence such as large language models and graph neural networks to solve tasks for and in addition to knowledge graphs. They can discuss open research questions in the area of knowledge graphs and the semantic web as well as in comparison to generative artificial intelligence and graph neural networks.
- Social skills and independence: Students work in groups to complete exercises and small projects. Students' independent practical work is encouraged through exercises, some of them directly on the computer.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Sven Groppe

Teacher:

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

Literature:

- M. Kejriwal, C. Knoblock: Knowledge graphs - MIT Press, 2021
- S. Groppe: Data Management and Query Processing in Semantic Web Databases - Springer, 2011
- W. L. Hamilton: Graph Representation Learning. In Synthesis Lectures on Artificial Intelligence and Machine Learning - Springer International Publishing, 2020
- D. Jurafsky, J. H. Martin: Speech and language processing - Upper Saddle River, NJ: Pearson, 2008
- D. Foster: Generative deep learning - Sebastopol, CA: O Reilly Media, 2023

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, written exam or oral exam, 100% of module grade

Previous name: Web Based Information Systems

CS4140-KP04, CS4140 - Mobile and Distributed Databases (MVDB)

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

Course of study, specific field and term:

- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2012 (optional subject), advanced curriculum distributed information systems, 3rd semester
- Master Computer Science 2012 (compulsory), specialization field software systems engineering, 1st semester

Classes and lectures:

- Mobile and Distributed Databases (lecture, 2 SWS)
- Mobile and Distributed Databases (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:

- Oral examination

Responsible for this module:

- Prof. Dr. Sven Groppe

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:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Active participation in lecture and tutorial

Module Examination(s):
- CS4140-L1: Mobile and Distributed Databases, oral exam, 100% of module grade.

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), Applied 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), Applied 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 in-classroom work
- 60 Hours private studies
- 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.

CS4151-KP04, CS4151 - Architectures for Distributed Applications (SVA)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd 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 distributed information systems, 2nd semester
- Master Computer Science 2012 (optional subject), advanced curriculum parallel and distributed system architecutres, 2nd or 3rd semester
- Master Computer Science 2012 (compulsory), specialization field software systems engineering, 2nd semester
- Master Computer Science 2012 (compulsory), advanced curriculum enterprise IT, 2nd semester

Classes and lectures:

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

Workload:

- 45 Hours in-classroom work
- 45 Hours private studies
- 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:

- Oral examination

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:

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):
- CS4151-L1 System Architectures for Distributed Applications, oral exam, 100% of 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), specific, 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), specific, 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), specific, 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), specific, 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

CS4210-KP06, CS4210 - Cryptographic Protocols (KrypProto)

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

Course of study, specific field and term:

- Master Media Informatics 2020 (optional subject), computer science, 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
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd semester

Classes and lectures:

- Cryptographic Protocols (lecture, 3 SWS)
- Cryptographic Protocols (exercise, 1,5 SWS)

Workload:

- 85 Hours private studies and exercises
- 75 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Complex cryptographic protocols, security analyses
- Anonymity and Privacy, Private Computation and Information Retrieval, Differential Privacy
- Quantum Cryptographie
- Steganography, digital seals and watermarks
- secure e-commerce, electronic money, online elections

Qualification-goals/Competencies:

- The students 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.

Grading through:

- Oral examination

Requires:

- Cryptology (CS3420-KP04, CS3420)

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

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

Literature:

- Lindell: Tutorials on the Foundations of Cryptography - Springer 2017
- J. Katz, Y. Lindell: Introduction to Modern Cryptography - CRC Press 2014
- 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:

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

CS4220-KP04, CS4220 - Pattern Recognition (Muster)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master MES 2014 (optional subject), medical engineering science, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Elective, 1st or 2nd semester
- Master CLS 2016 (compulsory), mathematics, 2nd semester
- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), medical image processing, 1st or 2nd 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:

- Written or oral exam as announced by the examiner

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:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester (at least 50% of max. points) and successful project task.

Modul exam:
- CS4220-L1:Pattern Recognition, written exam, 90 Min, 100% of modul grade

CS4271-KP08, CS4271 - Artificial Intelligence 2 and Medical Robotics (KI2MedRob)

Duration:	Turnus of offer:	Credit points:
2 Semester	each year, can be started in winter or summer semester	8

Course of study, specific field and term:

- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), medical image processing, 1st or 2nd semester
- Master Computer Science 2014 (compulsory), specialization field robotics and automation, 1st and 2nd semester

Classes and lectures:

- Medical Robotics (lecture, 2 SWS)
- Medical Robotics (exercise, 1 SWS)
- Artificial Intelligence 2 (lecture, 2 SWS)
- Artificial Intelligence 2 (exercise, 1 SWS)

Workload:

- 110 Hours private studies
- 90 Hours in-classroom work
- 40 Hours exam preparation

Contents of teaching:

- Support Vector Machines and Dualization
- Classification
- Regression
- Time-Series Prediction
- Lagrange Multipliers
- Sequential Minimal Optimization
- Geometric Reasoning

Qualification-goals/Competencies:

- Students are able to explain the concepts of forward and inverse kinematics for the examples of 3-joint and 6-joint robots.
- They are able to apply methods of medical robot systems and to simple practical applications.
- Students are able to transfer methods of motion learning to simple practical problems.
- Students are able to modify templates for dynamic calculations in order to create the calculations for their own constructions.
- The students are able to choose a method for machine learning for a given application amongst a variety of such methods.
- The chosen method can be customized to the needs of the application. The process of customization goes well beyond straightforward search of parameters and involves adjustments to the basic mathematical techniques.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Achim Schweikard

Teacher:

- Institute for Robotics and Cognitive Systems
- Prof. Dr.-Ing. Achim Schweikard

Literature:

- J. -C. Latombe: Robot Motion Planning - Dordrecht: Kluwer 1990
- J.J. Craig: Introduction to Robotics - Pearson Prentice Hall 2002
- : Vorlesungsskript: Med. Robotics
- P. Norvig, S. Russell: Künstliche Intelligenz - München: Pearson 2004

Language:

- offered only in English

Notes:

Note: Module will not be offered in winter semester 2024/2025

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):
- CS4271-L1: Artificial Intelligence 2 and Medical Robotics, written exam, 90min, 100% of the module grade

CS4332-KP06 - Model and AI-based image processing in medicine (MoKiBi)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (compulsory), medical image processing, 1st or 2nd semester

Classes and lectures:

- Model and AI-based image processing in medicine (lecture, 2 SWS)
- Model and AI-based image processing in medicine (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- Methods and algorithms for the analysis and visualization of medical images including current research activities in the field of medical image computing. The following methods and algorithms are explained:
- Fundamentals of neural networks in medical image processing
- Convolutional Neural Networks and Deep Learning in Medical Image Processing
- U-Nets for image segmentation
- Autoencoder and Generative Adversarial Networks in Medical Image Processing
- Data augmentation techniques
- Random Decision Forests for the segmentation of medical image data
- Statistical shape models: generation and application for image segmentation
- ROI-based segmentation and cluster analysis for the segmentation of multispectral image data
- Live wire segmentation
- Segmentation with active contour models and deformable models
- Non-linear image registration
- Atlas-based segmentation and multi-atlas segmentation using non-linear registration
- 3D Visualization techniques in medicine

Qualification-goals/Competencies:

- Students can classify and explain advanced methods for medical image analysis on the basis of their characteristics. They can select these methods based on a given specific application.
- They are able to explain advanced methods of cluster analysis and classification especially with Convolutional Neural Networks and Random Decision Forests and to characterize them by their properties.
- You can explain the conception of neural network architectures of U-Nets, GANs or auto-encoders in detail. They can explain in detail the conception of neural network architectures of U-Nets, GANs or auto-encoders.
- They know prerequisites, problems and limits as well as augmentation techniques for the use of neural networks in medical image processing.
- They know different approaches to model-based segmentation, can describe the different model assumptions made here and are able to explain the optimization strategies and algorithms used here.
- They are able to assess the properties of various non-linear image registration methods and to select and parametrize similarity measures and regularization terms for a specific registration problem.
- They are familiar with methods of multi-atlas segmentation and can explain and exemplify the properties of different label fusion approaches.
- They can differentiate between different medical visualization techniques, classify them according to their specific advantages and disadvantages, and select and apply them in a meaningful way depending on a specific application problem.
- They can practically work on and solve problems in medical image processing using neural networks.
- They master the problem-related selection and implementation of data augmentation techniques, suitable network topologies and training procedures as well as the evaluation of the results.

Grading through:

- Written or oral exam as announced by the examiner

Is requisite for:

- Seminar Model and AI-based image processing in medicine (CS4333-KP04)

Requires:

- Medical Image Computing (CS3310-KP09)

Responsible for this module:

- Prof. Dr. rer. nat. habil. Heinz Handels

Teacher:

- Institute of Medical Informatics
- Prof. Dr. rer. nat. habil. Heinz Handels

Literature:

- H. Handels: Medizinische Bildverarbeitung - 2. Auflage, Vieweg u. Teubner 2009
- T. Lehmann: Handbuch der Medizinischen Informatik - München: Hanser 2005
- M. Sonka, V. Hlavac, R. Boyle: Image Processing, Analysis and Machine - Elsevier, 2007
- B. Preim, C. Botha: Visual Computing for Medicine - 2nd Edition, Elsevier, 2013

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None (the competences of the modules mentioned under "requires" are needed for this module, but are not a formal prerequisite).

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

Module Exam(s):
- CS4332-L1 Model- and AI-based Image Processing in Medicine, written exam, 90min, 100% of the module grade.

This module replaces the discontinued module "CS4330 Image Analysis and Visualisation in Diagnostics and Therapy".

CS4333-KP04 - Seminar Model and AI-based image processing in medicine (MoKiBiS)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (advanced module), medical computer science, 1st or 2nd semester

Classes and lectures:

- Seminar Model and AI-based image processing in medicine (seminar, 2 SWS)

Workload:

- 40 Hours written report
- 30 Hours private studies
- 30 Hours in-classroom work
- 20 Hours oral presentation (including preparation)

Contents of teaching:

- Familiarisation with a scientific topic on the basis of selected publications from current research
- Treatment of a scientific problem and its solution process
- Presentation and discussion of the topic

Qualification-goals/Competencies:

- The students are familiar with current research topics and scientific methods of medical image processing and visualization from the seminar.
- They can thoroughly work on a challenging scientific topic.
- They are able to present the results in a written elaboration and in an oral presentation in an understandable way.
- They can present and discuss a scientific question.

Grading through:

- Written report

Requires:

- Model and AI-based image processing in medicine (CS4332-KP06)

Responsible for this module:

- Prof. Dr. rer. nat. habil. Heinz Handels

Teacher:

- Institute of Medical Informatics
- Prof. Dr. rer. nat. habil. Heinz Handels
- Prof. Dr. Mattias Heinrich

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None (the competences of the modules mentioned under "requires" are needed for this module, but are not a formal prerequisite).

Admission requirements for participation in module examination(s):
- Successful and regular participation in the seminar incl. written elaboration, presentation, contributions to the discussion according to the requirements at the beginning of the semester.

Module Exam(s):
- CS4333-L1 Seminar Model- and AI-based Image Processing in Medicine, graded seminar.

Previous or simultaneous participation in the module "CS4332-KP06 - Model- and AI-based Image Processing in Medicine" is recommended.

CS4340-KP04, CS4340SJ14 - Health Economy (GOEK14)

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

Course of study, specific field and term:

- Bachelor MES 2020 (optional subject), medical engineering science, 3rd semester at the earliest
- Master Medical Informatics 2019 (advanced module), medical computer science, 1st or 2nd semester
- Bachelor Biophysics 2016 (optional subject), no specific field, 6th semester
- Bachelor MES 2014 (optional subject), medical engineering science, 4th or 6th semester
- Master Medical Informatics 2014 (compulsory), medical computer science, 1st or 2nd semester

Classes and lectures:

- CS4340-V: Health Economy (lecture, 2 SWS)
- CS4340-Ü: Health Economy (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- The course comprises two thematic blocks. Part 1 teaches the basics of health economic evaluations. In part 2, the main part of the course, the basics of different types of modeling for conducting health economic evaluations are explained and corresponding models are programmed in suitable software using practical examples. The programming of decision trees and Markov cohort models in Microsoft EXCEL as well as the programming of microsimulations and epidemiological models (based on differential equations) in R is planned. The use of other software products or programming languages can be discussed during the course. In addition, exercises with practical examples will be worked on, dealing in particular with modeling.
- PART 1: BASICS OF HEALTH ECONOMIC EVALUATIONS
- Relevance and objectives of economic evaluation in the context of healthcare
- Forms of study
- Cost types
- Effectiveness measures
- Decision analyses
- Sensitivity analyses
- Evaluation of digital health applications
- PART 2: DECISION ANALYTICAL MODELING
- Decision trees
- Markov cohort models
- Microsimulations
- Mathematical models (differential equation models) for the spread of infectious diseases

Qualification-goals/Competencies:

- PART 1: FUNDAMENTALS OF HEALTH ECONOMIC EVALUATIONS
- They know the different forms of health economics studies and can differentiate between them.
- They can explain types of costs and measurement approaches for determining them in health economic studies.
- They know different measures of effectiveness and discuss the respective advantages and disadvantages.
- They know how to conduct cost-effectiveness analyses for medical interventions / health programs.
- They know the steps of decision analysis and can carry out corresponding analyses on the basis of evaluation results.
- They can assess the suitability of data sources for health economic studies, reflect on parameter assumptions and carry out sensitivity analyses by changing assumptions and data sources.
- They can apply the knowledge they have acquired to analyze and critically assess specific studies on the cost-effectiveness of medical products and procedures.
- PART 2: DECISION ANALYTICAL MODELING
- They know the strengths and limitations of different model types and are able to make an appropriate model selection for specific application examples.
- They can develop decision trees, Markov models, microsimulations and epidemiological models (based on differential equations) for specific application examples and program them in suitable software.
- They can use the above-mentioned model types to carry out health economic evaluations.
- They can program algorithms for univariate, multivariate and probabilistic sensitivity analyses (Monte Carlo simulations) in suitable software and carry out corresponding analyses.
- They can calibrate epidemiological models using epidemiological data.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. Alexander Kuhlmann

Teacher:

- Institute for Social Medicine and Epidemiology
- Prof. Dr. Katrin Balzer
- Prof. Dr. Alexander Kuhlmann

Literature:

- Fleßa S, Greiner W: Grundlagen der Gesundheitsökonomie - Eine Einführung in das wirtschaftliche Denken im Gesundheitswesen - 4. aktualisierte Auflage. Berlin: Springer Gabler 2020 (978-3-662-62115-8)
- Schöffski O, Graf von der Schulenburg JM (Hrsg.): Gesundheitsökonomische Evaluationen - 4. aktualisierte Auflage. Springer Berlin Heidelberg 2012 (ISBN: 978-3-642-21699-2)
- Briggs A, Claxton K, Sculpher M: Decision Modelling For Health Economic Evaluation - Oxford University Press 2006 (ISBN: 978-0198526629)
- Vynnycky E, White R: An Introduction to Infectious Disease Modelling - Oxford University Press 2010 (ISBN: 978-0198565765)

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):
- CS4340-L1: Health Economics, written exam, 90min, 100% of module grade

(Share of Institute of Social Medicine and Epidemiology in V is 100%)
(Share of Institute of Social Medicine and Epidemiology in Ü is 100%)

CS4352-KP06 - Medical Data Science for Assistive Health Technologies (MDS4AGT)

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

Course of study, specific field and term:

- Master Medical Informatics 2014 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Master Medical Informatics 2019 (compulsory), Medical Data Science / Artificial Intelligence, 1st or 2nd semester

Classes and lectures:

- Medical Data Science for Assistive Health Technologies (lecture, 2 SWS)
- Medical Data Science for Assistive Health Technologies (exercise, 2 SWS)
- Medical Data Science for Assistive Health Technologies (practical course, 1 SWS)

Workload:

- 75 Hours in-classroom work
- 65 Hours private studies
- 40 Hours exam preparation

Contents of teaching:

- Introduction to Medical Data Science for Assistive Health Technologies
- General Approach to Human Activity Recognition
- Multiple Sensor Integration and Synchronisation
- Feature Learning from Multimodal Sensor Data
- Supervised Classification of Multimodal Sensor Data
- General Approach to Indoor Localisation
- Statistical Representation of Multimodal Sensor Data
- Recursive Probability Density Estimation
- Particle Filtering and State Classification
- General Approach to Sleep Lab Data Analysis
- Multimodal Time Series Data Augmentation
- Transfer Learning for Time Series Classification
- Explainable Machine Learning
- Demonstrators from Current Research Projects
- Summary and Conclusions

Qualification-goals/Competencies:

- Students have an overview of known assistive health technologies and are able to motivate their application from the medical perspective.
- Students know the general approach to human activity recognition.
- Students know selected approaches of multiple sensor integration and synchronisation.
- Students know selected feature learning methods and are able to implement them in a programming language.
- Students know selected classification algorithms for multimodal sensor data are able to implement them in a programming language.
- Students know the general approach to indoor localisation.
- Students know selected models for statistical representation of multimodal sensor data and are able to implement them in a programming language.
- Students know the theory behind the recursive probability density estimation.
- Students know the particle filtering approach and are able to implement it in a programming language.
- Students know the general approach aiming at the interpretation of data recorded in a sleep lab.
- Students know selected methods for multimodal time series data augmentation and are able to implement them in a programming language.
- Students know selected transfer learning methods for time series classification and are able to implement it in a programming language.
- Students know selected methods of explainable machine learning.
- Students know the objectives and function of software systems from selected current medical data science research projects.
- Students know the societal relevance of assistive health technologies.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Marcin Grzegorzek

Teacher:

- Institute of Medical Informatics

- Prof. Dr.-Ing. Marcin Grzegorzek
- PD Dr. rer. nat. habil. Sebastian Fudickar

Literature:

- Peter J. Brockwell and Richard A. Davis: Introduction to Time Series and Forecasting - ISBN: 978-3-319-29852-8
- Marcin Grzegorzek: Sensor Data Understanding - ISBN: 978-3-8325-4633-5
- Andrew R. Webb: Statistical Pattern Recognition - ISBN: 978-0-470-68228-9
- Sergios Theodoridis and Konstantinos Koutroumbas: Pattern Recognition - ISBN: 978-1-597-49272-0
- Heinrich Niemann: Klassifikation von Mustern - ISBN: 978-3-642-47517-7
- Marcin Grzegorzek: Appearance-Based Statistical Object Recognition Including Color and Context Modeling - ISBN: 978-3-8325-1588-1
- Muhammad Adeel Nisar: Sensor-Based Human Activity Recognition for Assistive Health Technologies - ISBN: 978-3-8325-5571-9
- Frédéric Li: Deep Learning for Time-series Classification Enhanced by Transfer Learning Based on Sensor Modality Discrimination - ISBN: 978-3-8325-5396-8
- Frank Ebner: Smartphone-Based 3D Indoor Localization and Navigation - ISBN: 978-3-8325-5232-9
- Xinyu Huang: Sensor-Based Sleep Stage Classification Using Deep Learning - ISBN: 978-3-8325-5617-4

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 pracitcal tasks as specified at the beginning of the semester.

Module Exam(s):
- CS4352-L1: Medical Data Science for Assistive Health Technologies, oral exam, 100% of module grade.

CS4354-KP04 - Seminar Medical Data Science and eHealth (MDS4Health)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (advanced module), medical computer science, 1st or 2nd semester

Classes and lectures:

- Seminar Medical Data Science and eHealth (seminar, 2 SWS)

Workload:

- 60 Hours work on an individual topic from a recent field of research and written elaboration
- 30 Hours in-classroom work
- 30 Hours oral presentation (including preparation)

Contents of teaching:

- General state-of-the-art study in the field of Medical Data Science and e-Health.
- Specific state-of-the-art study regarding a selected research topic from the area of Medical Data Science and e-Health.
- Identification of open scientific problems in a selected research topic.
- Preparing a written summary regarding a selected research topic in English.
- Presentation and discussion of a selected research topic in English.

Qualification-goals/Competencies:

- Students know how to perform a state-of-the-art study in a selected research area using recommended literature.
- Students know how to identify open scientific problems in a selected research area.
- Students know how to describe the state-of-the-art of a selected research topic identifying its open scientific problems in a written summary in English.
- Students know how to present and discuss the state-of-the-art of a selected research topic identifying its open scientific problems in English.

Grading through:

- participation in discussions

Responsible for this module:

- Prof. Dr.-Ing. Marcin Grzegorzek

Teacher:

- Institute of Medical Informatics
- Prof. Dr.-Ing. Marcin Grzegorzek

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful and regular participation in the seminar incl. written elaboration, presentation, contributions to the discussion according to the requirements at the beginning of the semester.

Module Exam(s):
- CS4354-L1: Seminar Medical Data Science and eHealth, graded seminar, 100% of the module grade

CS4356-KP06 - Medical Information Retrieval (MIR)

Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly in the summer semester	6

Course of study, specific field and term:

- Master Medical Informatics 2019 (advanced module), Medical Data Science / Artificial Intelligence, 1st or 2nd semester

Classes and lectures:

- Medical Information Retrieval (lecture, 2 SWS)
- Medical Information Retrieval (exercise, 2 SWS)
- Medical Information Retrieval (practical course, 1 SWS)

Workload:

- 75 Hours in-classroom work
- 65 Hours private studies
- 40 Hours exam preparation

Contents of teaching:

- Introduction to Medical Information Retrieval (MIR)
- Main Components and Classification of MIR Systems
- Metadata of Medical Information Retrieval Systems
- Evaluation of Medical Information Retrieval Systems
- Set Theoretic Model: Boolean Retrieval
- Set Theoretic Model: Fuzzy Retrieval
- Vector Space Model: Similarity Measures
- Vector Space Model: Distance Functions
- Vector Space Model: Latent Semantic Indexing
- Probabilistic Model
- Text-based Retrieval of Medical Information
- Audio-based Retrieval of Medical Information
- Image-based Retrieval of Medical Information
- Demonstrators from Current Research Projects
- Summary and Conclusions

Qualification-goals/Competencies:

- Students have an overview of known MIR approaches and are able to motivate their application from the medical perspective.
- Students know the general approach towards medical information retrieval.
- Students are able to distinguish medical information retrieval from other related terms.
- Students know fundamental methods of metadata modelling for medical information retrieval.
- Students are able to quantitatively evaluate MIR systems and to interpret this evaluation.
- Students know selected set theoretical approaches for medical information retrieval.
- Students know selected MIR approaches following the concept of vector space model.
- Students know selected probabilistic approaches for medical information retrieval.
- Students know fundamental approaches for text-based medical information retrieval.
- Students know fundamental approaches for audio-based medical information retrieval.
- Students know fundamental approaches for image-based medical information retrieval.
- Students know objectives and function of software systems from selected current research projects related to MIR.
- Students know selected ethical aspects related medical information retrieval systems.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr.-Ing. Marcin Grzegorzek

Teacher:

- Institute of Medical Informatics
- Prof. Dr.-Ing. Marcin Grzegorzek

Literature:

- Christopher D. Manning, Prabhakar Raghavan, and Hinrich Schütze: Introduction to Information Retrieval - ISBN: 978-0-521-86571-5
- William Hersh: Information Retrieval: A Health and Biomedical Perspective - ISBN: 978-0-387-78702-2

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

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

Module Exam(s):
- CS4356-L1: Medical Information Retrieval, written exam, 120min, 100% of module grade.

CS4361-KP06 - Medical data integration - eHealth (MedDatInt)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (compulsory), ehealth / infomatics, 1st or 2nd semester

Classes and lectures:

- Medical data integration - eHealth (lecture, 2 SWS)
- Medical data integration - eHealth (exercise, 2 SWS)
- Medical data integration - eHealth (practical course, 1 SWS)

Workload:

- 75 Hours private studies and exercises
- 75 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- Middleware and Information Integration for Distributed Systems in the Healthcare Sector
- Standardized (generic) information models for improved semantic interoperability
- HL7 Version 3: Framework, incl. Generic Reference Information Model (RIM)
- HL7 CDA (Clinical Document Architecture)
- HL7 FHIR (Fast Healthcare Interoperability Resources)
- ISO 13606 or openEHR initiative => 2-level approach: reference model and integrable clinical content models (archetypes)
- Further standards, e.g. DICOM SR (images), ISO/IEEE 11073 (medical devices), CDISC (clinical studies), ...
- IHE (Integrating the Healthcare Enterprise): Integration Profiles
- Standardized vocabularies: Differentiation of classifications, terminologies, ontologies, etc.
- Unified Medical Language System (UMLS): Terminology servers and services
- Semantic Web Standards: RDF, RDF Schema, OWL, SPARQL, etc.
- Description logics: representation and inference for (formal) ontologies
- Reference terminology in medicine: SNOMED CT
- Other terminologies/ontologies: OBO (bioinformatics), RadLex (radiology), etc.
- Interference of information models and compositional terminologies (TermInfo)

Qualification-goals/Competencies:

- The students can explain the problem of syntactic, structural and semantic heterogeneity in distributed application systems and give examples.
- They can explain the model-based HL7 V3 standard with its static and dynamic model parts, including RIM model and derived models by cloning and constraining.
- They can explain HL7 CDA documents (incl. origin, structure, templates, processing principles, etc.) and edit them using XML-based tools.
- In contrast to HL7 V3, they can explain the alternative HL7 standard and architecture approach HL7 FHIR and implement interoperable applications using corresponding XML resources via REST communication.
- They can see more examples for (domain-dependent) standards with specific information models, templates(constraint mechanisms), vocabularies and identifiers, including ISO 13606 and openEHR (archetypes), ISO/IEEE 11073, DICOM SR, CDISC ...
- They can outline the IHE initiative with integration profiles for the concrete implementation of practice-relevant interoperability, including the role of Connectathons in the allocation of conformance statements.
- Starting from the semiotic triangle, they can differentiate terms (incl. term relations) from terms (incl. term relations) and, together with codes from standardized vocabularies, discuss the relationship to the topic of 'semantic interoperability'.
- They can differentiate (concept-oriented) terminologies or ontologies from (statistical) classifications and thesauri that are based on other order principles and are therefore supplemented by a concept level (e.g. ICD-11).
- They can create and interpret formalizations of content using description-logical constructors, especially taking into account the underlying 'Open World Assumption'.
- They can map these contents using the ontology editor Protégé and evaluate them using a proof system (reasoner).
- They can explain the OWL 2 language profile 'EL' used by SNOMED CT, including the SEP triple approach for modelling partitative conceptual relations.
- As an alternative to A-box deductions with Protégé, they can use a triplestore with RDF facts and OWL concept knowledge and formulate desired conclusions (e.g. drug interactions) using SPARQL queries.
- They can sketch the TermInfo problem, i.e. the overlapping of semantic representation in information models (such as HL7 RIM) and compositional terminologies (such as SNOMED CT).

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Informatics in Health Care - eHealth (CS3300-KP08, CS3300SJ14)

Responsible for this module:

- Dr. rer. nat. Hannes Ulrich

Teacher:

- Institute of Medical Informatics
- Dr. rer. nat. Hannes Ulrich

Literature:

- Benson T, Grieve G: Principles of Health Interoperability - SNOMED CT, HL7 and FHIR - Third Edition. London: Springer 2016 (ISBN 978-3-319-30370-3)
- Elkin P L.: Terminology and Terminological Systems - Springer 2012 (ISBN 978-1-447-12815-1)
- Baader F, et al.: The Description Logic Handbook: Theory, Implementation and Applications - 2. aktualisierte Auflage. Cambridge University Press 2010 (ISBN 978-0-521-15011-8)
- Staab S, Studer R.: Handbook on Ontologies - Springer 2009 (ISBN 978-3-540-70999-2)

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None (the competences of the modules mentioned under "requires" are needed for this module, but are not a formal prerequisite).

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

Module Exam(s):
- CS4361-L1: Medical Data Integration - eHealth, written exam, 90min, 100% of the module grade.

CS4368-KP06 - Advanced Data Analysis Methods for Digital Health Applications (ADA)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester

Classes and lectures:

- Advanced Data Analysis Methods for Digital Health Applications (lecture, 2 SWS)
- Advanced Data Analysis Methods for Digital Health Applications (exercise, 2 SWS)

Workload:

- 60 Hours work on project
- 60 Hours in-classroom work
- 40 Hours private studies
- 20 Hours exam preparation

Contents of teaching:

- Process of Relevant Physiological Biomedical Signals
- Acquisition of Biomedical Data (Sensors and sources of measurement errors)
- Signal Processing of Biomedical Signals
- Machine Learning Approaches for Biomedical Data
- Data Analysis Methods (Statistical, explainability)
- Student Project including Result-Presentation

Qualification-goals/Competencies:

- Students can explain the mechanisms of signal acquisition in relation to physiological functioning and propose suitable modalities for signal acquisition.
- Students can specify and explain the interaction between physiological functioning/phenomena, specific signal variations, and functional, neurological, and cardiovascular diseases.
- Students can select and setup appropriate measurement modalities, experimental setups for signal acquisition, as well as signal processing and machine learning approaches for specific physiological phenomena and diseases.
- Students can review and assess the data-quality in terms of potential errors and signal-to-noise ratio, and interpret the results in relation to specific medical questions.
- Students can illustrate and discuss their concepts, solutions, and results.
- Students can design and propose new studies for analyzing physiological signals.

Grading through:

- portfolio exam

Responsible for this module:

- PD Dr. rer. nat. habil. Sebastian Fudickar

Teacher:

- Institute of Medical Informatics
- PD Dr. rer. nat. habil. Sebastian Fudickar

Language:

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

Notes:

Admission requirements for taking the module:
- None (the competences of the modules mentioned under "requires" are needed for this module, but are not a formal prerequisite).

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

Module Exam(s):
- CS4368-L1: Advanced Data Analysis Methods for Digital Health Applications, portfolio exam consisting of: 60% for 90-minute written or oral examination (at the discretion of the lecturer) and 40% for an independent project work.

CS4371-KP08, CS4371 - Advanced Techniques of Medical Image Processing (FVMB)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester
- Master Medical Informatics 2019 (advanced module), medical computer science, 1st or 2nd semester
- Master MES 2014 (optional subject), medical engineering science, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), medical image processing, 1st or 2nd semester

Classes and lectures:

- Advanced Techniques of Medical Image Processing (lecture, 3 SWS)
- Advanced Techniques of Medical Image Processing (exercise, 2 SWS)
- Advanced Techniques of Medical Image Processing (practical course, 1 SWS)

Workload:

- 90 Hours in-classroom work
- 60 Hours private studies and exercises
- 60 Hours private studies
- 30 Hours exam preparation

Contents of teaching:

- Applications of medical image processing techniques
- Image superresolution
- Denoising and inhomogeneity correction
- Linear and non-linear dimensionality reduction
- Patch-based image processing and non-local means
- Fusion of (probabilistic) segmentations (NLM and STAPLE)
- Random-walk algorithm for interactive segmentation
- Non-linear registration and motion estimation (optical flow)
- Similarity metrics for multi-modal fusion
- Introduction into graphical models and discrete optimisation
- Viterbi algorithm and message passing (stereo depth estimation)
- Graph cut segmentation and further applications
- Extraction image features and descriptors
- Matching of corresponding landmarks

Qualification-goals/Competencies:

- Students know a wide range of methods for segmentation, registration and processing of medical images.
- They can describe these methods with correct technical terminology.
- They can transfer image processing techniques into energy minimisation problems.
- They can solve minimisation problems using sparse linear systems.
- They understand methodological relations between different applications and techniques.
- They understand the transfer of continuous problems into the discrete domain.
- They understand solvers for discrete optimisation problems.
- They can transfer mathematical concepts into practical algorithms for medical image processing.
- They can proficiently implement these concepts in C++.
- They can compare different algorithms to another and make suitable problem-related choices of methods.
- They have an extended overview of application areas for medical image analysis.

Grading through:

- Oral examination

Requires:

- Medical Image Computing (CS3310-KP04)
- Medical Image Computing (CS3310-KP08, CS3310SJ14)

Responsible for this module:

- Prof. Dr. rer. nat. habil. Heinz Handels

Teacher:

- Institute of Medical Informatics
- Prof. Dr. Mattias Heinrich

Literature:

- M. Sonka, V. Hlavac, R. Boyle: Image Processing, Analysis and Machine Vision - 2nd edition. Pacific Grove: PWS Publishing 1998

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None (the competences of the modules mentioned under "requires" are needed for this module, but are not a formal prerequisite).

Admission requirements for taking module examination(s):
- Successful completion of exercise assignments and programming tasks as specified at the beginning of the semester.

Module Exam(s):
- CS4371-L1: Advanced Methods in Medical Image Processing, oral examination.

This module replaces the module of the same name CS4370, which is no longer offered.

CS4374-KP06 - Medical Deep Learning (MDL)

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 Robotics and Autonomous Systems 2019 (optional subject), Elective, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), medical computer science, 1st or 2nd semester
- Master MES 2014 (optional subject), computer science / electrical engineering, 1st or 2nd semester
- Master Medical Informatics 2019 (advanced module), medical computer science, 1st or 2nd semester

Classes and lectures:

- Medical Deep Learning (lecture, 2 SWS)
- Medical Deep Learning (exercise, 2 SWS)

Workload:

- 80 Hours private studies
- 60 Hours in-classroom work
- 40 Hours exam preparation

Contents of teaching:

- Cardiac Healthcare:
- ECG signal analysis for arrhythmia detection or sleep apnea and for mobile low-cost devices
- MRI sequence analysis for anatomical segmentation and temporal modelling
- Multimodal Clinical Case Retrieval / Prediction:
- Pathology and Semantic Image Retrieval and Localisation
- Analysis of text / natural language (radiology reports/study articles) for multimodal data mining in Electronic Health Records (EHR)
- Computer Aided Detection and Disease Classification:
- CT Lung nodule detection for cancer screening with data augmentation and transfer learning
- Weakly-supervised abnormality detection and biomarker discovery
- Interpretable and reliable deep learning systems
- Human interaction and correction within deep learning models
- Visualisation of uncertainty and internally learned representations
- Deep Learning Concepts, Architectures and Hardware
- Convolutional Neural Networks, Layers, Deep Residual Learning
- Losses, Derivatives, Large-scale Stochastic Optimisation
- Directed Acyclic Graph Networks, Generative Adversarial Networks
- Cloud Computing, GPUs, Low Precision Computing, DL Frameworks

Qualification-goals/Competencies:

- Students know the importance of data security, patient anonymisation and ethics for clinical studies involving sensitive data
- They know methods and tools to collect, preprocess, store and annotate large datasets for deep learning from medical data
- They have an in-depth understanding of deep / convolutional neural networks for general data (signals / text / images) processing, their learning process and evaluation of their performance on unseen data
- They understand the principles of weakly-supervised learning, transfer learning, concept discovery and generative adversarial networks
- They know how to explore learned feature representations for retrieval and visualisation of high-dimensional abstract data
- They can implement modern network architectures in DL frameworks and are able to adapt and extend them to given problems in medicine
- They have a broad overview of current applications of deep learning in medicine in both research and clinical practice and can transfer their knowledge to newly emerging domains

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Mattias Heinrich

Teacher:

- Institute of Medical Informatics
- Prof. Dr. Mattias Heinrich

Literature:

- Ian Goodfellow, Yoshua Bengio and Aaron Courville: Deep Learning - The MIT Press

Language:

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

Notes:

Admission requirements for taking the module:
- None

Admission requirements for taking module examination(s):
- Successful completion of exercise assignments and programming tasks as specified at the beginning of the semester.

Module Exam(s):
- CS4374-L1 Medical Deep Learning, , oral examination.

CS4390-KP06 - Virtual Reality in Medicine (VRMed6)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	Currently not available	6	20

Course of study, specific field and term:

- Master Medical Informatics 2019 (advanced module), medical computer science, 1st or 2nd semester

Classes and lectures:

- Virtual Reality in Medicine (lecture, 2 SWS)
- Virtual Reality in Medicine (exercise, 2 SWS)

Workload:

- 90 Hours private studies and exercises
- 60 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- Selected topics of computer-aided surgery: Virtual and Augmented Reality methods in training, planning and navigation - in detail:
- Algorithms for the visuo-haptic presentation of medical image data including current research methods from Virtual (VR) and Augmented Reality (AR):
- Segmentation and model generation from volumetric medical image data:
- Surface models
- Volume models
- Advanced methods of direct and indirect volume rendering (e.g. ray tracing)
- Registration between real and virtual world
- Computer-aided navigation in medicine
- Visual immersion by stereo imaging
- Haptic immersion by force feedback using proxy methods
- Haptic 3D interactions in virtual bodies
- Hardware and software components of simulators, planning and navigation systems
- Evaluation methods of the training performance of the user (cf. serious computer games)
- Evaluation and quality assurance of VR systems during development
- Example Virtual/Augmented Reality applications in training, planning and navigation

Qualification-goals/Competencies:

- Students can classify, explain and select advanced VR and AR methods for a problem
- They are able to explain and characterize advanced methods of generating virtual organ and body models
- They know different approaches for patient modelling and can describe and explain the modelling assumptions
- They are able to assess the properties of different VR to real world registration methods and to select apparatuses and methods for a specific registration problem
- They know methods of computer-aided navigation and can explain the properties of different approaches and apply them exemplarily
- They will be able to characterize various advanced medical visualization techniques and to select and apply them in a meaningful and application-specific way
- They will be able to characterize different advanced haptic interaction techniques and to select and apply them in a problem-specific way
- The students know current evaluation methods on the one hand for practitioners exercises and on the other hand developed VR systems and can characterize and select these evaluation methods problem-specifically
- The students know current medical applications of VR simulation and can implement partial key components

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Medical Image Computing (CS3310-KP08, CS3310SJ14)

Responsible for this module:

- Prof. Dr. rer. nat. habil. Heinz Handels

Teacher:

- Institute of Medical Informatics
- N.N.

Literature:

- H. Handels: Medizinische Bildverarbeitung - 2. Auflage, Vieweg u. Teubner 2009
- B. Preim, C. Botha: Visual Computing for Medicine - Morgan Kaufmann, 2014
- P.M. Schlag, S. Eulenstein, T. Lange: Computerassistierte Chirurgie - Elsevier, 2010

Language:

- offered only in German

Notes:

This module replaces the CS4390-KP05 module of the same name.

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.

CS4410-KP08, CS4410 - Neuro-Informatics and Computer Vision (NeuroVisio)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), bioinformatics, 1st or 2nd semester
- Master Computer Science 2014 (compulsory), specialization field robotics and automation, 1st, 2nd, or 3rd semester
- Master Computer Science 2014 (compulsory), specialization field bioinformatics, 1st, 2nd, or 3rd semester

Classes and lectures:

- Neuro-Informatics (lecture with exercises, 3 SWS)
- Computer Vision (lecture with exercises, 3 SWS)

Workload:

- 240 Hours (see module parts)

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- see module parts

Grading through:

- Written or oral exam as announced by the examiner

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. rer. nat. Amir Madany Mamlouk

Literature:

- : see module parts

Language:

- German and English skills required

Notes:

Prerequisites for attending the module:
- None

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.

CS4441-KP08, CS4441 - Molecular Bioinformatics and Modelling Biological Systems (BioinfBioS)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (optional subject), bioinformatics, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), bioinformatics, 1st or 2nd semester
- Master Computer Science 2014 (compulsory), specialization field bioinformatics, 1st or 2nd semester

Classes and lectures:

- Molecular Bioinformatics (lecture with exercises, 3 SWS)
- Modelling Biological Systems (lecture with exercises, 3 SWS)

Workload:

- 240 Hours (see module parts)

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- see module parts

Grading through:

- Exercises
- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Martinetz

Teacher:

- Institute for Mathematics
- Institute for Neuro- and Bioinformatics

- Prof. Dr. rer. nat. Thomas Martinetz
- MitarbeiterInnen des Instituts
- Nachfolge von Prof. Dr. rer. nat. Karsten Keller
- Prof. Lars Bertram

Literature:

- : see module parts

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None

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.

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

CS4575-KP04 - Sequence Learning (SEQL)

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

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Master Psychology 2016 (optional subject), Elective, Arbitrary semester
- Master Biophysics 2023 (optional subject), Elective, Arbitrary semester
- Master Media Informatics 2020 (optional subject), Elective, Arbitrary semester
- Master MES 2020 (optional subject), Elective, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (optional subject), specific, Arbitrary semester

Classes and lectures:

- CS4575-V: Sequence Learning (lecture, 2 SWS)
- CS4575-Ü: Sequence Learning (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Introduction to Sequence Learning (Formalisms, Metrics, Recapitulation of Relevant Machine Learning Techniques)
- Recurrent Neural Networks (Simple RNN Models, Backpropagation Through Time)
- Gated Recurrent Networks (Vanishing Gradient Problem in RNNs, Long Short-Term Memories, Gated Recurrent Units, Stacked RNNs)
- Important Techniques for RNNs (Teacher Forcing, Scheduled Sampling, h-Detach)
- Bidirectional RNNs and related concepts
- Hierarchical RNNs and Learning on Multiple Time Scales
- Online Learning and Learning without BPTT (Real-Time Recurrent Learning, e-Prop, Forward Propagation Through Time)
- Reservoir Computing (Echo State Networks, Deep ESNs)
- Spiking Neural Networks (Spiking Neuron Models, Learning in SNNs, Neuromorphic Computing, Recurrent SNNs)
- Temporal Convolution Networks (Causal Convolution, Temporal Dilation, TCN-ResNets)
- Introduction to Transformers (Sequence-to-Sequence Learning, Basics on Attention, Self-Attention and the Query-Key-Value Principle, Large Language Models)
- State Space Models (Structured State Space Sequence Models, Mamba)

Qualification-goals/Competencies:

- Students get a comprehensive understanding of most relevant sequence learning approaches
- Students learn to analyze the challenges in sequence learning tasks and to identify well-suited approaches to solve them
- Students will understand the pros and cons of various sequence learning models
- Students can implement common and custom sequence learning models for time series analysis, classification, and forecasting
- Students know how to analyze the models and results, to improve the model parameters, and to interpret the model predictions and their relevance

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Sebastian Otte

Teacher:

- Institute for Robotics and Cognitive Systems
- MitarbeiterInnen des Instituts
- Prof. Dr. Sebastian Otte

Literature:

- Goodfellow, I., Bengio, Y., & Courville, A. (2016): Deep Learning - MIT Press. ISBN 978-0262035613
- Prince, S. J. D. (2023): Understanding Deep Learning - The MIT Press. ISBN 978-0262048644
- Deisenroth, M. P., Faisal, A. A., & Ong, C. S. (2020): Mathematics for Machine Learning - Cambridge University Press, 2020. ISBN 978-1108470049
- Nakajima, K., & Fischer, I. (2021): Reservoir Computing: Theory, Physical Implementations, and Applications - Cambridge University

Press, 2020. ISBN 978-1108470049
- Sun, R., & Giles, C. (2001): Sequence Learning: Paradigms, Algorithms, and Applications - Springer Berlin Heidelberg. ISBN 978-3540415978
- Bishop, C. M. (2006): Pattern Recognition and Machine Learning - Springer. ISBN 978-0387310732
- Recent publications on the related topics:

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None, but it is recommended to complete the course Deep Learning (CS4295-KP04) first

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

Module Exam(s):
- CS4575-L1: Sequence Learning, exam, 90 min

According to the decision of the examination board of computer science of 19.8.2024 this module can be chosen by students Master Computer Science SGO from 2019 in the area of 5th elective.

CS4670-KP04, CS4670 - Ambient Computing (AmbComp)

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

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (optional subject), specific, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Media Informatics 2014 (compulsory), media informatics, 2nd 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:

- 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

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

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

Module Examination(s):
- CS4670-L1: Ambient Computing, oral examination, 100% of module mark.

(share of Institute of Telematics in V is 100%)

CS4701-KP06 - Communication and System Security (KoSyS)

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

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master IT-Security 2019 (compulsory), IT-Security, 1st or 2nd semester

Classes and lectures:

- Communication and System Security (lecture, 2 SWS)
- Communication and System Security (seminar-style lectures with exercises, 2 SWS)

Workload:

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

Contents of teaching:

- Cryptographic procedures and protocols, security analyses
- IT security at system level, security mechanisms
- Security, privacy and trust of special systems such as Cloud and IoT
- Code analysis
- Security management, legal framework conditions
- Security problems in IT systems

Qualification-goals/Competencies:

- 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:

- Viva Voce or test
- written homework

Is requisite for:

- Current Topics in IT Security (CS5195-KP04)

Requires:

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

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute for IT Security

- Prof. Dr.-Ing. Thomas Eisenbarth
- Prof. Dr. Rüdiger Reischuk
- Prof. Dr. Esfandiar Mohammadi

Literature:

- Stallings, Brown: Computer Security: Principles and Practice - 4th ed., Pearson, 2018
- Katz, Lindell: Introduction to Modern Cryptography - 2nd ed., CRC Press, 2014
- Stinson: Cryptography: Theory and Practice - 4th ed., CRC Press, 2018

Language:

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

Notes:

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

CS4702-KP06 - Computer Security (CoSec)

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

Course of study, specific field and term:

- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, 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:

- Computer Security (lecture, 2 SWS)
- Computer Security (practical course, 3 SWS)

Workload:

- 85 Hours private studies
- 75 Hours in-classroom work
- 20 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: How TPMs, Secure Elements and Trusted Execution work environments, basics and cryptographic techniques, design basics for secure 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.

Grading through:

- Viva Voce or test
- written homework

Requires:

- Cybersecurity (CS2250-KP04)

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute for IT Security
- Prof. Dr.-Ing. Thomas Eisenbarth

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
- : Recent literature

Language:

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

Notes:

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

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.-Ing. 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.

CS5131-KP08, CS5131 - Web-Mining Agents (WebMining)

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

Course of study, specific field and term:

- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master CLS 2010 (optional subject), computer science, Arbitrary semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd 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
- Multimedia interpretation for web (re-)search (probabilistic ranking of interpretations, link analysis (e.g., citations), social network analysis)
- 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:

- Written or oral exam as announced by the examiner

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:

- 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

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 Exam(s):
- CS5131-L1: Web Mining Agents, oral exam, 100% of module grade.

Competencies from the following modules are required for this module (not a hard entry 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)

CS5140-KP04, CS5140 - Semantic Web (SemWeb)

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

Course of study, specific field and term:

- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2012 (optional subject), advanced curriculum distributed information systems, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), specialization field software systems engineering, 2nd or 3rd 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:

- Oral examination

Responsible for this module:

- Prof. Dr. Sven Groppe

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:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Active participation in lecture and tutorial

Module Exam(s):
- CS5140-L1: Semantic Web, oral exam, 100% of module grade.

CS5150-KP04, CS5150 - Organic Computing (OrganicCom)

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

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), bioinformatics, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), bioinformatics, 1st or 2nd semester
- Master Computer Science 2012 (optional subject), advanced curriculum parallel and distributed system architecutres, 2nd or 3rd semester
- Master CLS 2010 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2012 (compulsory), advanced curriculum organic computing, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), specialization field robotics and automation, 3rd 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:

- written exam

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

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:

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

CS5158-KP04, CS5158 - Advanced Internet Technologies (AdInternet)

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

Course of study, specific field and term:

- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2012 (optional subject), advanced curriculum enterprise IT, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), specialization field software systems engineering, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), advanced curriculum distributed information systems, 2nd or 3rd 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:

- Written or oral exam as announced by the examiner

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:

Admission requirements for taking the module:
- None

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

Module Examination(s):
- CS5158-L1: Advanced Internet Technologies, oral examination, 100% of module mark.

(Was also part of CS4518-KP12)

CS5161-KP04 - Nano communication networks (NanoNet)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester

Classes and lectures:

- Nano communication networks (lecture, 2 SWS)
- Nano communication networks (project work, 1 SWS)

Workload:

- 45 Hours in-classroom work
- 45 Hours private studies
- 15 Hours exam preparation
- 15 Hours work on project

Contents of teaching:

- Networks und protocols
- Self-assembly systems
- Reductions and compilation
- Definitions & associations of nanonetworks
- Simulation tools for nanonetworks
- Deployment in medical application scenarios

Qualification-goals/Competencies:

- Students know and understand the basic concepts of nanonetworks.
- Students know how to use advanced modeling techniques.
- Students know th basic concepts of nanoscale computational models.
- Students know the concepts of reductions and can apply it to nanoscale algorithms.
- Students know and understand self-assembly systems and crystal formation.
- Students know and understand the constraints and peculiarities at the nanoscale.
- Students posess in-depth understanding of network structures and topologies of nanonetworks
- Students know how to verify or falsify a model using simulation tools.
- Interdisciplinary aspects:
- Students have elementary modeling skills.
- Students can transfer basic theoretical concepts to related questions.
- Students can understand and implement various algorithms and transfer the knowledge they have acquired to other subjects.
- Students can work on simple tasks in a team.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics
- Dr. rer. nat. Florian-Lennert Lau

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 assignments during the semester.

CS5162-KP04 - Mobile communication systems (MobiCom)

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

Course of study, specific field and term:

- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester

Classes and lectures:

- Mobile communication systems (lecture, 2 SWS)
- Mobile communication systems (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Motivation and Overview (Introduction to mobile communication systems and their applications)
- Wireless Transmission (Frequencies, transmission properties, multipath transmission, mobility)
- Wireless Security Layer (Medium Access Control, scheduling, error control)
- Wireless Technologies (Wireless Local Area Networks, Wireless Personal Area Networks, Telecommunications, Broadcasting and Satellite Systems, Low Power Wide Area Networks)
- Location and Tracking (Applications, real-time automation in production, and logistics)

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.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing Horst Hellbrück

Teacher:

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

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

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.

CS5260-KP04, CS5260SJ14 - Speech and Audio Signal Processing (SprachAu14)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second semester	4

Course of study, specific field and term:

- Master CLS 2023 (optional subject), Elective, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Elective, Arbitrary semester
- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Master MES 2014 (optional subject), medical engineering science, Arbitrary semester
- Master CLS 2010 (optional suject), computer science, Arbitrary semester
- Master Medical Informatics 2014 (optional subject), computer science, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary 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:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr.-Ing. Markus Kallinger

Teacher:

- Institute for Signal Processing
- Prof. Dr.-Ing. Markus Kallinger

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.

Modul exam:
- CS5260-L1: Speech and Audio Signal Processing, written or oral exam, 100% of modul grade

Mentioned in SGO MML under CS5260 (without SJ14).

CS5275-KP04, CS5275 - Selected Topics of Signal Analysis and Enhancement (AMSAV)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second semester	4

Course of study, specific field and term:

- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Master MES 2014 (optional subject), medical engineering science, Arbitrary semester
- Master Medical Informatics 2014 (optional subject), medical image processing, 1st or 2nd semester
- Master CLS 2010 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2012 (optional subject), specialization field bioinformatics, 3rd semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 1st or 2nd semester
- Master Computer Science 2012 (optional subject), advanced curriculum signal and image processing, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), specialization field robotics and automation, 3rd semester
- Master Computer Science 2012 (optional subject), advanced curriculum intelligent embedded systems, 2nd or 3rd 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:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr.-Ing. Markus Kallinger

Teacher:

- Institute for Signal Processing
- Prof. Dr.-Ing. Markus Kallinger

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:

- German and English skills required

Notes:

Prerequisites for attending the module:
- None

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

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

CS5450-KP04, CS5450 - Machine Learning (MaschLern)

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

Course of study, specific field and term:

- Master CLS 2023 (optional subject), computer science, 3rd semester
- Master Auditory Technology 2022 (optional subject), computer science, 1st semester
- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Master Auditory Technology 2017 (optional subject), computer science, 1st semester
- Master CLS 2016 (optional subject), computer science, 3rd semester
- Master MES 2014 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master MES 2011 (optional subject), mathematics, 1st or 2nd semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), computer science, 1st or 2nd semester
- Master CLS 2010 (optional suject), computer science, Arbitrary semester
- Master Computer Science 2012 (optional subject), specialization field robotics and automation, 3rd semester
- Master Computer Science 2012 (optional subject), specialization field bioinformatics, 3rd 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:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Erhardt Barth

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

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):
- None

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

CS5460-KP06 - Analysis of High-Throughput Data in Bioinformatics (AnaHDD6)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (advanced module), medical computer science, 1st or 2nd semester

Classes and lectures:

- Analyse von Hochdurchsatzdaten (lecture, 2 SWS)
- Analyse von Hochdurchsatzdaten (exercise, 2 SWS)
- Analyse von Hochdurchsatzdaten (practical course, 1 SWS)

Workload:

- 75 Hours in-classroom work
- 55 Hours private studies
- 30 Hours work on project
- 20 Hours exam preparation

Contents of teaching:

- Learn statistical background and methods for analysis of next generation sequencing
- Introduction to common sequencing methods: RNA-seq, ChIP-seq, Whole Genome Sequencing, Whole Exome Sequencing, Hi-C seq, 4-C seq, 5-C seq, Single Cell Sequencing
- Basis of data analysis: statistics, methods and software
- Judge data quality and experimental design
- Use public databases for annotation, analysis and data download

Qualification-goals/Competencies:

- The students can analyse next generation high throughput sequencing data.
- The students know the different sequencing methods and their advantages and challenges.
- The students know how to approach the analysis of high throughput data, can interpret the results and annotate the data. The students know different workflows for data modelling and analysis.
- The students can use public databases for data download, integration and analysis
- Students can use high-throughput data from public databases and integrate the data into their own projects.
- Students can work on a project to independently analyze and integrate high-throughput data for personalized patient diagnosis.

Grading through:

- Written or oral exam as announced by the examiner

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. rer. nat. Anke Fähnrich
- Dr. Axel Künstner

Literature:

- Wing-Kin Sung: Algorithms for Next-Generation Sequencing - CRC Press, 18 May 2017
- Datta, Somnath, Nettleton, Dan (Eds.): Statistical Analysis of Next Generation Sequencing Data - Springer, Heidelberg, 2014

Language:

- German and English skills required

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- None

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

LS1600-KP04 - Organic Chemistry (OCKP04)

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

Course of study, specific field and term:

- Bachelor CLS 2023 (compulsory), life sciences, 4th semester
- Bachelor Biophysics 2024 (compulsory), life sciences, 2nd semester
- Master Medical Informatics 2019 (optional subject), bioinformatics, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), bioinformatics, 1st or 2nd semester
- Bachelor CLS 2016 (compulsory), life sciences, 4th semester
- Bachelor Biophysics 2016 (compulsory), life sciences, 2nd semester

Classes and lectures:

- Organic Chemistry (lecture, 3 SWS)
- Organic Chemistry (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Lectures:
- Alkanes, cycloalkanes
- Alkenes and Alkynes
- Aromatics
- Stereochemistry
- Substitution and elimination reactions
- Alcohols, phenols and thiols
- Ether and epoxides
- Aldehydes and ketones
- Carboxylic acids and derivativs
- Amines and derivativs
- Heterocycles
- Lipids
- Carbohydrates
- Amino acids and peptides
- Nucleotides and nucleic acids
- Exercises:
- Students discuss problems covering all topics of the lectures on the black board

Qualification-goals/Competencies:

- After successful completion of the course, students have a fundamental knowledge of organic chemistry. They are confident using structural formulas of substance classes and functional groups presented in the course. They are confident in the nomenclature and can correctly describe relative and absolute configurations of molecules.
- Students know the most important reactions, reaction types and reaction principles of organic chemistry. They understand the structural properties of functional groups and are able to formulate organic chemical reaction mechanisms of these groups.
- Students can transfer and apply the acquired skills to problems of other branches of chemistry and related sciences and are thus able to participate in continuative courses.

Grading through:

- written exam

Requires:

- General Chemistry (LS1100-KP04)

Responsible for this module:

- PD Dr. phil. nat. Thomas Weimar

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 (The competencies of the modules listed under 'Requires' are needed for this module, but are not a formal prerequisite)

Prerequisites for the exam:
- 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.

Module exam:
LS1600-L1: Organic Chemistry, written exam, 90 min, 100 of % module grade

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%

MA2600-KP04, MA2600 - Biostatistics 2 (BioStat2)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Master Biophysics 2019 (optional subject), Elective, 2nd semester
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Computer Science 2012 (optional subject), specialization field medical informatics, 3rd semester
- Master Computer Science 2012 (optional subject), specialization field bioinformatics, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), advanced curriculum stochastics, 2nd semester
- Bachelor CLS 2010 (compulsory), mathematics, 4th 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:

- written exam

Is requisite for:

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

Requires:

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

Responsible for this module:

- Prof. Dr. rer. biol. hum. Inke König

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.

MA3200-KP04, MA3200 - Genetic Epidemiology 1 (GenEpi1)

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

Course of study, specific field and term:

- Bachelor CLS 2023 (compulsory), mathematics, 3rd or 5th semester
- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Bachelor CLS 2016 (compulsory), mathematics, 3rd or 5th semester
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Computer Science 2012 (optional subject), specialization field medical informatics, 3rd semester
- Bachelor CLS 2010 (compulsory), mathematics, 3rd or 5th semester

Classes and lectures:

- Genetic Epidemiology 1 (lecture, 2 SWS)
- Genetic Epidemiology 1 (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Monogenic and complex diseases
- Hardy-Weinberg-equilibrium
- Coupling imbalance
- Genetic markers and genotyping
- Quality control
- Basics of association analysis
- Genome-wide association studies
- Population stratification
- Gene-environment interaction
- Replication, meta-analysis and imputation
- Ethical aspects

Qualification-goals/Competencies:

- Students are able to describe the generation of genetic data, its error sources and methods of detection.
- They can select and describe the most important approaches for genetic epidemiological association studies on the level of single markers.
- They are able to apply the basic test procedures manually and to interpret the results.
- They are able to describe the statistical evaluation steps in a genome-wide association study and interpret the results.

Grading through:

- Written or oral exam as announced by the examiner

Is requisite for:

- Seminar Genetic Epidemiology (MA5129-KP04, MA5129)
- Genetic Epidemiology 2 (MA4661-KP08, MA4661)

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Silke Szymczak

Teacher:

- Institute of Medical Biometry and Statistics
- Prof. Dr. rer. nat. Silke Szymczak
- MitarbeiterInnen des Instituts

Literature:

- Ziegler A, König IR.: A statistical approach to genetic epidemiology. Concepts and applications. - 2010. ISBN: 978-3-527-32389-0

- Bickeböller H, Fischer, C: Einführung in die Genetische Epidemiologie - 2007. ISBN: 978-3-540-25616-8

Language:

- German or English

Notes:

Prerequisites for attending the module:
- None (The competencies of the modules listed under 'Requires' are needed for this module, but are not a formal prerequisite)

Prerequisites for the exam:
- 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.

Module exam(s):
- MA3200-L1: Genetic Epidemiology 1, oral exam, 30 min, or written exam, 90 min, 100% of module grade

MA4500-KP04, MA4500 - Mathematical Methods in Image Processing (MatheBildv)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), medical image processing, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), medical image processing, 1st or 2nd semester
- Master MES 2014 (optional subject), mathematics / natural sciences, 1st or 3rd semester
- Master MES 2011 (optional subject), mathematics, 1st or 3rd semester
- Master Computer Science 2012 (optional subject), advanced curriculum imaging systems, 2nd or 3rd semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 1st or 3rd semester
- Master Computer Science 2012 (compulsory), advanced curriculum numerical image processing, 2nd or 3rd semester
- Master CLS 2010 (compulsory), mathematics, 1st or 3rd semester

Classes and lectures:

- Mathematics in Image Processing (lecture, 2 SWS)
- Mathematics in Image Processing (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Image processing
- Digital images
- Operators in the spatial domain
- Operators in the Fourier domain
- Deblurring
- Total variation
- Segmentation
- Level-set methods

Qualification-goals/Competencies:

- Students have a solid mathematical understanding of typical image processing methods.
- They can compare and assess typical mathematical image processing methods.
- They can derive typical mathematical methods for image processing.
- They understand fundamental operators in image processing.
- They understand fundamental discretization techniques.
- They understand typical numerical methods for image processing.
- They are able to implement fundamental numerical methods for image processing.
- Interdisciplinary qualifications:
- Students have advanced skills in modeling.
- They can translate theoretical concepts into practical solutions.
- They are experienced in implementation.
- They can think abstractly about practical problems.

Grading through:

- Written or oral exam as announced by the examiner

Is requisite for:

- Calculus of Variations and Partial Differential Equations (MA5034-KP04, MA5034)

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

- Prof. Dr. rer. nat. Jan Modersitzki
- Prof. Dr. rer. nat. Jan Lellmann

Literature:

- Gonzales/Woods: Digital Image Processing - Prentice Hall, 2007
- Russ: The Image Processing Handbook - CRC Press, 2011
- Handels: Medizinische Bildverarbeitung - Vieweg+Teubner, 2009

Language:

- German and English skills required

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.

MA4665-KP05 - Statistical Learning (StaLerKP05)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	every second year	5	20

Course of study, specific field and term:

- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester
- Master CLS 2023 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS 2023 (optional subject), mathematics, 5th or 6th semester
- Master CLS 2016 (optional subject), mathematics, 1st, 2nd, or 3rd semester
- Bachelor CLS 2016 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- Application scenarios and research questions for prediction models (focus: risk prediction)
- Study design and data preprocessing
- Overview of different machine learning methods (concepts, advantages and disadvantages)
- Development of prediction models
- Evaluation of prediction performance
- Comparison of prediction models
- Variable selection
- Extension to time-to-event outcomes with censoring

Qualification-goals/Competencies:

- Students can define research questions for applications of pediction models
- They can explain the individual steps in the development and evaluation of prediction models
- They can describe frequently occurring errors and problems as well als possible solutions
- They can describe central ideas of different machine learning methods and select suitable methods for applications
- They can develop and evaluate models in the programming language R

Grading through:

- project work
- Viva Voce or test

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Silke Szymczak

Teacher:

- Institute of Medical Biometry and Statistics
- Prof. Dr. rer. nat. Silke Szymczak
- MitarbeiterInnen des Instituts

Literature:

- Thomas Gerds und Michael Kattan: Medical Risk Prediction Models With Ties to Machine Learning - CRC Press: Bota Raton, FL (2022)

Language:

- German or English

Notes:

Admission requirements for taking the module:
- None (The competencies of the modules listed under 'Requires' are needed for this module, but are not a formal prerequisite)

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

Module exam(s):
- MA4665-L1: Statistical Learning, oral exam (20 min) or written exam (60 min), 50 % of module grade
- MA4665-L2: Research project incl. presentation and code documentation, 50 % of module grade

MA4666-KP05 - Interpretable Statistical Learning (IStLern)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	every second year	5	20

Course of study, specific field and term:

- Bachelor CLS 2023 (optional subject), mathematics, 5th or 6th semester
- Bachelor CLS 2016 (optional subject), mathematics, 5th or 6th semester
- Master CLS 2023 (optional subject), mathematics, Arbitrary semester
- Master CLS 2016 (optional subject), mathematics, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester

Classes and lectures:

- Interpretable Statistical Learning (lecture, 2 SWS)
- Interpretable Statistical Learning (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Definition: Interpretable statistical learning
- Interpretable models
- Global model-agnostic methods
- Partial Dependence Plots (PDP)
- Accumulated Local Effects (ALE)
- Variable importance measures
- Local model-agnostic methods
- Individual Conditional Expectation (ICE)
- Local Surrogates (LIME)
- Counterfactional Explanations
- Shapley Werte, SHAP

Qualification-goals/Competencies:

- Students can explain the central ideas of interpretable statistical learning.
- They know the difference between model-based and model-agnostic methods.
- The can explain the differences between different methods for model interpretation.
- They can choose suitable methods for a given applicational setting.
- They can implement and apply these methods in R.

Grading through:

- Viva Voce or test

Requires:

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

Teacher:

- Institute of Medical Biometry and Statistics
- Dr. rer. hum. biol. Björn-Hergen Laabs

Literature:

- Molnar, C.: Interpretable Machine Learning: A Guide for Making Black Box Models Explainable - Springer, New York 2022 (2nd ed.)
- Hastie, T., Tibshirani, R., Friedmann, J.: The Elements of Statistical Learning: Data Mining, Inference and Prediction - Springer, New York 2009 (2nd ed.)
- Wu, X., Kumar, V.: The Top Ten Algorithms in Data Mining - CRC Press, Boca Raton 2009

Language:

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

Notes:

Admission requirements for taking the module
- None (the competences of the modules mentioned under 'Requires' are needed for this module, but are not a formal prerequisite)

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

Module Exam(s):
- MA4666-L1: Interpretable Statistical Learning, oral exam (20 min) or written exam (60 min), 100% of the module grade

MA5030-KP04, MA5030 - Image Registration (Bildregist)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), medical image processing, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), medical image processing, 1st or 2nd semester
- Master MES 2014 (optional subject), mathematics / natural sciences, 1st semester
- Master Computer Science 2012 (optional subject), advanced curriculum imaging systems, 2nd or 3rd semester
- Master MES 2011 (optional subject), mathematics, 1st or 3rd semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 1st or 3rd semester
- Master CLS 2010 (optional subject), mathematics, 1st or 3rd semester
- Master Computer Science 2012 (optional subject), advanced curriculum numerical image processing, 2nd or 3rd semester

Classes and lectures:

- Image Registration (lecture, 2 SWS)
- Image Registration (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Introduction and basic principles
- Interpolation
- Deformation models
- Landmark-based registration
- Parametric registration
- Non-parametric registration and regularization strategies

Qualification-goals/Competencies:

- Students know the fundamental concepts in image registration.
- They are able to translate concrete problems into suitable models.
- They have experience with parametric and non-parametric registration problems.
- Interdisciplinary qualifications:
- Students have advanced skills in modeling.
- They can translate theoretical concepts into practical solutions.
- They are experienced in implementation.
- They can think abstractly about practical problems.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

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

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing
- Prof. Dr. Martin Leucker
- Prof. Dr. rer. nat. Jan Modersitzki

Literature:

- Goshtasby: 2D and 3D Image Registration - Wiley 2005
- Modersitzki: Numerical Methods for Image Registration - Oxford University Press 2004
- Modersitzki: FAIR: Flexible Algorithms for Image Registration - SIAM 2009

- Rohr: Landmark-Based Image Analysis - Kluwer 2001

Language:

- German and English skills required

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.

MA5032-KP04, MA5032 - Numerical Methods for Image Computing (NumerikBV)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), medical image processing, 1st or 2nd semester
- Master MES 2014 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master Medical Informatics 2014 (optional subject), medical image processing, 1st or 2nd semester
- Master MES 2011 (optional subject), advanced curriculum imaging systems, 2nd or 4th semester
- Master Computer Science 2012 (optional subject), advanced curriculum numerical image processing, 2nd or 3rd semester
- Master CLS 2010 (optional subject), mathematics, 2nd or 4th semester

Classes and lectures:

- Numerical Methods for Image Computing (lecture, 2 SWS)
- Numerical Methods for Image Computing (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Imaging process an imaging modalities
- Grids and image representation
- Operators in spatial and frequency domain
- Discrete Fourier Transform/FFT und Anwendungen
- JPEG
- Poisson equation and finite differences discretization
- Splitting methods
- Multigrid methods

Qualification-goals/Competencies:

- The students are familiar with fundamental numerical concepts in image computing.
- They have experience in realizing practical solutions.
- They can implement numerical algorithms on a computer.
- They understand selected methods for solving large linear systems.
- They can implement selected methods for solving large linear systems.
- Interdisciplinary qualifications:
- Students have advanced skills in modeling.
- They can translate theoretical concepts into practical solutions.
- They are experienced in implementation.
- They can think abstractly about practical problems.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

- Prof. Dr. rer. nat. Jan Modersitzki
- Prof. Dr. rer. nat. Jan Lellmann

Language:

- German and English skills required

Notes:

Prerequisites for attending the module:
- None (Familiarity with the topics of the required modules is assumed, but the modules are not a formal prerequisite for attending the course).

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 first examination.

Examination:
- MA5032-L1: Numerical Methods for Image Computing, written examination (90min) or oral examination (30min) as decided by examiner, 100% of final mark

MA5034-KP04, MA5034 - Calculus of Variations and Partial Differential Equations (VariPDE)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), medical image processing, 1st or 2nd semester
- Master MES 2014 (optional subject), mathematics / natural sciences, Arbitrary semester
- Bachelor CLS 2010 (optional subject), mathematics, 4th or 6th semester
- Master Medical Informatics 2014 (optional subject), medical image processing, 1st or 2nd semester
- Master MES 2011 (optional subject), mathematics, 2nd or 4th semester
- Master Computer Science 2012 (optional subject), advanced curriculum numerical image processing, 2nd or 3rd semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 2nd or 4th semester
- Master CLS 2010 (optional subject), mathematics, 2nd or 4th semester

Classes and lectures:

- Calculus of Variations and Partial Differential Equations (lecture, 2 SWS)
- Calculus of Variations and Partial Differential Equations (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Motivation and application examples
- Functional-analytic foundations
- Direct methods in the calculus of variations
- The dual space, weak convergence, Sobolev spaces
- Optimality conditions
- Classification of partial differential equations and typical PDEs
- Fundamental solutions, maximum principle
- Finite elements for elliptical partial differential equations

Qualification-goals/Competencies:

- Students understand variational modeling.
- They are able to formulate basic physical problems in a variational setting.
- They understand the connections between variational methods and partial differential equations.
- They can derive optimality conditions for energy functionals.
- They understand the mathematical theory behind selected variational problems.
- They can implement selected fundamental variational problems.
- They can formulate selected practical problems in the variational setting.
- Interdisciplinary qualifications:
- Students have advanced skills in modeling.
- They can translate theoretical concepts into practical solutions.
- They are experienced in implementation.
- They can think abstractly about practical problems.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. rer. nat. Jan Modersitzki

Teacher:

- Institute of Mathematics and Image Computing

- Prof. Dr. rer. nat. Jan Modersitzki
- Prof. Dr. rer. nat. Jan Lellmann

Literature:

- Vogel: Computational Methods for Inverse Methods - SIAM
- Aubert, Kornprobst: Mathematical Problems in Image Processing: Partial Differential Equations and the Calculus of Variations - Springer
- Scherzer, Grasmair, Grossauer, Haltmeier, Lenzen: Variational Methods in Imaging - Springer

Language:

- German and English skills required

Notes:

Prerequisites for attending the module:
- None (Familiarity with the topics of the required modules is assumed, but the modules are not a formal prerequisite for attending the course).

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 first examination.

Examination:
- MA5034-L1: Calculus of Variations and Partial Differential Equations, written examination (90min) or oral examination (30min) as decided by examiner, 100% of final mark

ME4030-KP04, ME4030 - Inverse Problems in Imaging (InversProb)

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

Course of study, specific field and term:

- Master Auditory Technology 2022 (optional subject), Auditory Technology, 2nd semester
- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), medical image processing, 1st or 2nd semester
- Master Auditory Technology 2017 (optional subject), Auditory Technology, 2nd semester
- Master MES 2014 (optional subject), medical engineering science, 1st or 2nd semester
- Master MES 2011 (optional subject), mathematics, 1st or 2nd semester
- Master Computer Science 2012 (optional subject), advanced curriculum signal and image processing, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), specialization field robotics and automation, 3rd semester
- Master Computer Science 2012 (optional subject), specialization field medical informatics, 3rd semester
- Master Computer Science 2012 (optional subject), advanced curriculum imaging systems, 2nd or 3rd semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 1st or 2nd semester
- Master CLS 2010 (optional subject), mathematics, 1st and 2nd semester

Classes and lectures:

- Tomographische Verfahren II: Inverse Probleme bei der Bildgebung (lecture, 2 SWS)
- Tomographische Verfahren II: Inverse Probleme bei der Bildgebung (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Introduction to inverse and ill-posed problems on the basis of selected examples (including seismology, impedance tomography, heat conduction, computed tomography, acoustic)
- Concept of ill-posedness of the inverse problem (Hadamard)
- Singular value decomposition and generalized inverse
- Regularization methods (eg Tikhonov, Phillips, Ivanov)
- Deconvolution
- Image restoration (deblurring, defocusing)
- Statistical methods (Bayes, maximum likelihood)
- Computed Tomography, Magnetic Particle Imaging

Qualification-goals/Competencies:

- Students are able to explain the concept of ill-posedness of the inverse problem and distinguish given inverse problems regarding good or bad posedness.
- They are able to formulate inverse problems of mathematical imaging and solve (approximate) with suitable numerical methods.
- They can assess the condition of a problem and the stability of a method.
- They master different regularization methods and are able to apply them to practical problems.
- They know methods to determine a suitable regularization.
- They can use methods of image reconstruction and restoration on real measurement data.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. rer. nat. Thorsten Buzug

Teacher:

- Institute of Medical Engineering
- Prof. Dr. rer. nat. Thorsten Buzug

Literature:

- Kak and Slaney: Principles of Computerized Tomographic Imaging - SIAM Series 33, New York, 2001
- Natterer and Wübbeling: Mathematical Methods in Image Reconstruction - SIAM Monographs, New York 2001

- Bertero and Boccacci: Inverse Problems in Imaging - IoP Press, London, 2002
- Andreas Rieder: Keine Probleme mit inversen Problemen - Vieweg, Wiesbaden, 2003
- Buzug: Computed Tomography - Springer, Berlin, 2008

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None

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.

ME4411-KP04 - Computed Tomography (CTKP04)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (optional subject), medical image processing, 1st or 2nd semester

Classes and lectures:

- Computed Tomography (lecture, 2 SWS)
- Computed Tomography (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Signal processing (recapitulation of fundamental principles in signal processing)
- Mathematical methods in image reconstruction and signal processing
- X-Ray (fundamental principles, quantum statistics)
- Computed Tomography * devices, * current and past technology, * signal processing, * Fourier-based 2D and 3D image reconstruction, * algebraic and statistical image reconstruction, * image artifacts, * technical and clinical applications, * dose.

Qualification-goals/Competencies:

- Students are able to create an overview of the signal chain for medical imaging.
- They are able to explain the mathematical background for the reconstruction of CT images.
- They are able to explain the basics for the creation of X-ray.
- They are able to list all generations of CT devices and explain differences and advances.
- They are able to apply the Fourier transform.
- They are able to explain the mathematical basics for the two-dimensional image reconstruction.
- They are able to create and apply an algebraic approach for the reconstruction of CT images.
- They are able to create and apply an statistical approach for the reconstruction of CT images.
- They are able to outline the differences between two dimensional and three dimensional image reconstruction.
- They are able to transfer methods from two dimensional to three dimensional image reconstruction.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Thorsten Buzug

Teacher:

- Institute of Medical Engineering
- Prof. Dr. rer. nat. Thorsten Buzug

Literature:

- T. M. Buzug: Computed Tomography, From Photon Statistics to Modern Cone Beam CT - Springer-Verlag, Berlin/Heidelberg, 2008
- T. M. Buzug: Einführung in die Computertomographie, Mathematisch-physikalische Grundlagen der Bildrekonstruktion - Springer-Verlag, Berlin/Heidelberg, 2004

Language:

- German and English skills required

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.

ME4414-KP06 - Magnetic Resonance Imaging and Nuclear Imaging (MRNukKP06)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (optional subject), medical image processing, 1st or 2nd semester

Classes and lectures:

- ME4412 T: Modul part: Magnetic Resonance Imaging (lecture, 2 SWS)
- ME4413 T: Modul part: Nuclear Imaging (lecture, 2 SWS)

Workload:

- 80 Hours private studies
- 70 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- as described for the module parts

Qualification-goals/Competencies:

- as described for the module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Martin Koch

Teacher:

- Institute of Medical Engineering
- Prof. Dr. rer. nat. Magdalena Rafecas
- Prof. Dr. rer. nat. Martin Koch

Literature:

- see literature of the module parts:

Language:

- German and English skills required

Notes:

Prerequisites for attending the module:
- None

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.

ME4520-KP04 - Introduction to Medical Device Regulation (EinfMPR)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	each winter semester	4	40

Course of study, specific field and term:

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

Classes and lectures:

- ME4520-V: Introduction to Medical Device Regulation (lecture, 2 SWS)
- ME4520-Ü: Introduction to Medical Device Regulation (exercise, 1 SWS)
- ME4520-S: Introduction to Medical Device Regulation (seminar, 1 SWS)

Workload:

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

Contents of teaching:

- Regulatory framework for the marketing of medical devices in the EU
- Requirements for manufacturers of medical devices
- Application of risk management to medical devices
- Application of usability to medical devices
- Quality management for medical device manufacturers
- Clinical evaluation of medical devices
- Software as a Medical Device
- Requirements for medical devices incorporating Artificial Intelligence

Qualification-goals/Competencies:

- Students describe the regulatory framework for the marketing of medical devices in the EU.
- They explain the concepts of regulatory requirements in the development, production, marketing, distribution, operation, maintenance and market surveillance of medical devices.
- They recognize and justify which requirements are relevant for a product.
- They apply norms and standards specifically to comply with requirements.
- They are proficient in risk analysis and assessment methods.
- They use elements of the usability-oriented development process.
- They assess the quality of a clinical evaluation and a software lifecycle processes.
- They compile contents of the technical documentation.

Grading through:

- portfolio exam

Responsible for this module:

- Prof. Dr. Maria Henke

Teacher:

- Institute for Robotics and Cognitive Systems
- Prof. Dr. Maria Henke

Literature:

- will be announced:

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):
ME4520-L1: Portfolio Exam Introduction to Medical Device Regulation with a total of 100 points, divided as follows:
- 70 points for active participation in the classroom sessions and group work, submission of homework assignments
- 20 points for elaboration and presentations
- 10 points for an e-test

An ungraded Category B Certificate of Achievement will be awarded.

The course is divided into three parts: The part Basic Knowledge is the basis for the course parts General Requirements and Software Requirements and must be completed by all students. Students can choose between the two other parts of the course.

The module focuses on medical device law from the perspective of manufacturers and developers of medical devices. However, the module is not only aimed at future technical developers of medical devices but all those who can contribute to the design of medical devices in interdisciplinary teams.

A maximum of 40 students can participate in one semester.

MZ4373-KP03, MZ4373 - Human Genetics (HumGen)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	3

Course of study, specific field and term:

- Master CLS 2023 (compulsory), MML with specialization in Genetic Statistics, 1st semester
- Master Medical Informatics 2019 (optional subject), bioinformatics, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), bioinformatics, 1st or 2nd semester
- Master CLS 2016 (compulsory), MML with specialization in Genetic Statistics, 1st semester
- Master CLS 2010 (compulsory), computational life science / biostatistics, 1st semester
- Master CLS 2010 (optional suject), mathematics, Arbitrary semester

Classes and lectures:

- Human Genetics for MML (lecture, 2 SWS)

Workload:

- 40 Hours private studies
- 30 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Human genome
- Heredity
- Genetics of mitochondria
- Mutations, detection and nomenclature of sequence variations
- Polymorphisms and SNP
- Linkage analyses
- Repetitive sequences
- Methods: isolation, amplification, screening, and analysis of nucleic acids
- Data bases
- Epigenetics

Qualification-goals/Competencies:

- Students are able to explain basic principles of heredity, the organization of the human genome, the relevance of sequence variations, and their application for medical biometrics.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Martin Kircher

Teacher:

- Institute of Human Genetics
- Prof. Dr. rer. nat. Martin Kircher
- Dr. Andreas Dalski
- MitarbeiterInnen des Instituts

Literature:

- Tom Strachan & Andrew P. Read: Molekulare Humangenetik - 3. Auflage (2005)

Language:

- German or English

Notes:

Prerequisites for attending the module:
- None

Prerequisites for participation in the exam(s):
- None

Module exam(s):
- MZ4373-L1: Human Genetics, written exam, 90 min, 100 % of module grade

MZ4374-KP03, MZ4374 - Molecular Human Genetics (MolHumGen)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	3 (Typ B)

Course of study, specific field and term:

- Master CLS 2023 (compulsory), MML with specialization in Genetic Statistics, 1st semester
- Master Medical Informatics 2019 (optional subject), bioinformatics, 1st or 2nd semester
- Master CLS 2016 (compulsory), MML with specialization in Genetic Statistics, 1st semester
- Master Medical Informatics 2014 (optional subject), bioinformatics, 1st or 2nd semester
- Master CLS 2010 (compulsory), computational life science / biostatistics, 1st semester

Classes and lectures:

- Molecular Human Genetics (practical course, 2 SWS)

Workload:

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

Contents of teaching:

- Safety instructions
- Isolation of nucleic acids
- Preparation and separation of nucleic acids
- Amplification of nucleic acids (PCR)
- Restriction of nucleic acids
- Theoretical consideration of pedigrees
- Data base search

Qualification-goals/Competencies:

- Students can perform fundamental molecular genetic experiments, they get basic knowledge in laboratory work

Grading through:

- continuous, successful participation in practical course, >80%

Requires:

- Human Genetics (MZ4373-KP03, MZ4373)

Responsible for this module:

- Prof. Dr. rer. nat. Martin Kircher

Teacher:

- Institute of Human Genetics

- Prof. Dr. rer. nat. Martin Kircher
- Dr. Andreas Dalski

Literature:

- Lecture notes: -

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:
- Regular and successful participation in the practical course, at least 80%

Module exam(s):
- MZ4374-L1: Molecular Human Genetics, ungraded practical course, 0 % of module grade, must be passed

PS4620-KP04, PS4620SJ14 - Ethics of Sciences (EthikKP04)

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

Course of study, specific field and term:

- Bachelor Interdisciplinary Courses for health sciences (optional subject), interdisciplinary competence, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), interdisciplinary competence, 1st or 2nd semester
- Bachelor MES 2014 (optional subject), no specific field, Arbitrary semester
- Master MES 2014 (optional subject), no specific field, 1st or 2nd semester
- Master Medical Informatics 2014 (optional subject), interdisciplinary competence, 1st or 2nd semester
- Master Interdisciplinary Courses (optional subject), Interdisciplinary modules, Arbitrary semester
- Bachelor Interdisciplinary Courses (optional subject), Interdisciplinary modules, Arbitrary semester

Classes and lectures:

- Ethics in the Life Sciences (seminar, 2 SWS)

Workload:

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

Contents of teaching:

- Societal and ethical implications of research in biomedical sciences and technologies
- Basics of philosophy and sociology of science
- Good scientific practice
- Basics of bioethics: duties of investigators, obligations to colleagues,
- Ethics of human subjects research and animal experiments, environmental ethics. Governance of technology,risk assessement
- Neuroethics
- Ethics of AI and robotics

Qualification-goals/Competencies:

- Students can explain the methodology of the physical sciences and technology and their philosophical basis
- They can recognize ethical dimensions of practice and deciding
- They can identify and assess ethical dimensions of action and decision-making in biotechnology and AI
- They can understand relevant laws in Germany
- They can participate in current discussions in bioethics and research ethics
- They can reflect on ethical dimensions of biomedical sciences

Grading through:

- continuous, successful participation in course

Responsible for this module:

- Prof. Dr. phil. Christoph Rehmann-Sutter

Teacher:

- Institute for History of Medicine and Science Studies

- Prof. Dr. med. Cornelius Borck
- Prof. Dr. phil. Christoph Rehmann-Sutter
- Prof. Dr. phil. Christina Schües
- Dr. phil. Frank Wörler

Literature:

- Urban Wiesing (Hg.):: Ethik in der Medizin. Ein Studienbuch - Stuttgart: Reclam 5. Aufl. 2020
- Ben Mepham: Bioethics. An Introduction for the Biosciences - Oxford: Oxford University Press 2008
- Jennifer A. Parks, Victoria S. Wike: Bioethics in a Changing World - Upper Saddle River, N.J.: Prentice Hall, 2010

Language:

- offered only in English

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Writing an essay and giving a lecture

CS5310-KP12 - Projektpraktikum Medizinische Informatik 1 (PPMI1)

Duration:	Turnus of offer:	Credit points:
1 Semester	each semester	12 (Typ B)

Course of study, specific field and term:

- Master Medical Informatics 2019 (compulsory), medical computer science, 3rd semester
- Master Medical Informatics 2014 (compulsory), medical computer science, 3rd semester

Classes and lectures:

- Projektpraktikum I (block practical course, 12 SWS)

Workload:

- 280 Hours work on project
- 60 Hours private studies and exercises
- 20 Hours written report

Contents of teaching:

- Project task in a concrete application scenario
- Documentation, presentation, motivation in heterogeneous environments
- The project task is always embedded in heterogeneous and living environments with considerable demands on communication about integration, planning, interfaces, resources, etc.

Qualification-goals/Competencies:

- The students have a deep understanding of selected aspects of medical informatics.
- They are able to implement selected aspects of medical informatics.
- They are able to document and present project results.
- They are capacble of presenting to particular audiences or under time restrictions (eg elevator pitch etc.).
- They have project experience in concrete application scenarios.
- They have basic skills in the field of project management.

Grading through:

- documentation

Responsible for this module:

- Studiengangsleitung Medizinische Informatik

Teacher:

- All Institutes and Clinics of the Universität zu Lübeck
-
- Scientific facilities at the Universität zu Lübeck or abroad with mandatory supervision by an university lecturer
- Institute for Neuro- and Bioinformatics
- Institute of Medical Informatics

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- Registration of the internships with the chair of the examination board is obligatory for later recognition. The corresponding forms can be found at https://www.uni-luebeck.de/index.php?id=5182.

Admission requirements for participation in module examination(s):
- Regular and successful participation in the internship

Module Exam(s):
- CS5310-L1: Project Practical Medical Informatics 1, ungraded practical, must be passed.

The internships can be completed both at the University of Lübeck and at external universities, research institutions and medical informatics companies in Germany and abroad. It is recommended to apply for a place abroad. One of the two block internships can be completed in a medical institute or a clinic. Both project internships can be combined to one large internship.

CS5320-KP12 - Projektpraktikum Medizinische Informatik 2 (PPMI2)

Duration:	Turnus of offer:	Credit points:
1 Semester	each semester	12 (Typ B)

Course of study, specific field and term:

- Master Medical Informatics 2019 (compulsory), medical computer science, 3rd semester
- Master Medical Informatics 2014 (compulsory), medical computer science, 3rd semester

Classes and lectures:

- Projektpraktikum Medizinische Informatik 2 (block practical course, 12 SWS)

Workload:

- 280 Hours work on project
- 60 Hours private studies and exercises
- 20 Hours written report

Contents of teaching:

- Project task in a concrete application scenario
- Documentation, presentation, motivation in heterogeneous environments
- The project task is always embedded in heterogeneous and living environments with considerable demands on communication about integration, planning, interfaces, resources, etc.

Qualification-goals/Competencies:

- The students have a deep understanding of selected aspects of medical informatics.
- They are able to implement selected aspects of medical informatics.
- They are able to document and present project results.
- They are capacble of presenting to particular audiences or under time restrictions (eg elevator pitch etc.).
- They have project experience in concrete application scenarios.
- They have basic skills in the field of project management.

Grading through:

- documentation

Responsible for this module:

- Studiengangsleitung Medizinische Informatik

Teacher:

- All Institutes and Clinics of the Universität zu Lübeck
-
- Scientific facilities at the Universität zu Lübeck or abroad with mandatory supervision by an university lecturer
- Institute of Medical Informatics
- Institute for Neuro- and Bioinformatics

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- Registration of the internships with the chair of the examination board is obligatory for later recognition. The corresponding forms can be found at https://www.uni-luebeck.de/index.php?id=5182.

Admission requirements for participation in module examination(s):
- Regular and successful participation in the internship

Module Exam(s):
- CS5320-L1: Project Practical Medical Informatics 2, ungraded practical, must be passed.

The internships can be completed both at the University of Lübeck and at external universities, research institutions and medical informatics companies in Germany and abroad. It is recommended to apply for a place abroad. One of the two block internships can be completed in a medical institute or a clinic. Both project internships can be combined to one large internship.

PS5000-KP06, PS5000 - Student Conference (ST)

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

Course of study, specific field and term:

- Master Psychology - Cognitive Systems 2022 (compulsory), psychology, 3rd semester
- Master Biophysics 2023 (compulsory), biophysics, 3rd semester
- Master Auditory Technology 2022 (compulsory), Auditory Technology, 3rd semester
- Master MES 2020 (compulsory), interdisciplinary competence, 3rd semester
- Master Medical Informatics 2019 (compulsory), interdisciplinary competence, 3rd semester
- Master Biophysics 2019 (compulsory), biophysics, 3rd semester
- Master Auditory Technology 2017 (compulsory), Auditory Technology, 3rd semester
- Master Interdisciplinary Courses (optional subject), Interdisciplinary modules, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (compulsory), Compulsory courses, 3rd semester
- Master Medical Informatics 2014 (compulsory), interdisciplinary competence, 3rd semester
- Master MES 2014 (compulsory), interdisciplinary competence, 3rd semester

Classes and lectures:

- Student Conference (seminar, 4 SWS)

Workload:

- 155 Hours work on an individual topic (research and development) and written elaboration
- 25 Hours in-classroom work

Contents of teaching:

- Preparation of a scientific publication in English based on the results of at least one of the project internships
- Preparation of a scientific poster in English based on the results of at least one of the project internships
- Presentation of a scientific poster in German or English, based on the results of at least one of the project internships
- Talk in English based on the results of at least one of the project internships
- Active participation in scientific discussions
- Active participation in a scientific peer-review process

Qualification-goals/Competencies:

- Students have experience in a comprehensive review of a scientific topic
- They are able to get an extensive overview of a complex scientific area
- They have the experience and ability to take an active part in scientific discussions
- They are able to defend one's work successfully in a scientific discourse
- They have knowledge of the peer-review process of publications
- They are able to constructively criticize in a blind peer-review process
-

Grading through:

- continuous, successful participation in course

Responsible for this module:

- Prof. Dr. rer. nat. habil. Heinz Handels
- Prof. Dr. rer. nat. Thorsten Buzug

Teacher:

- All Institutes and Clinics of the Universität zu Lübeck

Literature:

- is selected individually:

Language:

- offered only in English

Notes:

Admission requirements for the module:
- Successful completion of at least one project internship.
- Registration for at least one project internship is required.

Admission requirements for the examination:
- Regular and successful participation

Since the content of the presentation should reflect the results of at least one of the project internships, the students will be supervised by the same university lecturer that supervised the internships. Internships can be carried out at home or abroad in medical technology companies, audiology companies and IT companies in the healthcare industry as well as hospitals and scientific institutions. The supervision by an university lecturer is obligatory.

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

(The share of the Institute of Medical Technology in all is 75%)
(Share of medical informatics in all is 25%)

CS5991-KP30, CS5991 - Master Thesis Medical Computer Science (MScMI)

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

Course of study, specific field and term:

- Master Medical Informatics 2019 (compulsory), medical computer science, 4th semester
- Master Medical Informatics 2014 (compulsory), medical computer science, 4th semester

Classes and lectures:

- Kolloquium (supervised self studies, 1 SWS)
- Colloquium (presentation (incl. preparation), 1 SWS)

Workload:

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

Contents of teaching:

- Independent scientific work on a complex task of medical informatics and its applications
- Scientific presentation about the problem and the solution developed

Qualification-goals/Competencies:

- Students are able to solve a complex scientific problem by the means of their discipline.
- They have the expertise to plan, organize and carry out a project work.
- They can present complex information in written and oral form.
- They are experts for a roughly defined topic.

Grading through:

- Written report
- colloquium

Responsible for this module:

- Studiengangsleitung Medizinische Informatik

Teacher:

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

Literature:

- is selected individually:

Language:

- thesis can be written in German or English

Notes:

Admission requirements for taking the module:
- See study programme regulations (Earliest in the 3rd semester and certificates of achievement amounting to at least 75 CP are available at the examination office).

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

Module Exam(s):
- CS5991-L1: Master's thesis in medical informatics, final thesis with colloquium, 100% of the module grade.

CS4250 T - Module part: Computer Vision (CompVisioa)

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

Course of study, specific field and term:

- 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:

- 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 imaging
- Image features: edges, intrinsic dimension, SIFT, Hough transform, Fourier descriptors, and 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:

- exam type depends on main module

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 part of the module CS4410-KP08, CS4251-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.

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.

ME4412 T - Module part: Magnetic Resonance Imaging (MRT)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	3

Course of study, specific field and term:

- Master CLS 2023 (Module part of a compulsory module), MML with specialization in Image Processing, 1st semester
- Master MES 2020 (Module part of a compulsory module), medical engineering science, 1st semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Medical Informatics 2019 (module part), Module part, Arbitrary semester
- Master CLS 2016 (Module part of a compulsory module), MML with specialization in Image Processing, 1st semester
- Master Computer Science 2014 (module part), Module part, Arbitrary 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 of a compulsory module), medical engineering science, 1st semester

Classes and lectures:

- Magnetic Resonance Imaging (lecture, 2 SWS)

Workload:

- 40 Hours private studies
- 30 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Physical fundamentals of magnetic resonance imaging: nuclear magnetic resonance, relaxation mechanisms, principles of position encodingprinciples of spatial encoding, relaxation)
- Construction of basic imaging sequences, weighting
- Concept of k-space
- Coherence pathways
- Hardware components of a clinical MR system
- Possible sources of hazard for patients
- Influence of measurement parameters on signal-to-noise ratio
- Causes of image artefacts

Qualification-goals/Competencies:

- The students can explain the physical principles of NMR and MRI.
- They can explain the idea behind important imaging sequences, using a pulse sequence diagram.
- They can recognise the causes of important image artefacts.
- The can list advantages and disadvantages of MRT, compared to other imaging techniques.
- They can list possible sources of hazard for patients, explain their causes and point out strategies for avoiding these.

Grading through:

- Oral examination

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Medical Engineering
- Prof. Dr. rer. nat. Martin Koch

Literature:

- Liang, Z.-P., Lauterbur, P. C.: Principles of Magnetic Resonance Imaging: A Signal Processing Perspective - IEEE Press, New York 2000

Language:

- German and English skills required

Notes:

Prerequisites for attending the module:
- None

Prerequisites for participation in the exam(s):
- None

Module exam(s):
- ME4412-L1: Magnetic Resonance Imaging, oral exam, 30 min, 100 % of module grade

(Is module part of CS4512, ME4410-KP12, ME4415-KP06, ME4414-KP06)

ME4413 T - Module part: Nuclear Imaging (Nukl)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	3

Course of study, specific field and term:

- Master MES 2020 (Module part of a compulsory module), medical engineering science, 2nd 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 Medical Informatics 2019 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary 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 of a compulsory module), medical engineering science, 2nd semester

Classes and lectures:

- Nuclear Imaging (lecture, 2 SWS)

Workload:

- 40 Hours private studies
- 35 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Physical, biological and medical basics of nuclear imaging
- Scintigraphy
- Positron emission tomography (PET)
- Single photon emission computed tomography (SPECT)
- Clinical and preclinical applications

Qualification-goals/Competencies:

- Students are able to explain the physical principles and phenomena of nuclear imaging.
- They can describe relevant phenomena and procedures mathematically.
- They can understand the basics of nuclear medicine.
- They can explain the applications of nuclear imaging techniques.
- They can name and explain the advantages and disadvantages and limitations of nuclear imaging methods.

Grading through:

- Oral examination

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Medical Engineering
- Prof. Dr. rer. nat. Magdalena Rafecas

Literature:

- S. R. Cherry, J. A. Sorenson, M. E. Phelps: Physics in Nuclear Medicine - Elsevier, 2012
- M. N. Wernick, J. N. Aarsvold: Emission Tomography: The Fundamentals of PET and SPECT - Elsevier, 2004
- D. L. Bailey, D. W. Townsend, P. E. Valk , M N. Maisey (Editors): Positron Emission Tomography: Basic Sciences - Springer, 2005

Language:

- offered only in English

Notes:

Prerequisites for attending the module:
- None

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.