UNIVERSITÄT ZU LÜBECK

Module Guide for the Study Path

Master MES 2020

Version from 4. April 2024

interdisciplinary competence

medical engineering science

mathematics / natural sciences

computer science / electrical engineering

Elective

interdisciplinary

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
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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%)

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

CS4330-KP04, CS4330 - Image Analysis and Visualization in Diagnostics and Therapy (BAVIS)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	not available anymore	4	99

Course of study, specific field and term:

- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester
- Master MES 2014 (optional subject), medical engineering science, 1st or 2nd semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 2nd semester
- Master CLS 2010 (optional suject), computer science, Arbitrary semester
- Master Computer Science 2012 (compulsory), specialization field medical informatics, 2nd semester

Classes and lectures:

- Image Analysis and Visualization Systems in Diagnostics and Therapy (lecture, 2 SWS)
- Image Analysis and Visualization Systems in Diagnostics and Therapy (exercise, 1 SWS)

Workload:

- 55 Hours private studies and exercises
- 45 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:
- Data driven segmentation of multispectral image data
- Random Decision Forests for the segmentation of medical image data
- Convolutional Neural Networks and Deep Learning in Medical Image Processing
- live wire segmentation
- segmentation with active contour models and deformable models
- level set segmentation
- statistical shape models
- image registration
- atlas-based segmentation and multi atlas segmentation using non-linear registration
- visualization techniques in medicine
- direct volume rendering
- indirect volume rendering, ray tracing, ray casting
- haptic 3D interactions in virtual bodies
- virtual reality techniques in medical applications

Qualification-goals/Competencies:

- The students can classify advanced methods for medical image analysis and visualization, explain them, characterize them on the basis of their properties and select them problem-specifically for a concrete application.
- They are able to explain advanced methods of cluster analysis and classification, especially with Support Vector Machines and Random Decision Forests, and to characterize them based on their properties.
- 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 different non-linear image registration methods and to select and parameterize similarity measures and regularization terms for a specific registration problem.
- They are familiar with methods of multi-atlas segmentation and can explain and exemplarily apply the properties of different label fusion approaches.
- They can distinguish different medical visualization techniques, classify them according to their specific advantages and disadvantages and select and apply them depending on a concrete application problem.
- They can explain different haptic interaction techniques and can classify different systems for VR simulation in medicine.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Medical Image Computing (CS3310-KP09)
- Medical Image Computing (CS3310-KP08, CS3310SJ14)

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 - 2nd edition. Pacific Grove: PWS Publishing 1998
- B. Preim, D. Bartz: Visualization in Medicine - Elsevier, 2007

Language:

- offered only in German

Notes:

This module is no longer offered and will be replaced by the new module "CS4332-KP04 Model and AI based image processing in medicine".

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.

CS4332-KP04 - Model and AI-based image processing in medicine (MoKiBi_)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester

Classes and lectures:

- Model and AI-based image processing in medicine (lecture, 2 SWS)
- Model and AI-based image processing in medicine (exercise, 1 SWS)

Workload:

- 55 Hours private studies and exercises
- 45 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.
- They 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.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Medical Image Computing (CS3310-KP04)

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 as specified at the beginning of the semester

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

This module replaces the discontinued module "CS4330-KP04 Image Analysis and Visualisation in Diagnostics and Therapy".

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.

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

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.

ME4040-KP04, ME4040 - Quantenphysik der medizinischen Diagnostik und Therapie (QDT)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester
- Master MES 2014 (optional subject), medical engineering science, 1st or 2nd semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 1st or 2nd semester
- Master CLS 2010 (optional subject), mathematics, 2nd or 3rd semester

Classes and lectures:

- Quantenphysik der medizinischen Diagnostik und Therapie (seminar, 2 SWS)

Workload:

- 60 Hours private studies
- 35 Hours in-classroom work
- 25 Hours exam preparation

Contents of teaching:

- Uncertainty and metrology
- Elementary particles in medical technology
- Schrödinger equation: electrons in the wave picture
- Quantum mechanical foundations of electron, atomic force and scanning tunneling microscopy
- Quantum mechanical effects in magnetic resonance imaging and spectroscopy
- Radiotherapy: cross sections, proton and ion therapy; Interactions between radiation field and matter
- Quantum statistics in the nuclear medical diagnostics
- Infrared imaging and Planck's radiation law
- Synchrotron radiation in diagnosis and therapy
- Semiconductor detectors for biomedical imaging

Qualification-goals/Competencies:

- Students are able to explain the role of various quantum-mechanical processes in medical diagnostics and therapy.
- They can explain a number of diagnostic and therapeutic procedures, for which the understanding of quantum mechanics is important.
- They can name the pros and cons of competing procedures in radiotherapy.
- They can use the mathematical formulation of quantum mechanics to explain basic effects.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Magdalena Rafecas

Teacher:

- Institute of Medical Engineering

- Prof. Dr. rer. nat. Thorsten Buzug
- Prof. Dr. rer. nat. Martin Koch
- Prof. Dr. rer. nat. Magdalena Rafecas

Literature:

- is selected individually:

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.

ME4170-KP04, ME4170 - Mechanismen laserinduzierter Gewebseffekte (MechLasGew)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester
- Master MES 2014 (optional subject), medical engineering science, 1st or 2nd semester
- Master MES 2011 (advanced curriculum), biophysics and biomedical optics, 1st semester

Classes and lectures:

- Physical Mechanisms of Pulsed Laser Surgery of Cells and Tissues (lecture, 2 SWS)
- Physical Mechanisms of Pulsed Laser Surgery of Cells and Tissues/Excercises (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Introduction: Applications of Laser Surgery and Historical Overview
- Structure and properties of cells and tissues relevant for laser surgery
- Linear thermomechanical response to pulsed laser radiation
- Thermodynamics and Kinetics of Phase Transitions
- Dynamics of primary and secondary material ejection
- ablation models
- UV and IR ablation
- Ablation in liquid environment
- Models for plasma formation in water and biological tissue
- Plasma formation at energies above the threshold
- Chemical, thermal and mechanical plasma effects
- Control of precision, efficiency and side effects in various laser surgical applications

Qualification-goals/Competencies:

- The students can explain the basics of laser surgery via linear and non-linear light absorption.
- They can familiarize themself with a self-chosen part of this topic and present it.
- They can present a part of biomedical optics as an expert.
- They can deal with complex issues and present them in a compact way (orally and in writing).

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. rer. nat. Robert Huber

Teacher:

- Institute of Biomedical Optics

- Prof. Dr. rer. nat. Alfred Vogel

Literature:

- P.N. Prasad: Introduction to Biophotonics - Wiley 2003
- J. Popp, V. Tuchin, A. Chiou, S.H. Heinemann: Handbook of Biophotonics Vol 1 & 2 - Wiley-VCH 2011
- A.J. Welch, M. van Gemert: Optical-Thermal Response of Laser-Irradiated Tissue - Plenum 1995 (zweite Auflage 2011)

Language:

- offered only in German

ME4180-KP04, ME4180 - Bildgebende optische Diagnostik (BOD)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester
- Master MES 2014 (optional subject), medical engineering science, 1st or 2nd semester
- Master MES 2011 (advanced curriculum), biophysics and biomedical optics, 2nd semester

Classes and lectures:

- Bildgebende optische Diagnostik (lecture, 2 SWS)
- Seminar Bildgebende optische Diagnostik (seminar, 1 SWS)

Workload:

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

Contents of teaching:

- Overview, historical introduction
- Physical principles of optics
- Incoherent imaging
- Coherent imaging
- Fourier Optics
- Optical Scattering, scattering theory
- Optical coherence tomography
- Digital holography
- Confocal microscopy
- Optical tomography
- Optical computed imaging
- Related non-optical techniques (e.g. ultra sound X-ray, THz imaging)

Qualification-goals/Competencies:

- The students should know the basic physical principle of optical imaging and can present them in front of an audience.
- They can describe complex optical problems mathematically and solve numerically.
- They can describe applications and assess advantages and disadvantages of different imaging modalities. They can denominate reasonable applications.
- They can prepare themselves a scientific problem and present it in front of an audience.
- They can present complex issues in a compact and comprehensible oral or written report.
- They gain expert knowledge in small defiende area.

Grading through:

- participation in discussions

Requires:

- Moderne Techniken der biomedizinischen Optik 1 (UngenutztME4100)

Responsible for this module:

- Prof. Dr. rer. nat. Gereon Hüttmann

Teacher:

- Institute of Biomedical Optics

- Prof. Dr. rer. nat. Gereon Hüttmann

Literature:

- V.V. Tuchin: Handbook of optical biomedical diagnostics - SPIE Press 2002
- J. Goodman: Introduction to Fourier optics - Roberts & Co. Publishers, USA
- R. Liang: Optical Design for Biomedical Imaging - Spie Press Book
- J.D. Schmidt: Numerical Simulation of Optical Wave Propagation With Examples in MATLAB - SPIE Press
- M. Kaschke, K-H.Donnerhacke, M.S. Rill: Optical devices in ophthalmology and optometry technology, design principles and clinical applications - Wiley-VCH, 2014

Language:

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

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.

ME4185-KP04 - Computational Optical Imaging (COI)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester
- Master MES 2014 (optional subject), medical engineering science, 1st semester

Classes and lectures:

- Computational Optical Imaging (lecture, 2 SWS)
- Computational Optical Imaging (exercise, 1 SWS)

Workload:

- 75 Hours Self-study and group exercises
- 45 Hours in-classroom work

Contents of teaching:

- Introduction
- The physics of optics
- Fourier optics, Coherence
- Incoherent imaging
- Coherent imaging
- Statistical optics
- Digital holography, OCT, holoscopy
- Confocal imaging, deconvolution, super-resolution
- Light field photography
- Imaging with synthetic apertures
- Coded aperture imaging
- Compressed sensing, sparse sampling
- Ptychography
- Optical tomography (SLOT, ODT)
- Imaging by wavefront control
- Quantum imaging

Qualification-goals/Competencies:

- The students have knowledge of the basics of optics.
- They can describe complex optical problems mathematically and solve numerically.
- Students will assess pros and cons of different optical imaging technologies and can assign reasonable applications.
- They have knowledge of modern techniques of computational optical imaging.
- Students can present and advocate own solution of optical problems.
- They can present complex facts in a compact and comprehensible manner, orally and in writing.
- They can develop procedures and software for selected problems in computational optical imaging in a team.
- They are gaining research grade expertise in a selected field of computational optical imaging.

Grading through:

- exercises and project assignments

Requires:

- Moderne Techniken der biomedizinischen Optik 1 (UngenutztME4100)

Responsible for this module:

- Prof. Dr. rer. nat. Gereon Hüttmann

Teacher:

- Institute of Biomedical Optics

- Prof. Dr. rer. nat. Gereon Hüttmann

Literature:

- J. W. Goodman: Introduction to Fourier optics - Roberts & Co. Publishers, USA
- B. E. A. Saleh, and M. C. Teich: Fundamentals of Photonics - John Wiley & Sons, USA
- M. Born, and E. Wolf: Principles of Optics - Cambridge University Press, UK

- W. Lauterborn, and T. Kurz: Coherent Optics - Springer, Germany
- J. W. Goodman: Speckle Phenomena in Optics - Roberts & Co. Publishers, USA
- Additional literature: will be provided at the begin of the lecture

Language:

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

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Exercises and project assignments

ME4220-KP04, ME4220 - Microscopic optical techniques (MOV)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	each winter semester	4	12

Course of study, specific field and term:

- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester
- Master MES 2014 (optional subject), medical engineering science, 1st semester

Classes and lectures:

- Microscopic optical techniques (lecture, 2 SWS)
- Microscopic optical techniques (practical course, 1 SWS)

Workload:

- 45 Hours written report
- 30 Hours private studies
- 30 Hours in-classroom work
- 15 Hours group work

Contents of teaching:

- V: Geometrical optics, wave optics & Fourier optics of microscopic imaging
- P: Numerical aperture and resolution, Köhler illumination, interference and speckle, Michelson interferometer
- V: Phase contrast and differential interference contrast for visualization of phase objects, coherent filtering
- P: Diffraction & optical Fourier transformation, coherent filtering, phase contrast, DIC,
- V: Photophysics of organic dyes, fluorescence microscopy, nonlinear optics
- P: Fluorescence spectroscopy, filter sets, dyes, photobleaching
- V: Confocal & multiphoton laser scanning microscopy, Resolution beyond Abbe limit
- P: Confocal laser scanning and 2-photon microscope: preparation and imaging of various specimens
- V/P: Cell surgery with focused laser pulses and via nano-particlesd, laser-based specimen transport
- V/P: Wave front measurement and adaptive optics

Qualification-goals/Competencies:

- The students have gained a profound understanding of microscopic optical techniques and are able to apply it and to relate it to new applications.
- They can assess the function of optical components and are able to select them and to combine them for practical applications within a research or development project.
- The students are able to design complex optical setups and to arrange them on an optical bench.
- They have the professional, social and communication competencies to discuss scientific problems in tutorial groups and to implement potential solutions.

Grading through:

- Written report

Responsible for this module:

- Prof. Dr. rer. nat. Alfred Vogel

Teacher:

- Institute of Anatomy
- Institute of Biomedical Optics

- Prof. Dr. rer. nat. Alfred Vogel
- Prof. Dr. med. Peter König
- Prof. Dr. rer. nat. Gereon Hüttmann

Literature:

- Douglas B. Murphy: Fundamentals of Light Microscopy and Electronic Imaging - Wiley-Liss, 2001
- Christian Linkenheld: Pfad durch die Lichtmikroskopie
- Barry R. Masters, Peter T.C. So (Hrsg): Handbook of Biomedical Nonlinear Optical Microscopy - Oxford University Press, 2008
- Jerome Mertz: Introduction to Optical Microscopy - Roberts and Company, Colorado, 2011 (advanced)
- Joseph W. Goodman: Introduction to Fourier Optics - 3rd Ed.. Roberts and Company, Colorado, 2005 (advanced)

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.

ME4230-KP04 - Scanning imaging and 3D printing techniques (ScanBildge)

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

Course of study, specific field and term:

- Master MES 2014 (optional subject), medical engineering science, Arbitrary semester
- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester

Classes and lectures:

- ME4230-V: Scanning 3D Imaging and Printing Techniques (lecture, 2 SWS)
- ME4230-Ü: Scanning 3D Imaging and Printing Techniques (exercise, 1 SWS)

Workload:

- 45 Hours private studies
- 30 Hours oral presentation (including preparation)
- 30 Hours in-classroom work
- 15 Hours group work

Contents of teaching:

- Image formation and analog-to-digital converter
- Digital image acquisition
- Noise sources during signal and image acquisition
- Light sources and light source modulation
- Temporal signal sequences
- Pulse oximetry as an example of signal sequences
- Design and control of galvanometric scanners
- Generation of light distribution with scanning methods
- Scanning 3D microscopy (example: confocal microscopy)
- Scanning 3D distance measurement (example: LiDAR)
- Additive 3D printing processes using scanning methods

Qualification-goals/Competencies:

- Students learn the different components of scanning 3D imaging in a practical way: Light modulation of laser sources, beam deflection by means of galvanometric mirrors incl. electronic control, light detection and digitizing hardware and terms such as analog-to-digital converter (ADC), signal-to-noise ratio, noise sources etc., as well as digital image generation from temporal 1D measurement signals.
- Students acquire theoretical and, above all, practical knowledge of current technical 3D scanning methods and applications, such as LiDAR measurement technology, 3D microscopy and optical 3D printing as manufacturing processes, and can implement these independently in simple demonstrators.
- Students acquire technical, social and communication skills by discussing complex technical problems in a group.
- Within the framework of short presentations, you will learn to work out complex topics in a team and to present them in a compact way.

Grading through:

- scientific presentation
- continuous, successful participation in course

Responsible for this module:

- Prof. Dr. rer. nat. Sebastian Karpf

Teacher:

- Institute of Biomedical Optics

- Prof. Dr.-Ing. Maik Rahlves
- Prof. Dr. rer. nat. Sebastian Karpf

Literature:

- B. E. A. Saleh, M.C. Teich: Grundlagen der Photonik - John Wiley & Sons, USA
- L. Bergmann, C. Schäfer: Lehrbuch der Experimentalphysik - Bd.3, Optik, de Gruyter, Deutschland
- J. Fraden: Handbook of Modern Sensors - Springer, Deutschland
- Scientific articles provided within the course.:

Language:

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

ME4240-KP04 - Fundamentals of medical device technology for clinical ventilation and anesthesia (GMTKBA)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4 (B-Schein)

Course of study, specific field and term:

- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester

Classes and lectures:

- ME4240-V: Fundamentals of medical device technology for clinical ventilation and anesthesia (lecture, 2 SWS)
- ME4240-Ü: Fundamentals of medical device technology for clinical ventilation and anesthesia (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Fundamentals
- Physiology of respiration and anesthesia
- Working principles of clinical ventilation and anesthesia devices
- Sensor technology in ventilation and anesthesia devices
- Automation and real-time systems
- Development tools
- Functional safety
- Workplace infrastructure & gas management systems
- History and future development

Qualification-goals/Competencies:

- Students have an overview of requirements on medical devices for clinical ventilation and anesthesia
- Students understand the interaction between physiology and medical devices
- Students understand the operation principle of modern ventilation and anesthesia equipment

Grading through:

- continuous, successful participation in course

Responsible for this module:

- Prof. Dr. Dr. Karsten Hiltawsky

Teacher:

- Drägerwerk AG & Co. KGaA (Corporate Technology & Innovation)
- Institute for Electrical Engineering in Medicine

- Prof. Dr. Dr. Karsten Hiltawsky

Language:

- German and English skills required

ME4270-KP04 - Diffraction, Resolution and Superresolution - Limitations of Modern Microscopy (BAS)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester
- Master MES 2014 (optional subject), medical engineering science, Arbitrary semester

Classes and lectures:

- ME4270-V: Diffraction, Resolution and Superresolution (lecture, 2 SWS)
- ME4270-Ü: Diffraction, Resolution and Superresolution (exercise, 1 SWS)

Workload:

- 45 Hours private studies
- 30 Hours oral presentation (including preparation)
- 30 Hours in-classroom work
- 15 Hours group work

Contents of teaching:

- Wave optical properties of light
- Gaussian beams and diffraction phenomena
- Wavefront measurement and beam characterization
- Aberration compensation and adaptive optics
- Basics of Fourier optics
- Determination of the resolution limit of a microscope according to Abbe
- Experimental visualization of the Gouy phase
- Axial resolution enhancement in confocal microscopes
- Basics of super-resolution microscopy

Qualification-goals/Competencies:

- The overall goal is to provide a practical understanding of wave-optical light phenomena and their influence on microscopic resolution. Furthermore, super-resolution microscopy methods are discussed and made understandable experimentally:
- Students explore the wave-optical properties of light, from Gaussian ray optics to the diffraction of light at interfaces and in optical imaging.
- Students will learn about wavefront aberrations, their origin and quantification, and adaptive methods to compensate for them.
- Fourier optics fundamentals and their relation to modern microscopy are taught in a practical manner.
- Fundamentals of modern super-resolution microscopy will be taught. The underlying ideas of resolution enhancement beyond the diffraction limit are exemplified in the laboratory.
- Students acquire technical, social and communication skills through group discussion of complex technical problems.
- Within the framework of short presentations, you will learn to work out complex topics in a team and to present them in a compact way.

Grading through:

- scientific presentation
- continuous, successful participation in course
- protocols

Responsible for this module:

- Prof. Dr.-Ing. Maik Rahlves

Teacher:

- Institute of Biomedical Optics

- Prof. Dr.-Ing. Maik Rahlves
- Prof. Dr. rer. nat. Sebastian Karpf

Literature:

- B. E. A. Saleh, M.C. Teich: Grundlagen der Photonik - John Wiley & Sons, USA
- J.W. Goodman: Fourier Optics - Roberts & Company Publisher, USA
- L. Bergmann, C. Schäfer: Lehrbuch der Experimentalphysik - Bd.3, Optik, de Gruyter, Deutschland

Language:

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

ME4410-KP12, ME4410 - Imaging Systems (BS)

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

Course of study, specific field and term:

- Master MES 2020 (compulsory), medical engineering science, 1st and 2nd semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field medical engineering science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field medical engineering science, 1st and 2nd semester
- Master MES 2014 (compulsory), medical engineering science, 1st and 2nd semester

Classes and lectures:

- ME4411 T: Modul part: Computed Tomography (lecture, 2 SWS)
- ME4412 T: Modul part: Magnetic Resonance Imaging (lecture, 2 SWS)
- ME4413 T: Modul part: Nuclear Imaging (lecture, 2 SWS)
- Seminar Imaging Systems (seminar, 2 SWS)

Workload:

- 150 Hours private studies
- 125 Hours in-classroom work
- 45 Hours exam preparation
- 30 Hours written report
- 10 Hours oral presentation (including 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. Thorsten Buzug

Teacher:

- Institute of Medical Engineering

- Prof. Dr. rer. nat. Thorsten Buzug
- Prof. Dr. rer. nat. Martin Koch
- Prof. Dr. rer. nat. Magdalena Rafecas

Literature:

- as described for 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.

ME4411 T - Module part: Computed Tomography (CT)

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 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:

- Computed Tomography (lecture, 2 SWS)

Workload:

- 40 Hours private studies
- 35 Hours in-classroom work
- 15 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:

- Siehe Hauptmodul

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

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

Module exam(s):
- ME4411-L1: Computed Tomography, oral exam, 100 % of module grade

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

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.

ME4420-KP12, ME4420 - Biomedical Optics (BMO)

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

Course of study, specific field and term:

- Master Biophysics 2023 (compulsory), biophysics, 1st and 2nd semester
- Master MES 2020 (compulsory), medical engineering science, 1st and 2nd semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field medical engineering science, Arbitrary semester
- Master Biophysics 2019 (compulsory), biophysics, 1st and 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field medical engineering science, 1st and 2nd semester
- Master MES 2014 (compulsory), medical engineering science, 1st and 2nd semester

Classes and lectures:

- ME4421 T: Module part: Biomedical Optics 1 (lecture, 2 SWS)
- ME4422 T: Module part: Biomedical Optics 2 (lecture, 2 SWS)
- ME4423 T: Module part: Laser physics and -technologies (lecture, 2 SWS)
- Seminar Biomedical Optics (seminar, 2 SWS)

Workload:

- 135 Hours private studies
- 120 Hours in-classroom work
- 55 Hours exam preparation
- 30 Hours oral presentation (including preparation)
- 20 Hours written report

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. Robert Huber

Teacher:

- Institute of Biomedical Optics

- Dr. rer. nat. Norbert Linz
- Prof. Dr. rer. nat. Gereon Hüttmann
- Prof. Dr. rer. nat. Robert Huber
- Dr. rer. nat. Ralf Brinkmann
- Prof. Dr. rer. nat. Sebastian Karpf

Literature:

- as listed for the module parts:

Language:

- German and English skills required

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Examination requirement is the successful participation in one of the three module seminars (BMO1, BMO2, or Laser Physics). This includes mandatory attendance and a 20 minute scientific presentation followed by discussion.

Exam:
- A 30 minutes oral exam about the content of the lectures BMO1, BMO2 and laser physics.

ME4421 T - Module part: Biomedical Optics 1 (BioMedOp1)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	each winter semester	3

Course of study, specific field and term:

- 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 Biophysics 2019 (Module part of a compulsory module), biophysics, 1st 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
- Master Biophysics 2023 (Module part of a compulsory module), biophysics, 1st semester

Classes and lectures:

- Lecture Biomedical Optics 1 (lecture, 2 SWS)

Workload:

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

Contents of teaching:

- Tissue optics
- Photophysics of molecules, fluorescent markers, and targeting
- Photochemistry, photobiology, and photodynamic therapy
- Spectroscopic tissue characterization and diagnosis
- Raman spectroscopy and imaging
- Coherence of light, and implications for biomedical optics
- Generation, steering, and detection of light
- Thermal action of light on biomolecules and tissue, rate processes
- Selective treatment of ocular structures, guided by online-dosimetry
- Mechanisms of pulsed laser ablation
- Laser ablation at tissue surfaces and inside the body & surgery by high-intensity focused ultrasound
- Nonlinear interactions of light and matter
- Plasma-mediated surgery, exemplified on refractive corneal surgery and cataract surgery
- Optical manipulation of microstructures (Laser scissors, tweezers, and catapults)
- Plasmonic systems, nano-optics, and optical bio-sensors

Qualification-goals/Competencies:

- The students are able to describe, illustrate and compare the fundamental diagnostic and therapeutic optical techniques in biomedicine.
- They are able to assess advantages and disadvantages of these techniques and to draw conclusions for their implementation into possible applications.
- They can explain light and tissue interactions and relate them to the optical techniques in which they are used.
- The students are able to understand and classify complex optical techniques as a whole and to analyze their constitutents.
- They have a profound understanding of scientific optical techniques in biomedicine, can apply it independently, and are able to transfer their knowledge to related tasks.

Grading through:

- exam type depends on main module

Is requisite for:

- Module part: Biomedical Optics 2 (ME4422 T)

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Biomedical Optics

- Prof. Dr. rer. nat. Robert Huber
- Prof. Dr. rer. nat. Gereon Hüttmann

- Dr. rer. nat. Ralf Brinkmann
- Dr. rer. nat. Norbert Linz

Literature:

- P.N. Prasad: Introduction to Biophotonics - Wiley 2003
- J. Popp, V. Tuchin, A. Chiou, S.H. Heinemann: Handbook of Biophotonics Vol 1 & 2 - Wiley-VCH 2011
- A.J. Welch, M. van Gemert: Optical-Thermal Response of Laser-Irradiated Tissue - Plenum 1995 (zweite Auflage 2011)

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.

ME4422 T - Module part: Biomedical Optics 2 (BioMedOp2)

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 Biophysics 2019 (Module part of a compulsory module), biophysics, 2nd 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
- Master Biophysics 2023 (Module part of a compulsory module), biophysics, 2nd semester

Classes and lectures:

- Biomedical Optics 2 (lecture, 2 SWS)

Workload:

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

Contents of teaching:

- Light microscopy: geometrical optics, wave optics, Fourier optics
- Effects of incoherent and coherent microscope-illumination & technical realization
- Phase contrast and differential interference contrast (DIC)
- Marker and targeting techniques, GFP, quantum dots, FRET
- Deconvolution & optical sectioning via structured illumination, confocal microscopy, 2-photon imaging
- Nanoscopy beyond the Abbe-limit: principles and biological applications
- Optical coherence tomography (OCT): principles, technical realization, and clinical applications
- Opto-acoustic tomography and microscopy
- Electron microscopy: principles and biological applications of TEM, REM, and Cryo-EM

Qualification-goals/Competencies:

- The students have a profound understanding and knowledge of modern optical imaging techniques in biomedicine, are able to describe and illustrate them, and to relate them to applications.
- They can explain the light-tissue interaction relevant for the different techniques, describe them mathematically and predict their effects.
- The students are able to understand and classify complex optical imaging techniques as a whole and to analyze their constitutents.
- They are able to transfer and adopt their knowledge to related problems and to develop new concepts.

Grading through:

- exam type depends on main module

Requires:

- Module part: Biomedical Optics 1 (ME4421 T)

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Biomedical Optics

- Prof. Dr. rer. nat. Robert Huber
- Prof. Dr. rer. nat. Gereon Hüttmann
- Prof. Dr. rer. nat. Sebastian Karpf
- Dr. rer. nat. Norbert Linz
- Dr. rer. nat. Ralf Brinkmann

Literature:

- D. B. Murphy: Fundamentals of Light Microscopy and Electronic Imaging - Wiley-Liss 2001
- J. Mertz: Optical Microscopy - Roberts & Co. Publ. 2010
- J.B. Pawley (ed): Handbook of Confocal Microscopy - Springer 2006

- W. Drexler, J.G. Fujimoto (eds.): Optical Coherence Tomography - Springer 2008
- L. Wang (ed): Photoacoustic Imaging and Spectroscoy - CRC Press 2009

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:
- Talk and participation in discussion

ME4423 T - Module part: Laserphysics and -technologies (LaPhyTec)

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

Course of study, specific field and term:

- 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 Biophysics 2019 (Module part of a compulsory module), biophysics, 1st 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
- Master Biophysics 2023 (Module part of a compulsory module), biophysics, 1st semester

Classes and lectures:

- Lecture laser physics and -technologies (lecture, 2 SWS)

Workload:

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

Contents of teaching:

- Understanding the laser (What is a laser, the laser history, laser parameters)
- Basic properties of light, light propagation (Gaussian beam resonators, stability conditions, wavelength selective elements)
- Light and matter (radiation interactions, stimulated and spontaneous emission light amplification)
- Laser (Broad laser theory, rate equations, laser threshold, laser dynamics)
- Types of lasers (gas lasers, ion lasers, solid state lasers, fiber lasers, semiconductor lasers)
- nonlinear optics (frequency doubling and conversion)
- Ultrashort light pulses

Qualification-goals/Competencies:

- Students can assess what types of lasers are suitable for which applications.
- They can implement concepts for new laser applications.
- They can list the most important types of lasers.
- They can explain the basic concepts of laser physics.
- They can analyze laser formally.
- They can assess the potential of laser radiation on the basis of the parameters.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Biomedical Optics

- Prof. Dr. rer. nat. Robert Huber
- Dr. rer. nat. Ralf Brinkmann
- Prof. Dr. rer. nat. Sebastian Karpf

Literature:

- Dieter Meschede: Optics, Light and Lasers - Wiley-VCH 2007
- Walter Koechner: Solid State Laser Engineering - Springer 1999
- Saleh/Teich: Grundlagen der Photonik - Wiley-VCH 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.

ME4530-KP04 - Optical and Photonic Systems: Design, Modeling, Fabrication (OptPhoSys)

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

Course of study, specific field and term:

- Master MES 2014 (optional subject), medical engineering science, Arbitrary semester
- Master MES 2020 (optional subject), medical engineering science, Arbitrary semester

Classes and lectures:

- ME4530-V: Optical and Photonic Systems (lecture, 2 SWS)
- ME4530-Ü: Optical and Photonic Systems (exercise, 1 SWS)

Workload:

- 75 Hours Self-study and group exercises
- 45 Hours in-classroom work

Contents of teaching:

- Overview of optical systems in biomedicine
- Ray optics and wave optics
- Basics of Fourier optics
- Introduction to optical ray tracing
- Design of simple optical systems such as microscope/telescopes, etc.
- Optical aberrations and their compensation
- Determination of resolution, modulation transfer function (MTF)
- Tolerance analysis
- Beam parameters and design of beam shaping optics
- Optical simulation of Diffractive Optical Elements (DOEs)
- Diffraction efficiencies and rigorous description of DOEs.
- Applications and specific design of DOEs (spectrometers, microlenses).
- Manufacturing processes for optical systems and their characterization
- Optical fibers and photonic components
- Simulation of light propagation in waveguides (Beam Propagation Method, BPM)
- Rigorous design of photonic systems with FDTD
- Biomedical application example: surface plasmon sensing.

Qualification-goals/Competencies:

- Students will know basic optical components.
- They can model simple optical systems in the ray tracer and analyze their optical errors.
- They know the basics of the optimization of optical systems.
- They know different simulation methods and regimes for the design of different optical systems and can apply them system-specifically.
- They know the basics of diffractive optics and can implement basic numerical methods for their calculation and know applications in medical technology.
- They know manufacturing processes of optical components and can derive limits and application areas from this.
- They know the basics of different fibers and waveguides, application examples and can optically simulate and design simple fiber sensors.
- Students possess the social and communication skills to discuss within practice groups and to solve complex tasks in teams.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr.-Ing. Maik Rahlves

Teacher:

- Institute of Biomedical Optics

- Prof. Dr.-Ing. Maik Rahlves

Literature:

- H. Gross (Hrsg.): Handbook of Optical Systems - John Wiley & Sons, USA
- G. Litfin (Hrsg): Technische Optik in der Praxis - Springer, Deutschland

- J. W. Goodman: Introduction to Fourier optics - Roberts & Co. Publishers, USA
- B. E. A. Saleh, and M. C. Teich: Fundamentals of Photonics - John Wiley & Sons, USA
- M. S. Wartak: Computational Photonics - Cambridge University Press, USA

Language:

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

ME5500-KP12, ME5500 - Internship 1 (ProjPrak1)

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

Course of study, specific field and term:

- Master MES 2020 (compulsory), medical engineering science, 3rd semester
- Master MES 2014 (compulsory), medical engineering science, 3rd semester
- Master MES 2011 (compulsory), medical engineering science, 3rd semester

Classes and lectures:

- Internship I (September-November) (block practical course, 12 SWS)

Workload:

- 320 Hours work on project
- 40 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 vivid environments with significant demands on communication integration, planning, interfaces, resources, etc.

Qualification-goals/Competencies:

- The students have a deep understanding of selected aspects of medical engineering.
- They are able to implement selected aspects of medical engineering.
- 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 MIW

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
- Medical technology companies at the Universität zu Lübeck or abroad with mandatory supervision by an university lecturer

Literature:

- is selected individually:

Language:

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

Notes:

The internships can be completed in medical technology companies or scientific facilities outside the university as well. It is recommended to seek a place abroad.
One of the two internships can be completed in a medical institution or a clinic.
Both internships can be merged into one large internship.

Prerequisites for attending the module:
- The registration of the internships is obligatory. The corresponding forms can be found at www.miw.uni-luebeck.de.

Prerequisites for the exam:
- Regular and successful participation in the internship

ME5510-KP12, ME5510 - Internship 2 (ProjPrak2)

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

Course of study, specific field and term:

- Master MES 2020 (compulsory), medical engineering science, 3rd semester
- Master MES 2014 (compulsory), medical engineering science, 3rd semester
- Master MES 2011 (compulsory), medical engineering science, 3rd semester

Classes and lectures:

- Internship II (December-February) (block practical course, 12 SWS)

Workload:

- 320 Hours work on project
- 40 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 vivid environments with significant demands on communication integration, planning, interfaces, resources, etc.

Qualification-goals/Competencies:

- The students have a deep understanding of selected aspects of medical engineering.
- They are able to implement selected aspects of medical engineering.
- 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 MIW

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
-

Literature:

- is selected individually:

Language:

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

Notes:

The internships can be completed in medical technology companies or scientific facilities outside the university as well. It is recommended to seek a place abroad.
One of the two internships can be completed in a medical institution or a clinic.
Both internships can be merged into one large internship.

Prerequisites for attending the module:
- The registration of the internships is obligatory. The corresponding forms can be found at www.miw.uni-luebeck.de.

Prerequisites for the exam:
- Regular and successful participation in the internship

ME5990-KP30, ME5990 - Master Thesis Medical Engineering (MAMIW)

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

Course of study, specific field and term:

- Master MES 2020 (compulsory), medical engineering science, 4th semester
- Master MES 2014 (compulsory), medical engineering science, 4th semester
- Master MES 2011 (compulsory), medical engineering science, 4th semester

Classes and lectures:

- Master's Thesis (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 engineering sciences 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 MIW

Teacher:

- Scientific facilities at the Universität zu Lübeck or abroad with mandatory supervision by an university lecturer
- Medical technology companies at the Universität zu Lübeck or abroad with mandatory supervision by an university lecturer
- All Institutes and Clinics of the Universität zu Lübeck

- Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges

Literature:

- is selected individually:

Language:

- thesis can be written in German or English

Notes:

Prerequisites for attending the module:
- see Academic Regulations and Procedures for Students

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

LS4020 C-MIW - Module part: Single molecule methods (EinzelStrT)

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

Course of study, specific field and term:

- Master MES 2020 (module part), mathematics / natural sciences, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), mathematics / natural sciences, Arbitrary semester

Classes and lectures:

- Single molecule methods (lecture, 2 SWS)
- Seminar Single molecule methods (seminar, 1 SWS)

Workload:

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

Contents of teaching:

- Physical Fundamentals of Fluorescence
- Photophysics
- Methods of single molecule fluorescence microscopy
- Protein labeling and immobilization
- Fluorescence Resonance Energy Transfer (FRET)
- Enzyme activity with single molecules
- Single molecule protein folding
- Physical basis of optical tweezers
- Protein folding with optical tweezers

Qualification-goals/Competencies:

- Students will be able to explain and apply the physical principles of fluorescence.
- They can explain and apply the basics of photophysics and photochemistry.
- They can select suitable detection methods for single molecules.
- They can select appropriate protein labelling methods.
- They can analyze and critically evaluate the data obtained.
- They have an overview of current research in the field of fluorescence spectroscopy of individual biomolecules.
- They have an insight into the structures of the research landscape.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Introduction into Biophysics (LS2200-KP04, LS2200)

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Physics

- Prof. Dr. rer. nat. Christian Hübner

Literature:

- Lakowicz, Joseph R.: Principles of Fluorescence Spectroscopy - ISBN 978-0-387-46312-4
- Markus Sauer, Johan Hofkens, Jörg Enderlein: Handbook of Fluorescence Spectroscopy and Imaging: From Ensemble to Single Molecules - ISBN: 978-3-527-31669-4

Language:

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

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.

LS4020 F-MIW - Module part: Protein biophysics (PBPT)

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

Course of study, specific field and term:

- Master MES 2020 (module part), mathematics / natural sciences, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), mathematics / natural sciences, Arbitrary semester

Classes and lectures:

- Protein biophysics (lecture, 2 SWS)
- Protein biophysics (seminar, 1 SWS)

Workload:

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

Contents of teaching:

- Protein structure
- Energy landscapes
- Thermodynamics of protein folding
- Kinetics of protein folding
- Thermodynamics of enzymatic reactions
- Kinetics of enzymatic reactions

Qualification-goals/Competencies:

- Students will be able to name and explain the physical principles of protein folding, protein dynamics and protein interaction.
- Students can correctly apply the terms global state, micro state, sum of states, global variables and energy landscape.
- Students will be able to use the terms entropy and enthalpy correctly in the context of protein folding and protein interaction.
- Students can name and explain the basic principles of protein folding kinetics.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Introduction into Biophysics (LS2200-KP04, LS2200)

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Physics

- Prof. Dr. rer. nat. Christian Hübner

Literature:

- Hans Frauenfelder, Shirley Chan und Winnie Chan: Physics of Proteins: An Introduction to Molecular Biophysics (Biological and Medical Physics, Biomedical Engineering) - Springer, Berlin (Gebundene Ausgabe - 30. Dezember 2010)
- Alan Fersht: Structure & Mechanism in Protein Science: Guide to Enzyme Catalysis and Protein Folding - W H Freeman & Co (Gebundene Ausgabe - 15. Februar 1999)

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.

Identical to LS4020 F plus seminar

LS4022-KP04 - Single molecule methods (Einzel04)

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

Classes and lectures:

- Single molecule methods (lecture, 2 SWS)
- Seminar Single molecule methods (seminar, 1 SWS)

Workload:

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

Contents of teaching:

- Physical Fundamentals of Fluorescence
- Photophysics
- Methods of single molecule fluorescence microscopy
- Protein labeling and immobilization
- Fluorescence Resonance Energy Transfer (FRET)
- Enzyme activity with single molecules
- Single molecule protein folding
- Physical basis of optical tweezers
- Protein folding with optical tweezers

Qualification-goals/Competencies:

- Students will be able to explain and apply the physical principles of fluorescence.
- They can explain and apply the basics of photophysics and photochemistry.
- They can select suitable detection methods for single molecules.
- They can select appropriate protein labelling methods.
- They can analyze and critically evaluate the data obtained.
- They have an overview of current research in the field of fluorescence spectroscopy of individual biomolecules.
- They have an insight into the structures of the research landscape.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Introduction into Biophysics (LS2200-KP04, LS2200)

Responsible for this module:

- Prof. Dr. rer. nat. Christian Hübner

Teacher:

- Institute of Physics

- Prof. Dr. rer. nat. Christian Hübner

Literature:

- Lakowicz, Joseph R.: Principles of Fluorescence Spectroscopy - ISBN 978-0-387-46312-4
- Markus Sauer, Johan Hofkens, Jörg Enderlein: Handbook of Fluorescence Spectroscopy and Imaging: From Ensemble to Single Molecules - ISBN: 978-3-527-31669-4

Language:

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

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.

LS4023-KP04 - Protein biophysics (PBPT04)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester

Classes and lectures:

- Protein biophysics (lecture, 2 SWS)
- Protein biophysics (seminar, 1 SWS)

Workload:

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

Contents of teaching:

- Protein structure
- Energy landscapes
- Thermodynamics of protein folding
- Kinetics of protein folding
- Thermodynamics of enzymatic reactions
- Kinetics of enzymatic reactions

Qualification-goals/Competencies:

- Students will be able to name and explain the physical principles of protein folding, protein dynamics and protein interaction.
- Students can correctly apply the terms global state, micro state, sum of states, global variables and energy landscape.
- Students will be able to use the terms entropy and enthalpy correctly in the context of protein folding and protein interaction.
- Students can name and explain the basic principles of protein folding kinetics.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Introduction into Biophysics (LS2200-KP04, LS2200)

Responsible for this module:

- Prof. Dr. rer. nat. Christian Hübner

Teacher:

- Institute of Physics

- Prof. Dr. rer. nat. Christian Hübner

Literature:

- Hans Frauenfelder, Shirley Chan und Winnie Chan: Physics of Proteins: An Introduction to Molecular Biophysics (Biological and Medical Physics, Biomedical Engineering) - Springer, Berlin (Gebundene Ausgabe - 30. Dezember 2010)
- Alan Fersht: Structure & Mechanism in Protein Science: Guide to Enzyme Catalysis and Protein Folding - W H Freeman & Co (Gebundene Ausgabe - 15. Februar 1999)

Language:

- offered only in German

Notes:

Identical to LS4020 F plus seminar

LS4130 A - Module part: Membrane Biophysics (Biophy2Mem)

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

Course of study, specific field and term:

- Master MES 2020 (module part), mathematics / natural sciences, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), mathematics / natural sciences, Arbitrary semester
- Master MES 2014 (module part), mathematics / natural sciences, Arbitrary semester
- Master MLS 2009 (Module part of a compulsory module), structure biology, 2nd semester

Classes and lectures:

- Basics of Membrane Biophysics (lecture, 2 SWS)
- Basics of Membrane Biophysics (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Importance and function of cell membranes: structure, physical function and dynamic models
- Basics of the membrane components
- Thermodynamic self-assembling of lipids and reconstitution techniques
- Transmembrane and intrinsic membrane potentials
- Mechanical properties of lipid membranes
- Physical basics of membrane transport mechanisms
- Investigations using lipid monolayer
- Electrical and optical experiments using planar lipid bilayers
- Examples for interaction mechanisms between peptides/ proteins and planar membranes
- Spectroscopic methods on membranes and membrane proteins
- Light and force microscopy on membranes and membrane proteins
-

Qualification-goals/Competencies:

- The students can explain the components and the structure of biological membranes.
- They can explain the role and function of membrane lipids and proteins.
- They can explain the mechanical and electrical properties of membranes.
- They can explain the reconstitution of artificial lipid membranes.
- They can explain the methods for the investigation of artificial and natural membranes.
- They can explain the application of biophysical methods to biomedical questions, such as the characterization of membrane-active toxins.

Grading through:

- written exam

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Research Center Borstel, Leibniz Lung Center

- Prof. Dr. rer. nat. Thomas Gutsmann
- Prof. Dr. rer. nat. Andra Schromm
- Dr. Christian Nehls

Literature:

- Adam, P. Läuger, G. Stark: Physikalische Chemie und Biophysik - Springer-Verlag, 4. Auflage 2003
- W. Hanke, R. Hanke: Methoden der Membranphysiologie - Spektrum Akademischer Verlag, Auflage 1997
- Ole G. Mouritsen: Life - As a Matter of Fat - Springer 2005, ISBN 987-3-540-23248-3
- Thomas Heimburg: Thermal Biophysics of Membranes - Whiley-VCH 2007, ISBN 978-3-527-40471-1
- Lukas K. Buehler: Cell Membranes - Garland Science 2016, ISBN 978-0-8153-4196-3

Language:

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

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- None

Part of the module LS4130
One choise of two.

LS5710-KP04, LS5710 - Molecular Dynamics (MD)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2014 (optional subject), mathematics / natural sciences, 2nd or 4th semester
- Master MES 2011 (advanced curriculum), biophysics and biomedical optics, 2nd or 4th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

- The energy hyperspace: coordinate representation, ground state, transition states (saddle points), molecular oscillations, minimization methods, molecular dynamics
- Basic concepts of quantum mechanics: wave functions and operators, Schrödinger equation, harmonic oscillator, hydrogen atom, hydrogen molecule
- Force fields: Stretching, bending, torsion, van der Waals forces, types of force fields
- Method for calculating the electronic structure: Born-Oppenheimer approximation, separation of the many particle wave function into single particle functions (orbitals), base sets, Hartree-Fock method, density functional theory

Qualification-goals/Competencies:

- The students can name and explain the basics of force field models and quantum chemical processes.
- They can apply the basics of theoretical molecular dynamics to selected examples.
- They can create physical models in the field of molecular dynamics.
- They can critically evaluate the results of molecular dynamics calculations in the biophysical context.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Module part: Biophysik 1 (ME4600 C)

Responsible for this module:

- Prof. Dr. rer. nat. Christian Hübner

Teacher:

- Institute of Physics

- PD Dr. rer. nat. Hauke Paulsen
- Prof. Dr. rer. nat. Christian Hübner

Literature:

- Andrew R Leach: Molecular Modelling: Principles and Applications - Prentice Hall, 2nd edition 2001

Language:

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

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.

MA3445-KP04, MA3445 - Graph Theory (Graphen)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2020 (optional subject), mathematics, 5th or 6th semester
- Bachelor Medical Informatics 2019 (optional subject), mathematics, 4th to 6th semester
- Bachelor IT-Security 2016 (optional subject), mathematics, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), mathematics, 5th or 6th semester
- Bachelor Medical Informatics 2014 (optional subject), mathematics, 5th or 6th semester
- Master MES 2014 (optional subject), mathematics / natural sciences, 1st or 2nd semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 5th or 6th semester
- Master CLS 2010 (optional subject), mathematics, Arbitrary semester
- Master MES 2011 (optional subject), mathematics, 1st or 2nd semester
- Bachelor CLS 2010 (optional subject), mathematics, 5th or 6th semester
- Bachelor Computer Science 2012 (optional subject), mathematics, 5th or 6th semester

Classes and lectures:

- Graph theory (lecture, 2 SWS)
- Graph theory (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Hamiltonian graphs and degree sequences
- Menger's theorem - new proofs
- Matchings and decompositions of graphs
- The theorems of Turan and Ramsey
- Vertex and edge colourings
- The four colour theorem

Qualification-goals/Competencies:

- Ability to solve discrete problems using graph theoretical methods
- Knowledge of proof techniques and ideas of discrete mathematics
- Knowledge of fundamental and selected recent research results

Grading through:

- Oral examination

Requires:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)

Responsible for this module:

- PD Dr. rer. nat. Christian Bey

Teacher:

- Institute for Mathematics

- PD Dr. rer. nat. Christian Bey

Literature:

- F. Harary: Graph Theory - Reading, MA:.Addison-Wesley 1969
- R. Diestel: Graphentheorie - Berlin: Springer 2000
- D. Jungnickel: Graphen, Netzwerke und Algorithmen - Mannheim: BI-Wissenschaftsverlag1994
- J. Bang-Jensen, G. Gutin: Digraphs: Theory, Algorithms and Applications - London: Springer 2001
- B. Bollobas: Modern Graph Theory - Berlin: Springer 1998

Language:

- offered only in German

Notes:

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

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

Module Exam(s):
- MA3445-L1: Graph Theory, oral exam, 30 min, 100% of module grade.

MA4030 T - Module part: Optimization (OptiT)

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

Course of study, specific field and term:

- Master Biophysics 2023 (module part), advanced curriculum, 2nd semester
- Master MES 2020 (module part), mathematics / natural sciences, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 2nd semester
- Master MES 2014 (module part), mathematics / natural sciences, 2nd semester

Classes and lectures:

- Optimization (lecture, 4 SWS)
- Optimization (exercise, 2 SWS)

Workload:

- 130 Hours private studies and exercises
- 90 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Linear optimization (simplex method)
- Unconstrained nonlinear optimization (gradient descent, conjugate gradients, Newton method, Quasi-Newton methods, globalization)
- Equality- and inquality-constrained nonlinear optimization (Lagrange multipliers, active set methods)
- Stochastic methods for machine learning

Qualification-goals/Competencies:

- Students can model real-life problems as optimization problems.
- They understand central optimization techniques.
- They can explain central optimization techniques.
- They can compare and assess central optimization techniques.
- They can implement central optimization techniques.
- They can assess numerical results.
- They can select suitable optimization techniques for practical problems.
- Interdisciplinary qualifications:
- Students can transfer theoretical concepts into practical solutions.
- They are experienced in implementation.
- They can think abstractly about practical problems.

Grading through:

- exam type depends on main module

Is requisite for:

- Non-smooth Optimization and Analysis (MA5035-KP05)

Requires:

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

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Mathematics and Image Computing

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

Literature:

- J. Nocedal, S. Wright: Numerical Optimization - Springer
- F. Jarre: Optimierung - Springer
- C. Geiger: Theorie und Numerik restringierter Optimierungsaufgaben - Springer

Language:

- offered only in German

Notes:

(Sub-module of MA4310)

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.

MA4030-KP08, MA4030 - Optimization (Opti)

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

Course of study, specific field and term:

- Minor in Teaching Mathematics, Bachelor of Arts 2023 (compulsory), mathematics, 8th semester
- Bachelor CLS 2023 (compulsory), mathematics, 4th semester
- Master Auditory Technology 2022 (optional subject), mathematics, 2nd semester
- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Bachelor Computer Science 2019 (optional subject), Extended optional subjects, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester
- Minor in Teaching Mathematics, Bachelor of Arts 2017 (compulsory), mathematics, 8th semester
- Master Auditory Technology 2017 (optional subject), mathematics, 1st or 2nd semester
- Bachelor Computer Science 2016 (optional subject), advanced curriculum, Arbitrary semester
- Bachelor CLS 2016 (compulsory), mathematics, 4th semester
- Master MES 2014 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2011 (optional subject), mathematics, 2nd semester
- Master Computer Science 2012 (optional subject), advanced curriculum numerical image processing, 2nd or 3rd semester
- Bachelor MES 2011 (optional subject), medical engineering science, 6th semester
- Master Computer Science 2012 (optional subject), advanced curriculum analysis, 2nd or 3rd semester
- Bachelor CLS 2010 (compulsory), mathematics, 4th semester

Classes and lectures:

- Optimization (lecture, 4 SWS)
- Optimization (exercise, 2 SWS)

Workload:

- 130 Hours private studies and exercises
- 90 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Linear optimization (simplex method)
- Unconstrained nonlinear optimization (gradient descent, conjugate gradients, Newton method, Quasi-Newton methods, globalization)
- Equality- and inquality-constrained nonlinear optimization (Lagrange multipliers, active set methods)
- Stochastic methods for machine learning

Qualification-goals/Competencies:

- Students can model real-life problems as optimization problems.
- They understand central optimization techniques.
- They can explain central optimization techniques.
- They can compare and assess central optimization techniques.
- They can implement central optimization techniques.
- They can assess numerical results.
- They can select suitable optimization techniques for practical problems.
- Interdisciplinary qualifications:
- Students can transfer 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:

- Non-smooth Optimization and Analysis (MA5035-KP05)

Requires:

- Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
- Analysis 2 (MA2500-KP09)
- 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:

- J. Nocedal, S. Wright: Numerical Optimization - Springer
- F. Jarre: Optimierung - Springer
- C. Geiger: Theorie und Numerik restringierter Optimierungsaufgaben - Springer

Language:

- offered only in German

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:
- 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.

Examination:
- MA4030-L1: Optimization, written examination (90 min) or oral examination (30 min) as decided by examiner, 100 % of final mark

MA4300-KP12, MA4300 - Modellierung und Analyse zeitabhängiger biologischer Prozesse und Daten (MAPD)

Duration:	Turnus of offer:	Credit points:
2 Semester	starts every winter semester	12

Course of study, specific field and term:

- Master MES 2020 (advanced module), mathematics / natural sciences, Arbitrary semester
- Master Biophysics 2019 (advanced module), advanced curriculum, 1st and 2nd semester
- Master MES 2014 (advanced module), mathematics / natural sciences, 1st and 2nd semester
- Master Biophysics 2023 (advanced module), advanced curriculum, 1st or 2nd semester

Classes and lectures:

- MA4330 T: Module part: Biosignalanalyse (4ECTS) (course, 3 SWS)
- MA4450 T: Module part: Modellierung Biologischer Systeme (8 ECTS) (course, 4 SWS)

Workload:

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

Contents of teaching:

- see description of module parts

Qualification-goals/Competencies:

- see description of module parts

Grading through:

- Oral examination

Responsible for this module:

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

Teacher:

- Institute for Mathematics

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

Literature:

- see literature of module parts:

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- The module includes an oral examination with duration and scope according to PVO. Exercises are preliminary examinations.

MA4310-KP12, MA4310 - Numerical Optimization (NumOpt)

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

Course of study, specific field and term:

- Master MES 2020 (advanced module), mathematics / natural sciences, Arbitrary semester
- Master Biophysics 2019 (advanced module), advanced curriculum, 2nd semester
- Master MES 2014 (advanced module), mathematics / natural sciences, 2nd semester
- Master Biophysics 2023 (advanced module), advanced curriculum, 2nd semester

Classes and lectures:

- MA4030 T: Module part: Optimization (lecture, 4 SWS)
- MA5034 T: Module part: Calculus of Variations and Partial Differential Equations (4ECTS) (course, 3 SWS)
- MA5032 T: Module part: Numerical Methods for Image Computing (4ECTS) (course, 3 SWS)
- MA4030 T: Module part: Optimization (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- as stated in module parts

Qualification-goals/Competencies:

- as stated in module parts

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:

- as stated in module parts:

Language:

- German and English skills required

Notes:

The module MA4310: Numerical Optimization consists of the module MA4030: Optimization and annually alternating of the module MA5034: Calculus of Variations and Partial Differential Equations or the module MA5032: Numerical Methods for Image Computing.

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- The module includes an oral examination with duration and scope according to PVO. Exercises and presentation are preliminary examinations.

MA4330 T - Module part: Biosignal analysis (BioSAT)

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 MES 2020 (module part), mathematics / natural sciences, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 2nd semester
- Master MES 2014 (module part), mathematics / natural sciences, 2nd semester

Classes and lectures:

- Biosignal analysis (lecture, 2 SWS)
- Biosignal analysis (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Hilbert spaces
- Fourier series and Fourier transformation
- generalized functions
- discrete wavelet tranformation
- least square techniques
- application to biological and medical data

Qualification-goals/Competencies:

- Students have deepened knowledges of the mathematical background of signal analysis
- They master different methods of one-dimensional signal analysis
- They have practical skills in the application of these methods
- They have skills in working with Mathematica or MatLab

Grading through:

- exam type depends on main module

Requires:

- Analysis 2 (MA2500-KP04, MA2500)

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Mathematics

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

Literature:

- S. Mallat: A wavelet tour of signal processing - Academic Press, 1998
- A. N. Kolmogorov, S.V. Fomin: Reelle Funktionen und Funktionalanalysis - Deutscher Verlag der Wissenschaften 1975

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.

MA4330-KP04, MA4330 - Biosignal analysis (BioSA)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2014 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2011 (optional subject), mathematics, 2nd semester
- Master Computer Science 2012 (compulsory), advanced curriculum analysis, 2nd semester
- Master CLS 2010 (compulsory), mathematics, 2nd semester

Classes and lectures:

- Biosignal analysis (lecture, 2 SWS)
- Biosignal analysis (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Hilbert spaces
- Fourier series and Fourier transformation
- generalized functions
- discrete wavelet tranformation
- least square techniques
- application to biological and medical data

Qualification-goals/Competencies:

- Students have deepened knowledges of the mathematical background of signal analysis
- They master different methodsof one-dimensional signal analysis
- They have practical skills in the application of these methods
- They have skills in working with Mathematica or MatLab

Grading through:

- written exam
- Exercises

Requires:

- Analysis 2 (MA2500-KP04, MA2500)

Responsible for this module:

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

Teacher:

- Institute for Mathematics

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

Literature:

- S. Mallat: A wavelet tour of signal processing - Academic Press, 1998
- A. N. Kolmogorov, S.V. Fomin: Reelle Funktionen und Funktionalanalysis - Deutscher Verlag der Wissenschaften 1975

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.

MA4450 T - Module part: Modeling Biological Systems (MoBST)

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

Course of study, specific field and term:

- Master Biophysics 2023 (module part), advanced curriculum, 1st semester
- Master MES 2020 (module part), mathematics / natural sciences, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 1st semester
- Master MES 2014 (module part), mathematics / natural sciences, 1st semester

Classes and lectures:

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

Workload:

- 160 Hours private studies and exercises
- 60 Hours in-classroom work
- 20 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:

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

Responsible for this module:

- Siehe Hauptmodul

Teacher:

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

Literature:

- F. Braer, C. Castillo-Chavez: Mathematical Models in Population Biology - New York: Springer 2000
- H. Caswell: Matrix Population Models - 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:

The lecture is identical to that in module
MA4450.

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.

MA4450-KP08, MA4450-MML - Modeling Biological Systems (MoBS)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2014 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2011 (optional subject), mathematics, 1st or 3rd semester
- Bachelor CLS 2010 (compulsory), mathematics, 5th semester

Classes and lectures:

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

Workload:

- 130 Hours private studies and exercises
- 60 Hours in-classroom work
- 30 Hours work on project
- 20 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 and project assignments
- written exam

Requires:

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

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 - New York: Springer 2000
- H. Caswell: Matrix Population Models - 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:

The lecture is identical to that in module
MA4450.

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.

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.

MA4610-KP04, MA4610 - Stochastic processes and modeling (StochPrzMd)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2014 (optional subject), mathematics / natural sciences, 1st or 2nd semester
- Master Computer Science 2012 (optional subject), advanced curriculum stochastics, 2nd or 3rd semester
- Master CLS 2010 (compulsory), mathematics, 1st or 3rd semester

Classes and lectures:

- Stochastic processes and modeling (lecture, 2 SWS)
- Stochastic processes and modeling (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Conditional expectation
- Stochastic processes
- Filtrations
- Martingales
- Brownian motion

Qualification-goals/Competencies:

- Students can name stochastic processes on the basis of selected process classes and explain their properties.
- They have deepened the stochastic way of thinking and can explain the evidence of the lecture.
- They can explain and apply basic ideas and concepts of stochastic analysis.

Grading through:

- written exam

Requires:

- Stochastics 2 (MA4020-MML)
- Stochastics 1 (MA2510-KP04, MA2510)

Responsible for this module:

- Prof. Dr. rer. nat. Andreas Rößler

Teacher:

- Institute for Mathematics

- Prof. Dr. rer. nat. Andreas Rößler

Literature:

- :
- :
- Ioannis Karatzas, Steven E. Shreve: Brownian Motion and Stochastic Calculus - Springer Verlag, 2nd edition, 1991

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.

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 T - Module part: Numerical Methods for Image Computing (NumerikBVT)

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

Course of study, specific field and term:

- Master Biophysics 2023 (module part), advanced curriculum, 2nd semester
- Master MES 2020 (module part), mathematics / natural sciences, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 2nd semester
- Master MES 2014 (module part), mathematics / natural sciences, 2nd 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:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

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:

(Sub-module of MA4310)

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.

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 T - Module part: Calculus of Variations and Partial Differential Equations (VariPDET)

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

Course of study, specific field and term:

- Master Biophysics 2023 (module part), advanced curriculum, 2nd semester
- Master MES 2020 (module part), mathematics / natural sciences, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 2nd semester
- Master MES 2014 (module part), mathematics / natural sciences, 2nd 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:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

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:

(Sub-module of MA4310)

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.

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

ME4050-KP04, ME4050 - Fundamentals of Magnetic Methods in Medicine (GMMM)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2014 (optional subject), mathematics / natural sciences, Arbitrary semester

Classes and lectures:

- Fundamentals of Magnetic Methods in Medicine (lecture, 2 SWS)
- Fundamentals of Magnetic Methods in Medicine (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Basics of magnetism
- Dia- , para-, ferromagnetism including special forms like superparamagnetism
- Interaction between magnetic fields and magnetic solids
- Colloidal suspensions of magnetic nanoparticles
- Measurements of magnetic fields
- Detection of magnetic solids
- Manipulation of magnetic solid and ferrofluids with magnetic fields
- Behavior of magnetic nanoparticles in biological matrices
- Magnetic excitation of the peripheral nervous system and transcranial magnetic stimulation (TMS)
- Magnetometers in medical applications (z. B. magnetic relaxometry, magnetoencephalography)
- Imaging with magnetic fields (z. B. MRT, MPI, MRX)
- Therapeutics with magnetic nanoparticles

Qualification-goals/Competencies:

- Students know the basics of magnetisms
- They know which magnetic methods are used in medicine and on which basis those work
- They understand the different forms of magnetism
- They are able to model and solve physical problems involving magnetic fields and solids.
- They understand how magnetic solids and fields are detected

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Fundamentals of Electrical Engineering 2 (ME2700-KP08, ME2700)
- Fundamentals of Electrical Engineering 1 (ME2400-KP08, ME2400)
- Physics 2 (ME1020-KP08, ME1020)
- Physics 1 (ME1010-KP08, ME1010)

Responsible for this module:

- Prof. Dr. rer. nat. Thorsten Buzug

Teacher:

- Institute of Medical Engineering

- Dr. rer. nat. Alexander Neumann
- Prof. Dr. rer. nat. Thorsten Buzug

Literature:

- Chikazumi: Physics of Ferromagnetism - Oxford Science Publications
- Thanh: Magnetic Nanoparticles: From Fabrication to Clinical Applications - CRC Press
- Buzug & Borgert: Magnetic Particle Imaging - Springer
- Tumanski: Handbook of Magnetic Measurements - CRC Press

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.

ME4140-KP04, ME4140 - Mechanismen der Photobiologie und Photomedizin (MPP)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	each winter semester	4	10

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2014 (optional subject), mathematics / natural sciences, 1st or 2nd semester
- Master MES 2011 (advanced curriculum), biophysics and biomedical optics, 1st semester

Classes and lectures:

- Grundlagen und Anwendungen photothermischer Effekte (lecture, 2 SWS)
- Grundlagen und Anwendungen photothermischer Effekte (exercise, 1 SWS)

Workload:

- 70 Hours in-classroom work
- 50 Hours written report

Contents of teaching:

- Basic principles and applications of photothermic processes
- Lab experiments
- Practical Part (protocol required):- cell reactions after thermic stimulation of cells, vitality and wound healing proof, protein determination- Determination of the change in cellular metabolism based on oxidative stress with optical techniques

Qualification-goals/Competencies:

- Students are able to achieve basic knowledge about mechanisms of photochemically induced photobiological processes and their medical applications.
- They can perform basic lab experiments.
- They can associate applications with different biological problems.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Dr. med. Yoko Miura

Teacher:

- Institute of Biomedical Optics

- Dr. med. Yoko Miura

Literature:

- Editors: Welch, Ashley J., van Gemert, Martin JC: Optical-Thermal Response of Laser-Irradiated Tissue - Springer 2011, ISBN: 978-90-481-8831-4
- Editors: Asea, Alexzander A. A., Kaur, Punit: Heat Shock Proteins in Neuroscience (Heat Shock Proteins (20), Band 20) - Springer 2019, ISBN: 978-3-030-24285-5
- Gerd Poeggel: Kurzlehrbuch Biologie - Thieme 2013, ISBN: 9783131409836

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.

ME4190-KP04, ME4190 - Cell manipulation with optical methods (ZOM)			
Duration:	**Turnus of offer:**	**Credit points:**	**Max. group size:**
1 Semester	each winter semester	4	10

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2014 (optional subject), mathematics / natural sciences, 1st or 2nd semester
- Master MES 2011 (advanced curriculum), biophysics and biomedical optics, 1st semester

Classes and lectures:

- Cell manipulation with optical methods (lecture, 2 SWS)
- Cell manipulation with optical methods (exercise, 1 SWS)

Workload:

- 50 Hours private studies
- 45 Hours in-classroom work
- 25 Hours exam preparation

Contents of teaching:

- Principles of photothermal and photochemical induced effects on biological tissue.
- Laboratory experiments in cell elimination with laser irradiated gold nanoparticles.

Qualification-goals/Competencies:

- Students are able to explain the principle mechanisms of photothermal and photochemical induced biological processes.
- They are able to formulate different applications of optical nanotechnology in diagnostics and therapy.
- They are able to conduct laboratory experiments in the field of experimental phototherapy.

Grading through:

- continuous, successful participation in course

Responsible for this module:

- Dr. rer. nat. Ramtin Rahmanzadeh

Teacher:

- Institute of Biomedical Optics

- Dr. rer. nat. Ramtin Rahmanzadeh

Literature:

- Gstraunthaler G., Lindl T.: Zell- und Gewebekultur: Allgemeine Grundlagen und spezielle Anwendungen - Spektrum, 2013
- Schmitz S., Desel C.: Der Experimentator Zellbiologie - Springer, 2018
- Rai P., et al.: Development and Applications of Photo-triggered Theranostic Agents - Adv Drug Deliv Rev. 2010 Aug 30
- Nath S., et al.: Photoimmunotherapy of Ovarian Cancer: A Unique Niche in the Management of Advanced Disease - Cancers (Basel). 2019

Language:

- offered only in German

Notes:

This module is a block course.

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

ME4250 A - Module part: Instrumentation in Biophysics (InBp)

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

Course of study, specific field and term:

- Master MES 2020 (module part), mathematics / natural sciences, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), mathematics / natural sciences, Arbitrary semester

Classes and lectures:

- Instrumentation in Biophysics (lecture, 2 SWS)
- Instrumentation in Biophysics (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- UV-VIS spectroscopy
- Atomic force microscopy
- Fluorescence spectroscopy
- Film balance
- Patch clamp

Qualification-goals/Competencies:

- Students will be able to identify the appropriate instrumentation for a particular biophysics question
- The students are able to further develop the instruments of biophysics.
- The students are able to optimally use the instruments of biophysics.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Research Center Borstel, Leibniz Lung Center

- Prof. Dr. rer. nat. Thomas Gutsmann
- Dr. Christian Nehls

Literature:

- Lukas K. Buehler: Cell Membranes - Garland Science 2016, ISBN 978-0-8153-4196-3
- Yves Dufrene (Ed.): Life at the Nanoscale - Pan Stanford Publishing 2011, ISBN 978-981-4267-96-0

Language:

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

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.

ME4250-KP12, ME4250 - Biophysics (BioPhys)

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

Course of study, specific field and term:

- Master MES 2020 (advanced module), mathematics / natural sciences, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), technology field medical engineering science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), technology field medical engineering science, 2nd and 3rd semester
- Master MES 2014 (advanced module), mathematics / natural sciences, 1st and 2nd semester

Classes and lectures:

- See LS4020 C-MIW: Single molecule methods (course, 3 SWS)
- See LS4020 F-MIW: Protein-Biophysics (course, 3 SWS)
- See ME4260 T: Theoretical Biophysics (course, 3 SWS)
- See LS4130 A: Membrane Biophysics (course, 3 SWS)
- See ME4250 A: Instrumentation in Biophysics (course, 3 SWS)

Workload:

- 155 Hours private studies and exercises
- 145 Hours in-classroom work
- 60 Hours exam preparation

Contents of teaching:

- see description of the module parts

Qualification-goals/Competencies:

- see description of the module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Christian Hübner

Teacher:

- Institute of Physics

- Prof. Dr. rer. nat. Christian Hübner
- PD Dr. rer. nat. Hauke Paulsen

Literature:

- see literature of the module parts:

Language:

- offered only in German

Notes:

All module parts LS4020 C-MIW, LS4020 F-MIW, ME4260 T, LS4130 A, ME4250 A must be passed.

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.

ME4255-KP04 - Instrumentation in Biophysics (InstBph)

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

Course of study, specific field and term:

- Master MES 2020 (module part), mathematics / natural sciences, Arbitrary semester
- Master MES 2014 (module part), mathematics / natural sciences, Arbitrary semester

Classes and lectures:

- Instrumentation in Biophysics (lecture, 2 SWS)
- Instrumentation in Biophysics (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- UV-VIS spectroscopy
- Atomic force microscopy
- Fluorescence spectroscopy
- Film balance
- Patch clamp

Qualification-goals/Competencies:

- Students will be able to identify the appropriate instrumentation for a particular biophysics question
- The students are able to further develop the instruments of biophysics.
- The students are able to optimally use the instruments of biophysics.

Grading through:

- as announced by examiner

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Gutsmann

Teacher:

- Research Center Borstel, Leibniz Lung Center

- Prof. Dr. rer. nat. Thomas Gutsmann
- Dr. Christian Nehls

Literature:

- Lukas K. Buehler: Cell Membranes - Garland Science 2016, ISBN 978-0-8153-4196-3
- Yves Dufrene (Ed.): Life at the Nanoscale - Pan Stanford Publishing 2011, ISBN 978-981-4267-96-0

Language:

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

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.

ME4260 T - Module part: Theoretical Biophysics (TheoBiophy)

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

Course of study, specific field and term:

- Master MES 2020 (module part), mathematics / natural sciences, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), mathematics / natural sciences, Arbitrary semester

Classes and lectures:

- Theoretical Biophysics (lecture, 2 SWS)
- Theoretical Biophysics (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Basic concepts of quantum mechanics
- Intra- and intermolecular interactions
- Description of molecules by classical models
- Simulation of the dynamics of molecules by means of Newtonian mechanics
- Description of molecular dynamics with the help of thermodynamics

Qualification-goals/Competencies:

- Students can explain how the existence of atoms and molecules can be explained from the fundamental assumptions of quantum mechanics.
- They can explain, within what limits can be described by classical models the interactions between atoms.
- They can sketch an algorithm with which the dynamics of molecules can be simulated.
- They can list, which thermodynamic concepts are to describe the molecular dynamics.

Grading through:

- Oral examination

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Physics

- PD Dr. rer. nat. Hauke Paulsen

Literature:

- V. Schünemann: Biophysik - Berlin: Springer 2004
- M. Daune: Molekulare Biophysik - Braunschweig: Vieweg 1997

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.

ME4260-KP04 - Theoretical Biophysics (TheoBioph)

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

Classes and lectures:

- Theoretical Biophysics (lecture, 2 SWS)
- Theoretical Biophysics (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Basic concepts of quantum mechanics
- Intra- and intermolecular interactions
- Description of molecules by classical models
- Simulation of the dynamics of molecules by means of Newtonian mechanics
- Description of molecular dynamics with the help of thermodynamics

Qualification-goals/Competencies:

- Students can explain how the existence of atoms and molecules can be explained from the fundamental assumptions of quantum mechanics.
- They can explain, within what limits can be described by classical models the interactions between atoms.
- They can sketch an algorithm with which the dynamics of molecules can be simulated.
- They can list, which thermodynamic concepts are to describe the molecular dynamics.

Grading through:

- Oral examination

Responsible for this module:

- PD Dr. rer. nat. Hauke Paulsen

Teacher:

- Institute of Physics

- PD Dr. rer. nat. Hauke Paulsen

Literature:

- V. Schünemann: Biophysik - Berlin: Springer 2004
- M. Daune: Molekulare Biophysik - Braunschweig: Vieweg 1997

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.

ME4500-KP04, ME4500 - Advanced Methods in Control (FoMeReg)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), mathematics / natural sciences, Arbitrary semester
- Master MES 2014 (optional subject), mathematics / natural sciences, 1st semester

Classes and lectures:

- Advanced Methods in Control (lecture, 2 SWS)
- Advanced Methods in Control (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- State space models, canonical representations and properties
- Design of state feedback controllers and state observers
- Optimal control and state estimation
- Linear parameter-varying systems
- Model predictive control

Qualification-goals/Competencies:

- Students know how to describe and analyze state space models.
- Students know how to synthesize and design state feedback controllers.
- Students know how to design observers and observer-based controllers.
- Students know the basics about optimal control and how to utilize it.
- Students know the class of linear, parameter-varying systems and the basic principles of controller synthesis for this class of systems.
- Students understand the concept of model-predictive control and know how to implement such a control strategy.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine

- Prof. Dr. Philipp Rostalski

Literature:

- J. Lunze: Regelungstechnik 2 - Springer Verlag 2012, ISBN: 3642539432
- G.F. Franklin, J. Powell, A. Emami-Naeini: Feedback Control of Dynamic Systems - Global Edition Pearson 2014, ISBN: 1292068906

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):
- ME4500-L1: Advanced Methods in Control, oral exam, 100% of the module grade

CS3110-KP04, CS3110 - Computer-Aided Design of Digital Circuits (SchaltEntw)

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

Course of study, specific field and term:

- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester
- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Bachelor Computer Science 2016 (optional subject), major subject informatics, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2016 (optional subject), computer science, 5th or 6th semester
- Bachelor IT-Security 2016 (optional subject), computer science, Arbitrary semester
- Bachelor MES 2014 (optional subject), computer science / electrical engineering, 5th or 6th semester
- Bachelor Computer Science 2014 (optional subject), central topics of computer science, 5th or 6th semester
- Bachelor MES 2011 (optional subject), Applied computer science, 3rd, 5th, or 6th semester
- Bachelor CLS 2010 (optional subject), computer science, 5th or 6th semester
- Bachelor Computer Science 2012 (optional subject), central topics of computer science, 5th or 6th semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Requires:

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

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering

- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- F. Kesel, R. Bartholomä: Entwurf von digitalen Schaltungen und Systemen mit HDLs und FPGAs - Oldenbour Verlag 2009

- C.Maxfield: The Design Warrior's Guide to FPGAs - Newnes 2004

Language:

- offered only in German

Notes:

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

CS4138 T - Module part: Model Checking (ModelCha14)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

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

Literature:

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

Language:

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

Notes:

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

Prerequisites for attending the module:
- None

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

CS4138-KP06, CS4138SJ14 - Model Checking (ModelChe14)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master IT-Security 2019 (optional subject), IT Safety and Reliability, 1st, 2nd, or 3rd semester
- Master MES 2014 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Medical Informatics 2014 (optional subject), computer science, 1st or 2nd semester
- Master Computer Science 2014 (optional subject), specialization field IT security and safety, 1st or 2nd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages

- Prof. Dr. Martin Leucker

Literature:

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

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

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

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

Literature:

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

Language:

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

Notes:

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

Prerequisites for attending the module:
- None

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

CS4139-KP06, CS4139 - Runtime Verification and Testing (RVTesten)

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 Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master IT-Security 2019 (optional subject), IT Safety and Reliability, 1st, 2nd, or 3rd semester
- Master MES 2014 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Medical Informatics 2014 (optional subject), computer science, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2014 (optional subject), specialization field IT security and safety, 1st or 2nd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages

- Prof. Dr. Martin Leucker

Literature:

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

Language:

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

Notes:

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):
- CS4139-L1: Runtime Verification and Testing, oral exam, 100% of the 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), technology field computer science, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2019 (basic module), technical computer science, 1st or 2nd semester
- Master Medical Informatics 2019 (optional subject), technical computer science, 1st or 2nd semester
- Master IT-Security 2019 (basic module), technical computer science, 1st or 2nd semester
- Master MES 2014 (optional subject), computer science / electrical engineering, 1st semester
- Master Medical Informatics 2014 (basic module), computer science, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (basic module), technology field computer science, 1st or 2nd semester
- Master Computer Science 2014 (basic module), technical computer science, 1st or 2nd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- written exam

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering

- Prof. Dr.-Ing. Mladen Berekovic

Literature:

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

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

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

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

CS4220 T - Module part: Pattern Recognition (MEa)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exam type depends on main module

Responsible for this module:

- Prof. Dr.-Ing. Alfred Mertins

Teacher:

- Institute for Signal Processing

- Prof. Dr.-Ing. Alfred Mertins

Literature:

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

Language:

- offered only in German

Notes:

Admission requirements for the module:
- None

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

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

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

CS4250-KP04, CS4250 - Computer Vision (CompVision)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Erhardt Barth

Teacher:

- Institute for Neuro- and Bioinformatics

- Prof. Dr.-Ing. Erhardt Barth

Literature:

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

Language:

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

Notes:

Admission requirements for taking the module:
- None

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

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

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

CS4270-KP04, CS4270 - Medical Robotics (MedRob)

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 Biophysics 2019 (optional subject), Elective, 2nd semester
- Master MES 2014 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Biomedical Engineering (optional subject), Interdisciplinary modules, 2nd semester
- Master Computer Science 2012 (optional subject), advanced curriculum imaging systems, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), advanced curriculum signal and image processing, 2nd or 3rd semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 2nd semester
- Master Computer Science 2012 (compulsory), specialization field robotics and automation, 2nd semester
- Master Computer Science 2012 (optional subject), specialization field medical informatics, 2nd or 3rd semester

Classes and lectures:

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

Workload:

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

Contents of teaching:

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.

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
- : lecture notes (400 pages full text)

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):
- CS4270-L1: Medical Robotics, written exam, 90min, 100% of the module grade

CS4331 T - Module part: Image Analysis and Visualization in Diagnostics and Therapy (BAVIS_T)

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

Course of study, specific field and term:

- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 2nd semester

Classes and lectures:

- Image Analysis and Visualization Systems in Diagnostics and Therapy (lecture, 2 SWS)
- Image Analysis and Visualization Systems in Diagnostics and Therapy (exercise, 1 SWS)

Workload:

- 55 Hours private studies and exercises
- 45 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:
- Data driven segmentation of multispectral image data
- Random Decision Forests for the segmentation of medical image data
- Convolutional Neural Networks and Deep Learning in Medical Image Processing
- Live wire segmentation
- Segmentation with active contour models and deformable models
- Level set segmentation
- Statistical shape models
- Image registration
- Atlas-based segmentation and multi atlas segmentation using non-linear registration
- Visualization techniques in medicine
- Direct volume rendering
- Indirect volume rendering, ray tracing, ray casting
- Haptic 3D interactions in virtual bodies
- Virtual reality techniques in medical applications

Qualification-goals/Competencies:

- The students can classify advanced methods for medical image analysis and visualization, explain them, characterize them on the basis of their properties and select them problem-specifically for a concrete application.
- They are able to explain advanced methods of cluster analysis and classification, especially with Support Vector Machines and Random Decision Forests, and to characterize them based on their properties.
- 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 different non-linear image registration methods and to select and parameterize similarity measures and regularization terms for a specific registration problem.
- They are familiar with methods of multi-atlas segmentation and can explain and exemplarily apply the properties of different label fusion approaches.
- They can distinguish different medical visualization techniques, classify them according to their specific advantages and disadvantages and select and apply them depending on a concrete application problem.
- They can explain different haptic interaction techniques and can classify different systems for VR simulation in medicine.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Module part: Medical Image Computing (CS3310 T)

Responsible for this module:

- Siehe Hauptmodul

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 - 2nd edition. Pacific Grove: PWS Publishing 1998
- B. Preim, D. Bartz: Visualization in Medicine - Elsevier, 2007

Language:

- offered only in German

Notes:

This submodule is no longer offered and will be replaced by the new submodule "CS4332 T Model and AI based image processing in medicine".

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.

CS4332 T - Module part: Model and AI-based image processing in medicine (MoKiBi_T)

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

Course of study, specific field and term:

- Master MES 2014 (module part), computer science / electrical engineering, 2nd semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester

Classes and lectures:

- Model and AI-based image processing in medicine (lecture, 2 SWS)
- Model and AI-based image processing in medicine (exercise, 1 SWS)

Workload:

- 55 Hours private studies and exercises
- 45 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.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Medical Image Computing (CS3310-KP04)

Responsible for this module:

- Siehe Hauptmodul

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 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 submodule grade.

This module replaces the discontinued module parts CS4330 T and CS4331 T "Image Analysis and Visualisation in Diagnostics and Therapy".

CS4371 T - Module part: Advanced Methods in Medical Image Processsing (FVMBT)

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

Course of study, specific field and term:

- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st semester

Classes and lectures:

- Fortgeschrittene Verfahren der Med. Bildverarbeitung (lecture, 3 SWS)
- Fortgeschrittene Verfahren der Med. Bildverarbeitung (exercise, 2 SWS)
- Fortgeschrittene Verfahren der Med. Bildverarbeitung (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:

- Module part: Medical Image Computing (CS3310 T)

Responsible for this module:

- Siehe Hauptmodul

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 participation in 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 submodule replaces the submodule of the same name CS4370 T, 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.

CS4380-KP12, CS4380 - Medizinische Bildverarbeitung für MIW (VertMBV)

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

Course of study, specific field and term:

- Master MES 2020 (advanced module), computer science / electrical engineering, Arbitrary semester
- Master MES 2014 (advanced module), computer science / electrical engineering, 1st and 2nd semester

Classes and lectures:

- CS4332 T: Module part: Model and AI-based image processing in medicine (4ECTS) (course, 3 SWS)
- CS4371 T: Module part: Fortgeschrittene Verfahren der Medizinischen Bildverarbeitung (8ECTS) (course, 6 SWS)

Workload:

- 360 Hours (see module parts)

Contents of teaching:

-

Qualification-goals/Competencies:

-

Grading through:

- written exam

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

Literature:

- :

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):
- CS4332-L1 Model- and AI-based image processing in medicine, written exam, 90min, 33.4% of the module grade.
- CS4371-L1 Advanced Methods in Medical Image Processing, written exam, 90min, 66.6% of module grade

This module used to consist of the sub-modules of the same name CS4330T or CS4331T and CS4370T, which are no longer offered in this form.

(Consists of CS4332 T, CS4371 T)

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)

CS4405-KP04, CS4405 - Neuroinformatics (NeuroInf)

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

Course of study, specific field and term:

- Master CLS 2023 (compulsory), computer science, 2nd semester
- Master Auditory Technology 2022 (optional subject), Auditory Technology, 2nd semester
- Master Auditory Technology 2017 (optional subject), Auditory Technology, 2nd semester
- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master CLS 2016 (compulsory), computer science, 2nd semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Elective, 1st or 2nd semester
- Master MES 2014 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master MES 2011 (optional subject), mathematics, 2nd semester
- Bachelor MES 2011 (optional subject), optional subject medical engineering science, 6th semester
- Master Computer Science 2012 (optional subject), advanced curriculum organic computing, 2nd or 3rd semester
- Master MES 2011 (advanced curriculum), imaging systems, signal and image processing, 2nd semester
- Master Computer Science 2012 (optional subject), advanced curriculum intelligent embedded systems, 2nd or 3rd semester
- Master Computer Science 2012 (compulsory), specialization field robotics and automation, 2nd semester
- Master Computer Science 2012 (compulsory), specialization field bioinformatics, 2nd semester
- Master CLS 2010 (compulsory), computer science, 2nd 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
- Unsupervised 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:

- 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. rer. nat. Amir Madany Mamlouk

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:

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):
- CS4405-L1: Neuroinformatics, written exam, 90 min, 100% of module grade

According to the old version of the MES Bachelor Examination Regulations (until WS 2011/2012), an elective subject is scheduled for the 4th semester instead of the 6th semester.

CS4480-KP04 - System Identification (Sysiden)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master MES 2014 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, 1st or 2nd semester

Classes and lectures:

- System Identification (lecture, 2 SWS)
- System Identification (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Introductory topics:
- Discretization and Discrete-time (DT) models
- Least-square estimation
- Main topics:
- Parametric model identification: Prediction error method, Subspace identification
- Non-parametric model identification
- Data-driven models
- Model Validation

Qualification-goals/Competencies:

- The students can explain the general framework and basic properties of different identification methods including least-squares method, the prediction error method, the subspace method, standard non-parametric methods and the data-driven method.
- Students can formulate and implement algorithms for system identification.
- students are able to estimate mathematical models of a dynamical system from input-output data using the different methods presented in this course.
- They can evaluate the quality of the identified models.
- They can use Matlab System Identification Toolbox to identify linear dynamical models using different identification methods.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine

- Dr.-Ing. Hossameldin Abbas

Literature:

- Karel J. Keesman: System Identification: An Introduction - Springer-Verlag London Limited 2011
- Lennart Ljung and Torkel Glad: Modeling of Dynamic Systems - Prentice Hall 1994
- Lennart Ljung: System Identification - Theory for the User - Prentice Hall 1999

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

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

Module Exam(s):
- CS4480-L1: System Identification, Oral Examination, 100% of module grade

CS4507-KP12, CS4507 - Software Verification (SoftVeri)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

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

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages

- Prof. Dr. Martin Leucker

Literature:

- : see module parts

Language:

- German and English skills required

Notes:

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

2 of the 3 module parts must be chosen.

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- depending on the module parts

CS4510-KP12, CS4510 - Signal Analysis (SignalAna)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Markus Kallinger

Teacher:

- Institute for Signal Processing

- Prof. Dr.-Ing. Markus Kallinger

Literature:

- : See description of module parts

Language:

- German and English skills required

Notes:

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

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- CS4510-L3 (all exept Master Biophysics since 2023): Successful completion of the project assignment, seminar presentation and exercise assignments as specified at the beginning of the semester
- CS4510-L1 (only Master Biophysics since 2023): Successful completion of the exercise assignments as specified at the beginning of the semester
- CS4510-L2 (only Master Biophysics since 2023): Successful completion of the project assignment as specified at the beginning of the semester

Module Exam(s):
- CS4510-L3 (all exept Master Biophysics since 2023): Signal Analysis, oral exam, 100% of module grade
- CS4510-L1 (only Master Biophysics since 2023): partial exam Signal Analyse, oral exam, 100% of module grade
- CS4510-L2 (only Master Biophysics since 2023): partial exam Lab course Signal- and image processing, project, ungraded

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

CS4511-KP12, CS4511 - Learning Systems (LernSys)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- see module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Martinetz

Teacher:

- Institute for Neuro- and Bioinformatics

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

Literature:

- : see module parts

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

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

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

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

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

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), technology field computer science, 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. Thomas Eisenbarth

Teacher:

- Institute for IT Security

- Prof. Dr. 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

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

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

Course of study, specific field and term:

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

Classes and lectures:

- iRoom (practical course, 3 SWS)

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exam type depends on main module

Requires:

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

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Signal Processing

- Prof. Dr.-Ing. Markus Kallinger
- MitarbeiterInnen des Instituts

Language:

- offered only in German

Notes:

(Part of Module CS4510)

Prerequisites for attending the module:
- None

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

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

this project, 100% of module grade

CS5204-KP04, CS5204 - Artificial Intelligence 2 (KI2)

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

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 Biophysics 2019 (optional subject), Elective, 1st semester
- Master MES 2014 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Biomedical Engineering (optional subject), Interdisciplinary modules, 2nd semester
- Master CLS 2016 (optional subject), computer science, 3rd semester
- Master Computer Science 2012 (optional subject), advanced curriculum intelligent embedded systems, 2nd or 3rd semester
- Master Computer Science 2012 (optional subject), specialization field robotics and automation, 3rd semester

Classes and lectures:

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

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 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:

- 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.This leads to innovative applications for machine learning, designed and implemented by the students.The starting point are support vector machines.

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:

- P. Norvig, S. Russell: Künstliche Intelligenz - München: Pearson 2004

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

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

Module Exam(s):
- CS5204-L1: Artificial Intelligence 2, written exam, 90min, 100% of the module grade

CS5220 T - Module parte: Static Analysis (StatAnaa)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exam type depends on main module

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages

- Prof. Dr. Martin Leucker

Literature:

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

Language:

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

Notes:

(Part of Module CS4507-KP12)

Prerequisites for attending the module:
- None

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

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

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Signal Processing

- Prof. Dr.-Ing. 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:

- offered only in German

Notes:

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

For Details see main module.

Prerequisites for attending the module:
- None

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

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

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

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

Course of study, specific field and term:

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

Classes and lectures:

- Seminar Machine Learning (seminar, 2 SWS)

Workload:

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

Contents of teaching:

- Independent study of a specific field of machine learning

Qualification-goals/Competencies:

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

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Neuro- and Bioinformatics

- Prof. Dr.-Ing. Erhardt Barth
- MitarbeiterInnen des Instituts

Language:

- German and English skills required

Notes:

Admission requirements for the module:
- None

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

(Is part of the module CS4511)

CS5450 T - Module part: Machine Learning (MaschLerna)

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

Course of study, specific field and term:

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

Classes and lectures:

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

Workload:

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

Contents of teaching:

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

Qualification-goals/Competencies:

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

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Neuro- and Bioinformatics

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

Literature:

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

Language:

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

Notes:

Admission requirements for taking the module:
- None

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

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

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

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

ME2451-KP04, ME2451 - Control Systems (RegTech)

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

Course of study, specific field and term:

- Master CLS 2023 (optional subject), computer science, 2nd or 4th semester
- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master CLS 2016 (optional subject), computer science, 2nd or 4th semester
- Master MES 2014 (optional subject), computer science / electrical engineering, 2nd or 4th semester
- Master MES 2011 (optional subject), advanced curriculum, 2nd or 4th semester

Classes and lectures:

- Control Systems (lecture, 2 SWS)
- Control Systems (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Modeling of dynamic systems
- Dynamic behavior of systems
- Feedback concepts
- Controller design in time domain
- System representation in frequency domain
- Stability
- Controller design in frequency domain

Qualification-goals/Competencies:

- Students can model physical systems mathematically as well as describe and analyze their dynamic behavior.
- Students know the fundamental tools and can formulate requirements with respect to systems in the time and frequency domain. Students are able to design control loops using time and frequency domain-based tools.
- Students are able to analyze stability of feedback systems and can evaluate the resulting dynamic properties with respect to control performance and robustness.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine
- Prof. Dr. Philipp Rostalski

Literature:

- G.F. Franklin, J.D. Powell, A. Emami-Naeini: Feedback Control of Dynamic Systems - Pearson Verlag - 2014
- J. Lunze: Regelungstechnik 1 - Springer Verlag 2012
- J. Lunze: Regelungstechnik 2 - Springer Verlag 2012

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

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

Module exam(s):
- ME2451-L1: Control Systems, oral exam, 100% of module grade

ME2452-KP04, ME2452 - Mechatronics (Mech)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master MES 2014 (optional subject), computer science / electrical engineering, Arbitrary semester

Classes and lectures:

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

Workload:

- 50 Hours work on project
- 40 Hours in-classroom work
- 20 Hours exam preparation
- 10 Hours oral presentation and discussion (including preparation)

Contents of teaching:

- Design of mechatronic systems
- Systems engineering
- Basic mechanical engineering
- Basic electrical engineering
- Actuators/Sensors/Circuits
- Basic control engineering
- Practical project

Qualification-goals/Competencies:

- Students understand the basics principles on how mechatronic systems are designed.
- Students can understand and model basic electrical circuits with passive elements in AC and DC conditions.
- Students understand the basic principles of modelling mechanical systems, particularly kinematics and kinetics and know how to use them.
- Students know how to classify, select and use actuators and sensors.
- Students know the basics of PID control and know how to implement it.
- Students can execute and present a small mechatronic development project on their own.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine
- Prof. Dr. Philipp Rostalski

Literature:

- B. Heimann, W. Gerth, K. Popp: Mechatronik: Komponenten - Methoden - Beispiele - Carl Hanser Verlag 2006, ISBN: 3446405992

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):
- ME2452-L1: Mechatronics, oral exam, 100% of the module grade

ME2460-KP04, ME2460 - Electrical Machines (EM)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master MES 2014 (optional subject), computer science / electrical engineering, 1st or 2nd semester

Classes and lectures:

- Electrical Machines (lecture, 2 SWS)
- Electrical Machines (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Physical foundations
- DC motors
- Transformers
- Asynchronous machine
- Synchronous machine

Qualification-goals/Competencies:

- Students know the main technical terms for electrical machines and the mechanism of electromechanical energy transformation.
- Students can distinguish the main types of electrical machines and their specific advantages and disadvantages.
- Students know how to operate and analyze the main types of electrical machines.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Physics 2 (ME1020-KP08, ME1020)
- Fundamentals of Electrical Engineering 2 (ME2700-KP08, ME2700)
- Fundamentals of Electrical Engineering 1 (ME2400-KP08, ME2400)

Responsible for this module:

- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine

- Prof. Dr. Philipp Rostalski

Literature:

- F. Rolf: Elektrische Maschinen - ISBN: 3446226931

Language:

- offered only in German

Notes:

currently suspended

ME2470-KP04, ME2470 - Power Electronics (LE)		
Duration:	**Turnus of offer:**	**Credit points:**
1 Semester	irregularly	4

Course of study, specific field and term:

- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master MES 2014 (optional subject), computer science / electrical engineering, 1st or 2nd semester

Classes and lectures:

- Power Electronics (lecture, 2 SWS)
- Power Electronics (exercise, 1 SWS)

Workload:

- 65 Hours in-classroom work
- 35 Hours private studies
- 20 Hours exam preparation

Contents of teaching:

- Tasks of power electronics
- Elements of power electronics (power transistors, thyristor, triacs, diodes)
- DC-DC converter (topologies, operation)
- AC-DC converter
- Frequency converter (topologies, operation)

Qualification-goals/Competencies:

- Students know the main power electronics tasks, elements and basic circuits.
- Students can evaluate the different converter topologies and know their specific areas of operation.

Grading through:

- Written or oral exam as announced by the examiner

Requires:

- Fundamentals of Electrical Engineering 2 (ME2700-KP08, ME2700)
- Fundamentals of Electrical Engineering 1 (ME2400-KP08, ME2400)

Responsible for this module:

- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine
- Lübeck University of Applied Sciences

- Prof. Dr. Philipp Rostalski

Literature:

- D. Schröder: Leistungselektronische Bauelemente - ISBN: 3540287280
- M. Michel: Leistungselektronik: Einführung in Schaltungen und deren Verhalten - ISBN: 3642159834

Language:

- offered only in German

Notes:

currently suspended

ME4500 T - Module part: Advanced Methods in Control (FoMeRegT)

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

Course of study, specific field and term:

- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st or 2nd semester
- Master Computer Science 2014 (module part), specialization field robotics and automation, 2nd or 3rd semester

Classes and lectures:

- Advanced Methods in Control (lecture, 2 SWS)
- Advanced Methods in Control (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- State space models, canonical representations and properties
- Design of state feedback controllers and state observers
- Optimal control and state estimation
- Linear parameter-varying systems
- Model predictive control

Qualification-goals/Competencies:

- Students know how to describe and analyze state space models.
- Students know how to synthesize and design state feedback controllers.
- Students know how to design observers and observer-based controllers.
- Students know the basics about optimal control and how to utilize it.
- Students know the class of linear, parameter-varying systems and the basic principles of controller synthesis for this class of systems.
- Students understand the concept of model-predictive control and know how to implement such a control strategy.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Siehe Hauptmodul
- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine
- Prof. Dr. Philipp Rostalski

Literature:

- J. Lunze: Regelungstechnik 2 - Springer Verlag 2012, ISBN: 3642539432
- G.F. Franklin, J. Powell, A. Emami-Naeini: Feedback Control of Dynamic Systems - Global Edition Pearson 2014, ISBN: 1292068906

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.

RO4001-KP04 - Model Predictive Control (MPCKP04)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master MES 2014 (optional subject), computer science / electrical engineering, Arbitrary semester

Classes and lectures:

- Model Predictive Control (lecture, 2 SWS)
- Model Predictive Control (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- LQ optimal control and Kalman filter
- Convex optimization
- Invariant sets
- Theory of Model Predictive Control (MPC)
- Algorithms for numerical optimization
- Explicit MPC
- Practical aspects (Robust MPC, Offset-free tracking, etc.)
- MPC applications

Qualification-goals/Competencies:

- Students get a comprehensive introduction to methods of optimal control.
- Students get an overview of the fundamentals of numerical optimization.
- Students are able to design model predictive controllers for linear and nonlinear systems.
- Students get acquainted with several tools to implement model predictive controllers.
- Students are able to establish system theoretic properties of model predictive controllers.
- Students gain insight into possible applications areas for MPC.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Georg Schildbach

Teacher:

- Institute for Electrical Engineering in Medicine

- Prof. Dr. Georg Schildbach

Literature:

- F. Borrelli, A. Bemporad, M. Morari: Predictive Control for Linear and Hybrid Systems - Cambridge University Press, 2017 (ISBN: 978-1107016880)

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

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

Module Exam(s):
- RO4001-L1: Model Predictive Control, written exam, 90min, 100% of module grade.

Submodule for Master Robotics and Autonomous Systems of RO4000-KP12 Autonomous Systems

RO4400-KP08 - Control Systems (RegelSys)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Bachelor Robotics and Autonomous Systems 2020 (compulsory), Robotics and Autonomous Systems, 6th semester
- Bachelor Robotics and Autonomous Systems 2016 (compulsory), Robotics and Autonomous Systems, 6th semester

Classes and lectures:

- Control Systems (lecture, 2 SWS)
- Advanced Methods in Control (lecture, 2 SWS)
- Control Systems (exercise, 1 SWS)
- Advanced Methods in Control (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Modeling of dynamic systems
- Dynamic behavior of systems
- Feedback concepts
- Controller design in time domain
- System representation in frequency domain
- Stability
- Controller design in frequency domain
- State space models, canonical representations and properties
- Design of state feedback controllers and state observers
- Optimal control and state estimation
- Linear parameter-varying systems
- Model predictive control

Qualification-goals/Competencies:

- Students can model physical systems mathematically as well as describe and analyze their dynamic behavior.
- Students know the fundamental tools and can formulate requirements with respect to systems in the time and frequency domain. Students are able to design control loops using time and frequency domain-based tools.
- Students are able to analyze stability of feedback systems and can evaluate the resulting dynamic properties with respect to control performance and robustness.
- Students know how to describe and analyze state space models.
- Students know how to synthesize and design state feedback controllers.
- Students know how to design observers and observer-based controllers.
- Students know the basics about optimal control and how to utilize it.
- Students know the class of linear, parameter-varying systems and the basic principles of controller synthesis for this class of systems.
- Students understand the concept of model-predictive control and know how to implement such a control strategy.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine

- Prof. Dr. Philipp Rostalski
- Prof. Dr.-Ing. Christian Herzog

Literature:

- as described for the module parts:

Language:

- German and English skills required

Notes:

This module replaces ME2450-KP08

Admission requirements for taking the module:
- None

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

Module Exam(s):
- RO4400-L1: Control Systems, written exam, 90min, 100% of module grade.

RO4400-KP12 - Control Systems (RegelSys12)

Duration:	Turnus of offer:	Credit points:
1 Semester	every summer semester	12

Course of study, specific field and term:

- Master MES 2020 (advanced module), computer science / electrical engineering, Arbitrary semester
- Master MES 2014 (advanced module), computer science / electrical engineering, 2nd or 4th semester

Classes and lectures:

- Control Systems (lecture, 2 SWS)
- Advanced Methods in Control (lecture, 2 SWS)
- Control Systems (exercise, 1 SWS)
- Advanced Methods in Control (exercise, 1 SWS)
- Practical Course in Control Systems (practical course, 3 SWS)

Workload:

- 185 Hours private studies
- 135 Hours in-classroom work
- 40 Hours exam preparation

Contents of teaching:

- Modeling of dynamic systems
- Dynamic behavior of systems
- Feedback concepts
- Controller design in time domain
- System representation in frequency domain
- Stability
- Controller design in frequency domain
- State space models, canonical representations and properties
- Design of state feedback controllers and state observers
- Optimal control and state estimation
- Linear parameter-varying systems
- Model predictive control
- Planning and realization of typical control applications in a team

Qualification-goals/Competencies:

- Students can model physical systems mathematically as well as describe and analyze their dynamic behavior.
- Students know the fundamental tools and can formulate requirements with respect to systems in the time and frequency domain. Students are able to design control loops using time and frequency domain-based tools.
- Students are able to analyze stability of feedback systems and can evaluate the resulting dynamic properties with respect to control performance and robustness.
- Students know how to describe and analyze state space models.
- Students know how to synthesize and design state feedback controllers.
- Students know how to design observers and observer-based controllers.
- Students know the basics about optimal control and how to utilize it.
- Students know the class of linear, parameter-varying systems and the basic principles of controller synthesis for this class of systems.
- Students understand the concept of model-predictive control and know how to implement such a control strategy.
- Students will have comprehensive knowledge of using control algorithms in practice.
- They are able to realize control systems in teamwork and in a self-directed manner.
- They have the communication competency to document and present project results.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine

- Prof. Dr. Philipp Rostalski
- Prof. Dr.-Ing. Christian Herzog

Literature:

- as described for the module parts:

Language:

- German and English skills required

Notes:

Prerequisites for attending the module:
- None

RO5501-KP04 - Graphical Models in Systems and Control (GMSC)

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 CLS 2016 (optional subject), computer science, 3rd semester
- Master MES 2014 (optional subject), computer science / electrical engineering, 1st or 2nd semester

Classes and lectures:

- Graphical Models in Systems and Control (lecture, 2 SWS)
- Graphical Models in Systems and Control (exercise, 1 SWS)

Workload:

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

Contents of teaching:

- Introduction to Probability Theory, Discretely and Continuously Distributed Random Variables
- Fundamentals on Probabilistic Graphical Models
- Forney-Style Factor Graphs as a Probabilistic Graphical Model
- Message Passing via Sum- and Max-Produkt Algorithms
- Gaussian Message Passing
- State Estimation (Kalman Filtering and Smoothing including Nonlinear Extensions)
- Parameter Estimation via Expectation Maximization
- Expectation Propagation
- Control on Factor Graphs

Qualification-goals/Competencies:

- Students develop and extend their fundamental knowledge on probability theory and the transformation of discretely as well as continuously distributed random variables.
- Students can understand simple linear algorithms, such as the Kalman filter, with the help of graphical probabilistic models.
- Students can combine elements of probabilistic algorithms to novel ones with the help of graphical probabilistic models.
- Students can understand, extend and apply advanced algorithms in signal processing, parameter and state estimation as well as control to relevant problems with the help of graphical probabilistic models.

Grading through:

- written exam, oral exam and/or presentation as announced by the examiner

Responsible for this module:

- Prof. Dr. Philipp Rostalski

Teacher:

- Institute for Electrical Engineering in Medicine

- Prof. Dr.-Ing. Christian Herzog
- Prof. Dr. Philipp Rostalski

Literature:

- Loeliger, Hans-Andrea; Dauwels, Justin; Hu, Junli; Korl, Sascha; Ping, Li; Kschischang, Frank R.: The Factor Graph Approach to Model-Based Signal Processing - Proc. IEEE, Vol. 95, No. 6, 2007
- Loeliger, Hans-Andrea: An Introduction to factor graphs - IEEE Signal Process. Mag., Vol. 21, No. 1, 2004
- Hoffmann, Christian; Rostalski, Philipp: Current Publications from Research at the IME
- Miscellaneous: Current Publications from Research

Language:

- offered only in English

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- informations in first lecture

CS4295-KP04 - Deep Learning (DEEPL)

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

Course of study, specific field and term:

- Master MES 2020 (optional subject), Elective, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (optional subject), Elective, Arbitrary semester

Classes and lectures:

- CS4295-V: Deep Learning (lecture, 2 SWS)
- CS4295-Ü: Deep Learning (exercise, 2 SWS)

Workload:

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

Contents of teaching:

- Foundations and Deep Learning Basics (Learning Paradigms, Classification and Regression, Underfitting and Overfitting)
- Shallow Neural Networks (Basic Neuron Model, Multilayer Perceptions, Backpropagation, Computational Graphs, Universal Approximation Theorem, No-Free Lunch Theorems, Inductive Biases)
- Optimization (Stochastic Gradient Descent, Momentum Variants, Adaptive Optimizer)
- Convolutional Neural Networks (1D Convolution, 2D Convolution, 3D Convolution, ReLUs and Variants, Down and Up Sampling Techniques, Transposed Convolution)
- Regularization (Early Stopping, L1 and L2 Regularization, Label Smoothing, Dropout Strategies, Batch Normalization)
- Very Deep Networks (Highway Networks, Residual Blocks, ResNet Variants, DenseNets)
- Dimensionality Reduction (PCA, t-SNE, UMAP, Autoencoder)
- Generative Neural Networks (Variational Autoencoder, Generative Adversarial Networks, Diffusion Models)
- Graph Neural Networks (Graph Convolutional Networks, Graph Attention Networks)
- Fooling Deep Neural Networks (Adversarial Attacks, White Box and Black Box Attacks, One-Pixel Attacks)
- Physics-Aware Deep Learning (Physical Knowledge as Inductive Bias, PINN, PhyDNet, Neural ODE, FINN)

Qualification-goals/Competencies:

- Students get a fundamental understanding deep learning basics such as backpropagation, computational graphs, and auto-differentiation
- Students understand the implications of inductive biases
- Students get a comprehensive understanding of most relevant deep learning approaches
- Students learn to analyze the challenges in deep learning tasks and to identify well-suited approaches to solve them
- Students will understand the pros and cons of various deep learning models
- 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
- 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

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

Module Exam(s):
- CS4295-L1: Deep Learning, exam, 90 min

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 MES 2020 (optional subject), Elective, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (optional subject), Elective, 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

PS1030-KP04, PS1030 - English for Bachelor and Master students MLS (Engl)

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

Course of study, specific field and term:

- Bachelor Molecular Life Science 2024 (optional subject), interdisciplinary competence, Arbitrary semester
- Master MES 2020 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor MES 2020 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor MLS 2018 (optional subject), interdisciplinary competence, Arbitrary semester
- Bachelor MLS 2016 (optional suject), interdisciplinary competence, Arbitrary semester
- Bachelor Biophysics 2016 (optional subject), no specific field, 6th semester
- Master MES 2014 (optional subject), no specific field, 2nd semester
- Bachelor MES 2014 (optional subject), no specific field, 4th or 6th semester
- Master MLS 2009 (optional subject), interdisciplinary competence, Arbitrary semester
- Bachelor MES 2011 (optional subject), medical engineering science, Arbitrary semester
- Master CLS 2010 (optional subject), interdisciplinary competence, Arbitrary semester
- Bachelor MLS 2009 (optional subject), interdisciplinary competence, Arbitrary semester

Classes and lectures:

- English for Bachelor and Master students MLS (exercise, 4 SWS)

Workload:

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

Contents of teaching:

- Exercise:The content follows a curriculum, modified depending on the given skills and the thematic interests of the participants.
- Creating a CV in English

Qualification-goals/Competencies:

- Students acquire basic knowledge of the English language in word and writing.
- They improve their communication in English.
- They improve their skills in reading and writing English texts, including specialist literature.

Grading through:

- written exam

Responsible for this module:

- B. Sc. Sara Meitner

Teacher:

-
- B. Sc. Sara Meitner

Literature:

- : - Up-to-date publications and articles

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.

PS5430-KP04 - Ethical Design Considerations in Medical Technology (EthMedTech)

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

Course of study, specific field and term:

- Master Interdisciplinary Courses (optional subject), Interdisciplinary modules, Arbitrary semester
- Master MES 2020 (optional subject), interdisciplinary, Arbitrary semester
- Medicine clinical part (optional subject), Elective, Arbitrary semester
- Master MES 2014 (optional subject), no specific field, 2nd semester at the earliest

Classes and lectures:

- Ethical Design Considerations in Medical Technology (lecture, 2 SWS)
- Ethical Design Considerations in Medical Technology (project work, 1 SWS)

Workload:

- 75 Hours private studies
- 30 Hours in-classroom work
- 15 Hours work on project

Contents of teaching:

- Basic concepts and methods in ethics.
- Ethical decision models.
- Case studies and projects in ethical decision-making in medical technology.
- Innovation methods based on the adapted BIODESIGN principle.
- Innovation games, business-, value proposition- and ethics-canvas

Qualification-goals/Competencies:

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Grading through:

- portfolio exam
- participation in discussions
- certificate for exercises
- Presentation of oral talk/poster
- contributions to the discussion

Responsible for this module:

- Prof. Dr.-Ing. Christian Herzog

Teacher:

- Institute for Electrical Engineering in Medicine

- Prof. Dr.-Ing. Christian Herzog

Language:

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

Notes:

Prerequisites for attending the module:
- None

PY1200-KP04, PY1200-MIW - General Psychology 1 (APKP04)

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

Course of study, specific field and term:

- Bachelor MES 2014 (optional subject), no specific field, Arbitrary semester
- Master MES 2014 (optional subject), no specific field, 1st or 2nd semester
- Master MES 2020 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor MES 2020 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor Biophysics 2016 (optional subject), no specific field, 5th semester

Classes and lectures:

- General Psychology 1 (lecture, 2 SWS)

Workload:

- 90 Hours private studies and exercises
- 30 Hours in-classroom work

Contents of teaching:

- Acquisition of basic knowledge in the topics perception, action, cognition and language
- Teaching of basic ideas, concepts and theories of perception and cognitive psychology
- Learning basic principles of experimental psychology work for planning and conducting experiments
- Understanding and judgment of basic ideas, theories and methods of perception, cognition and language

Qualification-goals/Competencies:

- Students can explain and apply psychological concepts in the areas of perception, action, cognition and language.
- They can translate psychological research questions into empirical research.
- They can use their knowledge in basic psychological research to scientifically reason, think and discuss.
- They have acquired social competence through discussion skills and knowledge transfer.
- They have acquired self-competence in the areas of concentrated absorption of knowledge, critical reflection and dealing with scientific literature.
- They can structure newly acquired knowledge themself.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Ulrike Krämer

Teacher:

- Institute of Medical Psychology

- Prof. Dr. rer. nat. Ulrike Krämer
- Dr. rer. nat. Dipl.-Psych. Frederike Beyer

Literature:

- Goldstein: Wahrnehmungspsychologie - Spektrum, 2007
- Müsseler (Hrsg.): Allgemeine Psychologie - Spektrum, 2007
- Anderson: Kognitive Psychologie (7. Auflage) - Springer, 2013

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.

PY4210-KP05 - Engineering Psychology (IngPsy5)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	5

Course of study, specific field and term:

- Master MES 2020 (optional subject), interdisciplinary, Arbitrary semester
- Bachelor MES 2020 (optional subject), interdisciplinary, 3rd semester at the earliest
- Master Media Informatics 2020 (compulsory), psychology, 1st to 3th semester

Classes and lectures:

- Engineering Psychology (lecture, 2 SWS)
- Engineering Psychology (seminar, 1 SWS)

Workload:

- 105 Hours private studies and exercises
- 45 Hours in-classroom work

Contents of teaching:

- Fundamentals of Engineering Psychology
- human-machine systems
- Information Processing in Human-Technology Interaction
- Selective attention in interface interaction
- Situation awareness and mental models
- Situation assessment and action selection
- Manual control and election response tasks
- Errors
- Workload and stress
- Multitasking and Resource Management
- Automation (levels, automation trust)
- User diversity

Qualification-goals/Competencies:

- Students can receive, classify and use psychological engineering research contributions.
- The students can explain central theories and findings of engineering psychology with reference to relevant questions of human-technology interaction and interface conception.
- Students can derive design guidelines for man-machine systems from concepts and findings in engineering psychology.

Grading through:

- portfolio exam
- written exam

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Franke

Teacher:

- Institute for Multimedia and Interactive Systems

- Prof. Dr. rer. nat. Thomas Franke

Literature:

- Wickens, C., Hollands, J., Banbury, S., & Parasuraman, R. (2013): Engineering psychology and human performance. - Boston: Pearson
- Proctor, R., & van Zandt, T. (2018): Human Factors in Simple and Complex Systems - Boca Raton: CRC Press.

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None

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