Medical Engineering (Masters of Science)

Courses taught in English SS 18 + WS 18/19:

(Prospectively)

M1 Medical Specialisation (suitable for all branches of study)

M 1.4 Medical physics in radiation therapy, 10 ECTS, Christoph Bert, WS2017/2018,2Sem.

Content:

This module is one out of three options currently offered within M1. It gives the most detailed introduction to medical physics in radiation therapy. Based on an introductory lecture offered each year in the winter term, details will be taught in the summer in a lab and a lecture on a special topic (varies each year). Apart from basics also needed and taught in other disciplines such as dosimetry or the basics of imaging modalities, the focus is on the physics aspects of modern radiation therapy techniques. These include: Intensity modulated radiation therapy (IMRT), Image Guided Radiation Therapy (IGRT), brachytherapy, motion compensated radiation therapy, hyperthermia and proton/ion beam therapy. The lab course intensifies the content of the lecture by hands-on sessions. The second lecture will specify on one or two of the topics in details (e.g., organ motion or dosimetry).

M 1.9 Introduction to simulation, network and data analysis in Medical Systems Biology, 2.5ECTS, Julio Vera-Gonzalez, WS2017/2018

Content:

Systems Biology is a novel approach, in which quantitative biomedical data are investigated using advanced computational tools for data analysis, modeling and simulation. The ultimate aim is to elucidate the structure and regulation of biochemical networks, giving support in the construction of hypotheses and the design of experiments to biomedical researchers, but also in the interpretation of high throughput patient biomedical data. The targeted audience are master students, PhD students and young post-docs in the area of Medical Engineering, Bioinformatics, Computational Biology and Bioengineering.

Course Sections:

1. Introduction to the Systems Biology approach
2. Biological and biomedical highthroughput data processing and analysis
3. Biochemical network reconstruction and analysis
4. Mathematical modeling and simulation of biochemical systems

Educational objectives/skills:

Aims: In this course the basic concepts and tools for data analysis, network reconstruction and modeling used in systems biology will be introduced, discussed and practiced. These concepts will be illustrated with real case studies from biomedicine.

M 1.7 Medical Physics in Nuclear Medicine (MPNM) ,2.5ECTS, Philipp Ritt, und Mitarbeiter/innen, WS2017/2018

Content:

With this module, participating students should increase and consolidate their knowledge and understanding of medical physics in the field of Nuclear Medicine. For this, all necessary physical foundations and principles will be taught in order that the students are able to explain, interpret, and apply these (for example calculations for the interaction of photons and electrons with matter). With these foundations, the students compare different types of detectors for spatially-resolved photon detection, formulate the principles of imaging in nuclear medicine, and transfer this knowledge to 3-dimensional emission computed tomography. The students differentiate Positron Emission Tomography (PET) and

Single-Photon Emission Computed Tomography (SPECT) and understand the principle of 3-D image reconstruction from projection data. They acquire differentiating criteria and quality metrics for image data and use them for assessing reconstruction- and correction methods of PET and SPECT. The students use their acquired knowledge of emission tomography and other imaging modalities such as CT and MRI in order to explain the function principle of multimodal devices such as SPECT/CT, PET/CT, and PET/MRI and in order to evaluate their pros and cons. The students differentiate the relevant application fields of Nuclear Medicine imaging, which are therapeutic, diagnostic and preclinical research and interpret the according image data. Based on the acquired competences and with methods obtained from literature review, the students develop solutions for image based dosimetry in Nuclear Medicine therapies and calculate radiation organ doses for representative data. The students translate theory, principle, and rationale of quality assurance of imaging devices to practice and explain the underlying effects. With help of rules and standards, the students understand principles and core of radiation protection and apply these to the field of Nuclear Medicine.

Competences:

The students acquire professional and methodical competences in the following aspects:

They are able to:

- understand and apply the physical principles of nuclear medicine
- differentiate the multiple approaches of spatially resolved photon detection and apply them to 3-D emission tomography (PET, SPECT)
- explain and differentiate multiple reconstruction methods such as e.g. back-projection and iterative reconstruction
- distinguish the most important image-influencing effects (partial volume, attenuation, scattering) and outline according correction methods
- characterize multimodal imaging devices (e.g. SPECT/CT, PET/CT), name and assess their pros and cons

- describe and differentiate the most important clinical and pre-clinical applications of emission tomography
- deduce and apply methods for image based dosimetry in Nuclear Medicine therapies
- name appropriate quality control procedures of imaging devices and characterize/differentiate the underlying effects
- report the legal and methodical principles of radiation protection and apply them to the field of Nuclear Medicine

M 1.5 Medical physics in radiation therapy lab only (MSPL), 7.5ECTS, Christoph Bert, WS2017/2018, (course is 2 semesters long)

Content:

This module is one out of three options currently offered within M1. It covers the introductory lecture in the winter term and the lab in the summer term, but not the lecture on a special topic. Apart from basics also needed and taught in other disciplines such as dosimetry or the basics of imaging modalities, the focus is on the physics aspects of modern radiation therapy techniques. These include: Intensity modulated radiation therapy (IMRT), Image Guided Radiation Therapy (IGRT), brachytherapy, motion compensated radiation therapy, hyperthermia and proton/ion beam therapy. The lab course intensifies the content of the lecture by hands-on sessions.

M 1.2 Applications of nanotechnology in cardiovascular diseases, 2.5ECTS, Iwona Cicha, Christoph Alexiou, WS2017/2018

Content:

The special focus of the seminar is on:

- nanoparticulate contrast agents for the detection of vulnerable atherosclerotic plaques using stateof- the-art techniques;
- drug-delivery nanosystems for cardiac and cerebral ischemia and thrombosis;
- nano-biomaterials and nanofibre composites for vascular and cardiac tissue regeneration;
- novel nanoparticle-eluting and bio-degradable stents.

The clinical utility of these novel approaches is critically discussed.

Competences:

At this seminar, students learn about the basic pathomechanisms of cardiovascular diseases and the possible applications of nanotechnologies for diagnosis and therapy of different cardiovascular disorders. After attending the course, the students should be able to identify the key challenges in cardiovascular field and critically review novel technologies.

M 1.6 Medical physics in radiation therapy special topic only (MSPS), 5ECTS, Christoph Bert, WS2017/2018, (course is 2 semesters long)

Content:
This module is one out of three options currently offered within M1. Based on an introductory lecture offered each year in the winter term, more details will be taught on a special topic in a second lecture in the summer term. Apart from basics also needed and taught in other disciplines such as dosimetry or the basics of imaging modalities, the focus is on the physics aspects of modern radiation therapy techniques. These include: Intensity modulated radiation therapy (IMRT), Image Guided Radiation Therapy (IGRT), brachytherapy, motion compensated radiation therapy, hyperthermia and proton/ion beam therapy. The second lecture will specify on one or two of the topics in details (e.g., organ motion or dosimetry).

M 1.10 Medical communications (MedCom) , 2.5ECTS, Miyuki Tauchi-Brück, WS2017/2018

Content:
Advancement in medicine is a huge collaborative work involving physicians, patients, medical professionals, engineers, scientists, and authorities to name a few. To promote and ease the development, there are rules and regulations to follow that enable interdisciplinary groups work together. Skills and knowledge for the entire structure in medical development belong to “medical communications". This lecture is to introduce “medical communications" to undergraduate and graduate students with medicine-related majors. The contents include physicians-patients and researchers-authorities communication in relation to pre-clinical and clinical studies. The focus of the lecture is on clinical studies. Published articles in medical journals, regulatory documents, and/ or websites from different organizations will be used as study materials and active participation of students is expected.
1. Clinical studies
1a. Phase 0-IV clinical studies for a new drug Study designs/ terminologies Objective of studies in each phase Different study designs for different objectives Subjects Ethical issues in clinical studies
Key statistics often used in clinical studies
1b. Clinical study for medical devices Classification of medical devices
2. Communications
2a. Formality Guidelines from International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use (ICH) Regulations in studies with animal subjects (preclinical studies) European legislation Regulations in studies with human subjects (clinical studies) Arzneimittelgesetz (AMG)Sechster Abschnitt: Schutz des Menschen bei der klinischen Prüfung Declaration of Helsinki Good Clinical Practice Requirement for drug approval Requirement for CE marking of medical device.
2b. Publication Journals: Manuscript writing/ reading Guidelines: CONSORT, STROBE, CARE, ARRIVE, etc Terminologies: MedDRA Conferences: Oral/ poster presentation
2c. Patients and publication ethics Patients’ information/ informed consent Who are patients? What patients want to know: Information source for patients

Competences:

The aim is to let the students:

- Understand the structures and designs of clinical studies, including drugs and medical devices;

- Be aware of ethical issues in clinical studies;
- Find problems and solutions in patient-physician communications;
- Practice soft skills used in medical communications, including “skimming and scanning" journal articles in unfamiliar fields, summarizing, writing, and presenting data.

M4 Medical Engineering Core Skills suitable for all branches of study

Seminar Medical Engineering and Medical Ethics

Advanced Seminar on Medical Electronics and Systems for Ambient Assisted Living AAL(SEM MELAAL), 2.5 ECTS, Jasmin Kolpak, WS 2017/2018

Content:
During the seminar current issues in the field of "Modern concepts in medical electronics" will be discussed. After a joint briefing the students will independently work on the chosen topic under the guidance of a supervisor. The results are summarized in a four-page seminar thesis. The main task of the seminar is a 30-minute presentation of each student. A discussion with the listeners concludes the seminar. Attendance during the whole workshop day is mandatory for passing the seminar.

Topics:
- Electronics for medical diagnostics and therapy
- Electronics based human assistance systems
- Electronic systems for AAL Ambient Assisted Living
- Electronical Systems incorporating Microsystem Components (MEMS)
- BAN body area networks
- Coupling of medical electronic systems to Patient health record data bases
- Near body Energy Harvesting and Scavenging
- Circuit design for microwave based blood analysis
- MEMS Lab-on-chip
- Vital parameter supervision

Competences:
- Students will acquire basic knowledge in research, topics preparation and presentation techniques.
- Students will focus on technical issues for a given topic in the field of medical electronics.
- Students will independently deepen a technical issue on a concrete example.
- Students will learn the ability to familiarize themselves with unknown problems and to present the results.
- Students will achieve the ability to formulate questions as a active listener and to discuss technical issues.

Seminar Medical Ethics (Medtech Ethik), 5 ECTS, Jens Ried, WS 2017/2018

Content:

- Seminar Medizinethik/Seminar Medical Ethics:

The course introduces essential elements of ethical reasoning within the field of biomedicine and

medical technology to the students. Basic concepts and models of ethics in general and medical ethics in particular will be studied in historical and systematic perspectives with a focus on Aristotle, Kant and Utilitarianism. Interrelations of different philosophical traditions with religious aspects as well as intercultural dimensions of global ethics will be considered. By reference to paradigmatic cases, current issues of medical ethics including the moral status of the human embryo and stem cell research, brain death and organ transplantation, euthanasia / assisted suicide, neuro-enhancement and animal research will be discussed.

- Seminar Medical Engineering: Special topic in the field of medical engineering

Competences:

- Seminar Medical Ethics: Students can analyze ethical questions in a medical context and give argument for their own position.
- Seminar Medical Engineering: Students are able to work on their own on a topic of the seminar which is related to medical engineering. They can present their topic in an oral presentation and a written report.

Introduction to Medical Engineering & Economics
Economics and innovation

M 4.1 Innovation Technology - Master & Diplom (Inn Tec), 5 ECTS, Kathrin M. Möslein, Alle Assistenten, WS 2017/2018

Content:

The class covers social and technological aspects of innovation technologies. As a future core technology, the semantic web will serve as a basis for linking different types of technologies across the boundaries of socio-technical systems. The lecture will thus explore social, organizational theory and technical concepts around a semantic web as an innovation technology. Social and organizational theory will amongst others contain:

- Systems theory, semiotics and communication theory,
- Basics of open innovation, open research, interactive value creation and open evaluation,
- Legal and societal aspects,
- Aspects regarding organizational knowledge creation (e.g. sensemaking, practicing, frames of reference)
- The technological aspect of the class will deal with:
- Theory, Infrastructure and underlying technologies of the world wide web from web 1.0 to web 3.0
- Web scripting and markup languages and associated design theory (e.g.: PHP, JavaScript, XHTML, XML, OWL, RDF, RDFa, CSS)
- Thematic problems within publishing, filtering & selection and quality control

Competences:

The students: can differentiate between and evaluate the main information and communication theories. can differentiate between and assess the most important develop-ments on the Web. develop a research design for a literature overview or a design-ori-ented project. International Information Systems (IIS) Master of Science

M 4.1 International Projekt Management (IntPM), 5 ECTS, Jens-Ole Kueck, Jan Weyand, WS2017/2018

<u>Content:</u>
1. Culture
Definition of culture: Cultural Theory, Culturism vs. Universalism, Emic vs. etic cultural Theory
Intercultural Studies: Study of Hofstede; Study of Hall; Study of Trompenaars; Studies of Thomas; Globe Study
Validity of Cultural Studies: Stereotyping; Cultural bias; Levels of culture; Impact of culture; Cultural standards in different regions and countries; Germany; Latin America; China; USA
2. Application of Cultural Standards to Project Scenarios, Stakeholder management and project environment; Organization Structure; Virtual Organizations; Scope definition; Resource planning; Risk Management; Quality management; Controlling; Teambuilding; Conflict resolution; Communication,Leadership

M 4.1 Product Management (PROJ 5-ECTS), 5 ECTS, Dirk Riehle, WS 2017/2018

<u>Content:</u>
This course teaches students the concepts, methods, and tools of software product management. Product management is an important function in software development organizations. A product manager conceives and defines new products. His or her task is to understand the market incl. customers, to develop a product vision from that understanding, to translate it into product requirements, define those requirements on a by-feature basis and work with engineering to ensure these features are properly realized in the product under development.

- Role, tasks, and responsibilities of a product manager
- Process, methods, techniques and tools of product management
- Managing incremental/sustaining as well as disruptive innovation
- Open source product management; new trends in product management

Students can choose one or both of two components:

- VUE (lecture + homework), 2 SWS, 5 ECTS. VUE uses teaching cases as commonly used in MBA programs. The teaching cases are available for free at http://pmbycase.com.
- PROJ (small project), 2 SWS, 5 ECTS. In PROJ, students perform a small product management project, either individually or in teams. The available projects will be presented at the beginning of the course. Students will assess the market opportunity, develop a product specification, and make a final presentation about the project results.

PROD projects are run as shared projects, in which all participants contribute and get to participate in the project results. Read more at https://wp.me/pDU66-2p4.
Class is run as two 90min blocks. The first block discusses the teaching cases. The second block is a coaching session for the projects (10 ECTS only).

The overall schedule can be found at http://goo.gl/tTAI0 . Please sign up for the course on StudOn (link accessible through schedule spreadsheet) as soon as possible.

Competences:

- Understand the role, function, and responsibilities of a product manager
- Understand key concepts, methods, and tools of software product management
- Understand different business situations, incl. Incremental vs. disruptive innovation

M 4.1 Product Management (VUE 5-ECTS), 5 ECTS, Dirk Riehle, WS 2017/2018

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Competences:

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M 4.1 Management of change processes in a global world (VHB), 2.5 ECTS, N.N., WS 2017/2018

Content:

Change processes are a core element of the professional life in companies today. The challenges coming with change, are well known. Already in 1532, Niccolò Machiavelli described in his book "The prince" the difficulties to implement changes. A variety of projects in companies still fail at these challenges today, for lots of different reasons. In globally operating companies intercultural aspects increase the difficulties. A number of prominent examples shows this: the attempt of the merger between Daimler and Chrysler, or BMW and Rover. Especially the cultural component is often neglected in an organizational change - too often the goals are purely data-driven. Yet many studies have shown, that the corporate culture is just as important for a successful change as the strategy and the structure of a company. This course offers an overview of this important topic: What is change management? Why is change so difficult? And what are the key success factors? These aspects are discussed with a specific focus on changes in international environments. Globalization offers both opportunities and challenges, which are considered in more detail. A prerequisite for participating in this course is a very god command of the English language. The course - all lectures, as well as all tasks and the exam – will be completely in English. In order to receive the ECTS for this course, participants need to hand in a group task every week (group size 4-6 students), as well as pass the exam at the end of the semester.

Chapter 1: The case for change

- Why change is necessary for a company in a global word
- What are the key triggers for change in a global world?
- Why is change inevitable if you want to continue to grow?
- What are typical scenarios to initiate change?

Chapter 2: The nature of change in an international setting

- How do people react to change - the psychological dimension
- forms of resistance and ways to overcome them

Chapter 3: Change Management or Change Leadership in a global context?

- Is Change Management an oxymoron?
- Who drives change?
- What is the key responsibility of leaders?

Chapter 4: Communication as the key tool to manage change effectively

- Why is communication crucial to the success of a change process?
- What are effective communication tools?

Chapter 5: Managing the (inter-)cultural aspect of a change process

- What is culture and how does it influence change projects?
- What is the role of culture in (international) mergers?

Chapter 6: Change Management - Summary and review

- Implement your learnings in a real change project
- preparation for the exam

Competences:

The learning goals for this course are listed here. You will:

- receive a comprehensive overview on the current status of change management in theory and in practice
- get to know the most important theoretical models and learn about their relevancy in corporate practice

- understand the biggest challenges in change projects, and the way people react to change
- learn about ways how to deal with these reactions
- understand the role of leaders in change

M 4.1 Leadership and communication in a global world (VHB), 2.5 ECTS, N.N., WS 2017/2018

Content:

In a more and more global business environment with increasing complexity and speed of change, companies face new challenges nearly every day. These companies are steered by leaders, which is why their role and responsibilities become increasingly demanding as well. To be able to deal with these challenges successfully, leaders need sufficient qualifications and a solid knowledge base. This course gives an introduction and an overview of the principles of people management in an intercultural context. The various aspects of leadership are considered in direct reference to an intercultural context. The challenges for leaders to lead employees with different cultural backgrounds and to create a motivating working environment form the base for understanding the relevant tasks and tools of
leadership. In addition, the model of ethic-oriented leadership is introduced as a core concept for sustainable success. A prerequisite for participating in this course is a very god command of the English language. The course - all lectures, as well as all tasks and the exam - will be completely in English. In order to receive the ECTS for this course, participants need to hand in a group task every week (group size 4-6 students), as well as pass the exam at the end of the semester.

Chapter 1: Leadership and Communication in a global world - an Introduction

- What is leadership and why is it important?
- What are the most important leadership theories and models?

Chapter 2: Introduction to communication and intercultural differences

- What are the basic principles of communication?
- Which role does communication have for leaders?
- What is culture? And does it really matter?
- What are the cultural dimensions explaining the differences?
- How can leaders consider different cultures in their work?

Chapter 3: Leadership and communication in an intercultural setting? basic principles

- What do different cultures expect from a good leader?
- Are there leadership similarities or differences across cultures?
- What is the magnitude of cultural effects on leadership?
- Which consequences do those similarities and differences have for leaders?

Chapter 4: Leadership tasks and tools from an intercultural perspective

- What are the most important leadership tasks (e.g. goal-setting, performance appraisal, giving feedback, developing employees)?
- How can leaders fulfill these tasks successfully in practice?
- What are relevant intercultural differences in accomplishing the tasks and using the tools?

Chapter 5: Ethical Leadership

- What is ethical leadership and why is it relevant?
- How can leaders lead in an ethic-oriented way?

Competences:
The learning goals for this course are listed here. You will:

- receive a comprehensive overview on leadership in theory and in practice
- get to know the most important tasks and tools of a leader
- understand the importance of communication for leaders
- learn about the principles of communication
- understand cultural differences and the influence of culture on leadership
- gain an understanding of ethic-oriented leadership

M7 Flexible Budget

Engineering Mathematics (EngMathE), 5 ECTS, Serge Kräutle, SS 2017

Content:
Function Theory: Elementary functions of complex variables, holomorphic functions, Cauchy integral theorem, theory of residues. Vector Calculus: Potential functions, volume-, surface- and line-integrals, parameterization, transformation theorem, theorems for integrals, differential operators

Learning objectives and qualifications:
The students

- analyze elementary complex functions
- review and evaluate properties of these functions
- apply the integral theorem of Cauchy
- apply the theory of residues
- calculate integrals over multidimensional spaces
- observe relationships between volume, surface and curve integrals
- Calculate volume, surface and line integrals
- apply basic differential operators
- derive statements by basic proof techniques in above-mentioned areas
- note the advantages of a regular follow-up and deepen the learning material

Advanced Programming Techniques (AdvPT), 7.5 ECTS, Harald Köstler, WS 2017/2018

Content:
The content of the lecture will consist of various topics of advanced C++ programming, aimed at teaching the proper and efficient usage of C++ for professional software development. These are basic language concepts, the C++11/C++14/C++17 standards, object oriented programming in C++, static and dynamic polymorphism, template metaprogramming, and C++ idioms and design patterns.

Branch of study "Medical Image and Data Processing”

M2 Engineering Core Modules (IDP)

M 2.27 Dependable Embedded Systems, 5 ECTS, Hananeh Aliee, SS 2017

Content:

Introduction

Shrinking structure devices enabled the design and manufacturing of smaller and smaller, yet more and more powerful and at the same time affordable embedded systems. Given their use in both safety critical environments but also in the entertainment domain, we expect these systems to be dependable to avoid fatal accidents as well as disappointed customers, respectively. With these device structures,novel problems arise: There exist severe manufacturing tolerances and the structures themselves show an increasing susceptibility for aging and radiation effects. In fact, future embedded systems cannot be design based on the assumption of properly working components anymore - we need to design dependable embedded systems from unreliable components.

Course Purpose

In this course, the students will (a) be introduced to typical faults and their causes that occur in embedded systems at the lowest levels of abstraction, (b) learn about countermeasures that can be applied at different levels, and (c) apply countermeasures and analyze their costs and effects to be able to design high-quality, i.e., dependable and cost-efficient, embedded systems.

Content

Embedded systems typically consist of a combination of processors, hardware accelerators, and communication infrastructure. This course will at first introduce faults and their causes (e.g. radiation effects or aging effects like NBTI) that occur in the system components and then discuss how faults propagate in the system all the way up to the applications. Afterwards, focus is put on countermeasures that can be applied to enhance the system’s dependability. Here, different levels of abstraction like the circuit, register transfer, microarchitecture, and the system level and respective techniques that typically apply redundancy in either space or time to increase the reliability are covered. As will be shown, these techniques do not come for free, but their cost and effect needs to be considered. Thus, the lecture will introduce dependability analysis techniques (e.g. BDD- and success tree-based analysis) that enable to quantify the cost and benefits of applied techniques. Finally, the lecture will put emphasis on the aspect of design automation. Here, techniques for the automatic and efficient integration of dependability-enhancing techniques (e.g. based on meta-heuristics like Evolutionary Algorithms) across different levels of abstraction are introduced.

M 2.10 Pattern Recognition, 5 ECTS, Elmar Nöth, Sebastian Käppler, WS 2017/2018

Suggested requirements

- Well grounded in probability calculus, linear algebra/matrix calculus
- The attendance of our bachelor course ’Introduction to Pattern Recognition’ is not required but certainly helpful.

Content:

- Mathematical foundations of machine learning based on the following classification methods:
- Bayesian classifier
- Logistic Regression
- Naive Bayes classifier

- Discriminant Analysis
- norms and norm dependent linear regression
- Rosenblatt's Perceptron
- unconstraint and constraint optimization
- Support Vector Machines (SVM)
- kernel methods
- Expectation Maximization (EM) Algorithm and Gaussian Mixture Models (GMMs)
- Independent Component Analysis (ICA)
- Model Assessment
- AdaBoost

Competences:

Students

- understand the structure of machine learning systems for simple patterns
- explain the mathematical foundations of selected machine learning techniques
- apply classification techniques in order to solve given classification tasks
- evaluate various classifiers with respect to their suitability to solve the given problem
- understand solutions of classification problems and implementations of classifiers written in the programming language Python

M 2.18 Reconfigurable Computing with Extended Exercises, 7.5 ECTS, Jürgen Teich, Daniel Ziener, WS 2017/2018

Content:

Reconfigurable (adaptive) computing is a novel yet important research field investigating the capability of hardware to adapt to changing computational requirements such as emerging standards, late design changes, and even to changing processing requirements arising at run-time. Reconfigurable computing thus benefits from a) the programmability of software similar to the Von Neumann computer and b) the speed and efficiency of parallel hardware execution. The purpose of the course reconfigurable computing is to instruct students about the possibilities and rapidly growing interest in adaptive hardware and corresponding design techniques by providing them the necessary knowledge for understanding and designing reconfigurable hardware systems and studying applications benefiting from dynamic hardware reconfiguration.

After a general introduction about benefits and application ranges of reconfigurable (adaptive) computing in contrast to general-purpose and application-specific computing, the following topics will be covered:

- Reconfigurable computing systems: Introduction of available technology including fine grained look up table (LUT-) based reconfigurable systems such as field programmable gate arrays (FPGA) as well as newest coarse grained architectures and technology.
- Design and implementation: Algorithms and steps (design entry, functional simulation, logic synthesis, technology mapping, place and route, bit stream generation) to implement (map) algorithms to FPGAs. The main focus lies on logic synthesis algorithms for FPGAs, in particular LUT technology mapping.
- Temporal partitioning: techniques to reconfigure systems over time. Covered are the problems of mapping large circuits which do not fit one single device. Several temporal partitioning techniques are studied and compared.

- Temporal placement: Techniques and algorithms to exploit the possibility of partial and dynamic (run-time) hardware reconfiguration. Here, OS-like services are needed that optimize the allocation and scheduling of modules at run-time.
- On-line communication: Modules dynamically placed at run-time on a given device need to communicate as well as transport data off-chip. State-of-the-art techniques are introduced how modules can communicate data at run-time including bus-oriented as well as network-on-a-chip (NoC) approaches.
- Designing reconfigurable applications on Xilinx Virtex FPGAs: In this part, the generation of partial bitstreams for components to be placed at run-time on Xilinx FPGAs is introduced and discussed including newest available tool flows.
- Applications: This section presents applications benefiting from dynamic hardware reconfiguration.
- It covers the use of reconfigurable systems including rapid prototyping, reconfigurable supercomputers, reconfigurable massively parallel computers and studies important application domains such as distributed arithmetic, signal processing, network packet processing, control design, and cryptography.

Competences:

- The students know to exploit run-time reconfigurable design methodologies for adaptive applications.
- The students understand the mapping steps, and optimization algorithms.
- The students classify different types and kinds of reconfigurable hardware technologies available today.
- The students clarify pros and cons of reconfigurable computing technology.
- The students summarize applications benefiting from reconfigurable computing.
- The students apply design tools for implementation of circuits and systems-on-a-chip (SoC) on
- FPGAs during practical training.
- The students perform group work in small teams during practical training.

M 2.24 Applied Visualization, 5 ECTS, Roberto Grosso, SS 2017

Content:

Visualization includes all aspects related to the visual preparation of usually large data sets from technical or scientific experiments and simulation. For a better understanding and a meaningful representation of complex phenomena, methods from interactive computer graphics are applied. This lecture introduces basic algorithms and data structures and gives an overview of available software tools and common data formats.

The lecture covers the following topics:

- scenarios for visualization
- meshes and data representation
- methods for 2D scalar and vector fields
- methods for 3D scalar and vector fields
- methods for multivariate data
- volume rendering with iso-surfaces
- direct volume rendering

M2. Transformations in Signal Processing, 2.5 ECTS, Jürgen Seiler, SS 2018

Content:

The lecture "Transforms in Signal Processing" covers several different transforms which are used in the field of signal processing. For this, first the basic concepts of transforms are discussed and the advantages which are offered by the different transforms are presented. Subsequent to this, fundamental properties of integral transforms are considered and the Laplace- and the Fourier-Transform are examined in detail. To be able to transform time-varying signals, the Short-Time Fourier-Transform and the Gabor-Transform are introduced, afterwards. Subsequent to this, the impact of sampling on transformed signals is analyzed before the z-Transform as a transform for discrete signals is covered. Finally, further transforms for discrete signals like the Discrete Fourier-Transform or Linear-Block Transforms are discussed.

Competences:

Educational Objectives and Competences: After attending the lecture, students will be able to

- determine applications of transforms
- contrast and examine integral transforms
- question the existence of transforms
- evaluate the uniqueness of transforms
- develop theorems and properties of transforms
- evaluate to transforms corresponding inverse transforms
- evaluate the relationships between different transforms
- asses the relationship between original signal and transformed signals
- devise the symmetry properties of transforms
- devise the relationship between continuous and discrete signals

M 2.33 Heterogene Rechnerarchitekturen Online, 5 ECTS, Marc Reichenbach, Thomas Heller, Johannes Hofmann, WS 2017/2018

Content:

Whereas heterogeneous architectures and parallel computing has filled an academic niche in the past it has become now a commodity technique with the rising of multi-core processors and programmable graphic cards. Even FPGAs play a role hereby in a certain extent due to their increasing importance as accelerator hardware what is clearly observable in the scientific community. However, on one side parallel hardware like multi-core and GPUs are now available nearly for everybody and not only for a selected selection of people, who have access to a parallel supercomputer. On the other side the knowledge about programming of this commodity hardware, and we mean here in particular hardwareorientated programming in order to squeeze out all offered GFlops and TFlops of such hardware, is still missing as well as the knowledge about the architecture details. To overcome this lack we offer this course HETRON. The e-learning course HETRON for the exploitation of parallel and heterogeneous computer architectures) focuses on two main topics which are closely related to each other. This concerns on one side the benefits of using different kinds of multi-core processors and parallel architectures built-up on base of these multicore processors. These architectures differ among each other in the number and in the complexity of its single processing nodes. We distinguish between systems consisting of a large number of simpler, so called fine-grained, processor cores vs. systems consisting of a smaller number of more complex, so called coarse-grained, processor cores. On the other side we lay our focus on that we want to do with these different heterogeneous parallel architectures, namely the execution of parallel programs. Of course this requires the use of parallel programming languages and environments, like CUDA or OpenMP. However, besides these questions of using the right syntax and the right compiler switches to optimize a parallel program it is a pre-requisite to understand how parallel computing really works. This refers (i) to the comprehension which basic mechanisms of parallel computing exist, (ii) where are the limits of getting more performance with parallel computing and (iii) in what context stand these mechanisms to heterogeneous architectures. In other words it handles the question which architecture is the best one for a certain parallelization technique. To teach these three topics, is one main goal we pursuit with the course HETRON, and of course, this more fundamental basics of heterogeneous and parallel computing have to be proven by means of concrete application examples to deepen the acquired knowledge about heterogeneous architectures and parallel computing principles.

M 2.18 Reconfigurable Computing, 5 ECTS, Jürgen Teich, Daniel Ziener, WS 2017/2018

<u>Content:</u>
Reconfigurable (adaptive) computing is a novel yet important research field investigating the capability of hardware to adapt to changing computational requirements such as emerging standards, late design changes, and even to changing processing requirements arising at run-time. Reconfigurable computing thus benefits from a) the programmability of software similar to the Von Neumann computer and b) the speed and efficiency of parallel hardware execution.
The purpose of the course reconfigurable computing is to instruct students about the possibilities and rapidly growing interest in adaptive hardware and corresponding design techniques by providing them the necessary knowledge for understanding and designing reconfigurable hardware systems and studying applications benefiting from dynamic hardware reconfiguration.
After a general introduction about benefits and application ranges of reconfigurable (adaptive) computing in contrast to general-purpose and application-specific computing, the following topics will be covered:
Reconfigurable computing systems: Introduction of available technology including fine grained look up table (LUT-) based reconfigurable systems such as field programmable gate arrays (FPGA) as well as newest coarse grained architectures and technology.
Design and implementation: Algorithms and steps (design entry, functional simulation, logic synthesis, technology mapping, place and route, bit stream generation) to implement (map) algorithms to FPGAs. The main focus lies on logic synthesis algorithms for FPGAs, in particular LUT technology mapping.
Temporal partitioning: techniques to reconfigure systems over time. Covered are the problems of mapping large circuits which do not fit one single device. Several temporal partitioning techniques are studied and compared.
Temporal placement: Techniques and algorithms to exploit the possibility of partial and dynamic (run-time) hardware reconfiguration. Here, OS-like services are needed that optimize the allocation and scheduling of modules at run-time.
On-line communication: Modules dynamically placed at run-time on a given device need to communicate as well as transport data off-chip. State-of-the-art techniques are introduced how

modules can communicate data at run-time including bus-oriented as well as network-on-a-chip (NoC) approaches.
Designing reconfigurable applications on Xilinx Virtex FPGAs: In this part, the generation of partial bitstreams for components to be placed at run-time on Xilinx FPGAs is introduced and discussed including newest available tool flows.
Applications: This section presents applications benefiting from dynamic hardware reconfiguration. It covers the use of reconfigurable systems including rapid prototyping, reconfigurable supercomputers, reconfigurable massively parallel computers and studies important application domains such as distributed arithmetic, signal processing, network packet processing, control design, and cryptography.

Competences:
Knowledge
- The students know to exploit run-time reconfigurable design methodologies for adaptive applications.

Understanding
- The students understand the mapping steps, and optimization algorithms.
- The students classify different types and kinds of reconfigurable hardware technologies available today.
- The students clarify pros and cons of reconfigurable computing technology.
- The students summarize applications benefiting from reconfigurable computing.
- The students describe the design of circuits and systems-on-a-chip (SoC) on FPGAs.

Functional Analysis for Engineers, 5 ECTS, Christoph Pflaum, WS 2017/2018

Content:
- vector spaces, norms, principal axis theorem
- Banach spaces, Hilbert spaces
- Sobolev spaces
- theory of elliptic differential equations
- Fourier transformation
- distributions

Competences:
Students learn advanced methods in linear algebra and basic concepts of functional analysis. Furthermore, students learn applications in solving partial differential equations. The course teaches abstract mathematical structures.

M 2.20 Information Theory and Coding, 5 ECTS, Ralf Müller, WS 2017/2018

Content:
1. Introduction: binomial distribution, (7,4)-Hamming code, parity-check matrix, generator matrix
2. Probability, entropy, and inference: entropy, conditional probability, Bayes' law, likelihood, Jensen's inequality
3. Inference: inverse probability, statistical inference
4. The source coding theorem: information content, typical sequences, Chebychev inequality, law of large numbers

5. Symbol codes: unique decidability, expected codeword length, prefix-free codes, Kraft inequality, Huffman coding
6. Stream codes: arithmetic coding, Lempel-Ziv coding, Burrows-Wheeler transform
7. Dependent random variables: mutual information, data processing lemma
8. Communication over a noisy channel: discrete memory-less channel, channel coding theorem, channel capacity
9. The noisy-channel coding theorem: jointly-typical sequences, proof of the channel coding theorem, proof of converse, symmetric channels
10. Error-correcting codes and real channels: AWGN channel, multivariate Gaussian pdf, capacity of AWGN channel
11. Binary codes: minimum distance, perfect codes, why perfect codes are bad, why distance isn't everything
12. Message passing: distributed counting, path counting, low-cost path, min-sum (=Viterbi) algorithm
13. Exact marginalization in graphs: factor graphs, sum-product algorithm
14. Low-density parity-check codes: density evolution, check node degree, regular vs. irregular codes,girth
15. Lossy source coding: transform coding and JPEG compression

Competences:

- The students apply Bayesian inference to problems in both communications and everyday's life.
- The students explain the concept of digital communications by means of source compression and forward-error correction coding.
- For the design of communication systems, they use the concepts of entropy and channel capacity.
- They calculate these quantities for memoryless sources and channels.
- The students proof both the source coding and the channel coding theorem.
- The students compare various methods of source coding with respect to compression rate and complexity.
- The students apply source compression methods to measure mutual information.
- The students factorize multivariate functions, represent them by graphs, and marginalize them with respect to various variables.
- The students explain the design of error-correcting codes and the role of minimum distance.
- They decode error-correcting codes by means of maximum-likelihood decoding and message passing.
- The students apply distributed algorithms to problems in both communications and everyday's life.
- The students improve the properties of low-density parity-check codes by widening the girth and/or irregularity in the degree distribution.
- The students transform source images into the frequency domain to improve lossy compression.

M 2.8 Computer Graphics -VU, 5 ECTS, Marc Stamminger, WS 2017/2018

Content:
This lecture covers the following aspects of Computer Graphics:

- graphics pipeline
- clipping
- 3D transformations
- hierarchical display structures
- perspective transformations and projections
- visibility determination
- raster graphics and scan conversion
- color models
- local and global illumination models
- shading models
- ray tracing and radiosity
- shadows and textures

Educational objectives and skills:
Students should be able to

- describe the processing steps in the graphics pipeline
- explain clipping algorithms for lines and polygons
- explain, characterize and compute affine and perspective transformations in 2D and 3D, and provide an intuitive description of the general form of corresponding transformation matrices in homogeneous coordinates
- depict techniques to compute depth, occlusion and visibility
- compare the different color models
- describe data structures to represent 3D virtual models and complex scenes
- explain the algorithms for rasterization and scan conversion
- solve problems with shading and texturing of 3D virtual models
- classify different shadowing techniques
- explain the difference between local and global illumination techniques and formulate algorithms for ray tracing and radiosity

M 2.36 Deep Learning, 5 ECTS, Andreas Maier, Tobias Würfl, Vincent Christ Christlein, Lennart Husvogt, WS 2017/2018

Content:
Deep Learning (DL) has attracted much interest in a wide range of applications such as image recognition, speech recognition and artificial intelligence, both from academia and industry. This lecture introduces the core elements of neural networks and deep learning, it comprises:

- (multilayer) perceptron, backpropagation, fully connected neural networks
- loss functions and optimization strategies
- convolutional neural networks (CNNs)
- activation functions
- regularization strategies
- common practices for training and evaluating neural networks
- visualization of networks and results
- common architectures, such as LeNet, Alexnet, VGG, GoogleNet
- recurrent neural networks (RNN, TBPTT, LSTM, GRU)
- deep reinforcement learning

- unsupervised learning (autoencoder, RBM, DBM, VAE)
- generative adversarial networks (GANs)
- weakly supervised learning
- applications of deep learning (segmentation, object detection, speech recognition, ...)

The accompanying exercises will provide a deeper understanding of the workings and architecture of neural networks.

Competences:
The students

- explain the different neural network components,
- compare and analyze methods for optimization and regularization of neural networks,
- compare and analyze different CNN architectures,
- explain deep learning techniques for unsupervised / semi-supervised and weakly supervised learning,
- explain deep reinforcement learning,
- explain different deep learning applications,
- implement the presented methods in Python,
- autonomously design deep learning techniques and prototypically implement them,
- effectively investigate raw data, intermediate results and results of Deep Learning techniques on a computer,
- autonomously supplement the mathematical foundations of the presented methods by self-guided study of the literature,
- discuss the social impact of applications of deep learning applications.

➢ M 2.6 Digital Communications, 5 ECTS, Robert Schober, Arman Ahmadzadeh, WS 2017/2018

M 2.21 Channel Coding, 5 ECTS, Clemens Stierstorfer, WS 2017/2018

Content:
1 Introduction and Motivation 1.1 Definition,Related Fields 1.2 Basic Principles 1.2.1 Schemes 1.2.2 How to Add Redundancy 1.2.3 Applications 1.3 Historical Notes
2 Fundamentals of Block Coding 2.1 General Assumptions 2.2 Transmission Channels 2.2.1 Discrete-Time AWGN Channel 2.2.2 Binary Symmetric Channel(BSC) 2.2.3 Channels with Memory 2.3 Motivation for Coding 2.4 Fundamentals of Block Coding 2.4.1 Code and Encoding 2.4.2 Decoding
3 Introduction to Finite Fields I 3.1 Group 3.1.1 Orders of Elements and Cycles 3.1.2 Subgroups, Cosets 3.2 Field 3.3 Vector Spaces
4 Linear Block Codes 4.1 Generator Matrix 4.2 Distance Properties 4.3 Elementary Operations 4.4 Parity-Check Matrix 4.5 Dual Codes 4.6 Syndrome Decoding 4.7 Error Probability and Coding Gain 4.7.1 Error Detection 4.7.2 Error Correction - BMD 4.7.3 Error Correction - ML Decoding 4.7.4 Coding Gain 4.7.5 Asymptotic Results 4.8 Modifications of Codes 4.9 Bounds on the Minimum Distance 4.10 Examples for Linear Block Codes 4.10.1 Binary Hamming Codes (q=2) 4.10.2 Simplex Codes 4.10.3 Ternary Golay Code 4.10.4 Reed-Muller Codes
5 Linear Cyclic Codes 5.1 Modular Arithmetic 5.2 Generator Polynomial 5.3 Parity-Check Polynomial 5.4 Dual Codes 5.5 Discrete Systems over Fq 5.6 Encoders for Cyclic Codes 5.6.1 Generator Matrix 5.6.2 Non-Systematic Encoding 5.6.3 Systematic Encoding 5.6.4 Systematic Encoding Using h(x) 5.7 Syndrome Decoding 5.7.1 Syndrome 5.7.2 Decoding Strategies 5.8

Examples for Linear Cyclic Block Codes 5.8.1 Repetition Code and Single Parity-Check Code 5.8.2 Binary Hamming Codes 5.8.3 Simplex
Codes 5.8.4 Golay Codes 5.8.5 CRC Codes
6 Introduction to Finite Fields II 6.1 Extension Fields 6.2 Polynomials over Finite Fields 6.3 Primitive Element 6.4 Existence of Finite Fields 6.5 Finite Fields Arithmetic 6.6 Minimal Polynomials, Conjugate Elements, and Cyclotomic Cosets 6.7 Summary of Important Properties of Finite Fields 6.8 (Discrete) Fourier Transform over Finite Fields
7 BCH and RS Codes 7.1 The BCH Bound 7.2 Reed-Solomon Codes 7.3 BCH Codes 7.4 Algebraic Decoding of BCH Codes and RS Codes 7.4.1 Basic Idea 7.4.2 The Berlekamp-Massey Algorithm 7.5 Application: Channel Coding for CD and DVD 7.5.1 Error Correction for the CD 7.5.2 Error Correction for the DVD
8 Convolutional Codes 8.1 Discrete Systems over F 8.2 Trellis Coding 8.3 Encoders for Convolutional Codes 8.4 (Optimal) Decoding of Convolutional Codes 8.4.1 Maximum-Likelihood Sequence Estimation (MLSE) 8.4.2 Maximum A-Posteriori Symbol-by-Symbol Estimation
9 Codes with Iterative Decoding 9.1 State of the Art 9.2 Preliminaries 9.2.1 Check Equations 9.2.2 Repetition Code, Parallel Channels 9.2.3 Log-Likelihood Ratios(LLR) 9.3 Turbo Codes 9.4 LDPC Codes

Competences:
Students define the problems of channel coding, how to distinguish it from other coding methods (such as source coding) and how to describe the various different approaches to error correction and detection. They are able to list example application areas of channel coding and give an overview of the historical development of the field. Furthermore, they describe and analyze transmission scenarios for the application of channel coding which consist of transmitter, transmission channel and receiver, taking into account the general assumptions for applying block codes or modeling the channels. They formulate mathematical descriptions of encoding, optimal decoding and sub-optimal methods.
Students illustrate the principles of error-correcting linear block codes and describe them mathematically using vectors and matrices over finite fields. They implement and analyze corresponding encoder and decoder structures, in particular syndrome decoders, and modify generator matrices, construct test matrices and create syndrome tables. They estimate the minimum Hamming distance of codes using (asymptotic) bounds and are able to explain the coding gain that can be achieved in individual cases. They analyze and use example code families (e.g. Hamming codes, simplex codes, Reed-Muller codes).
Students explain the advantages of cyclic linear block codes and how to describe them with polynomials over finite fields. They apply polynomial modular arithmetic to implement systematic encoders and realize syndrome decoders using shift register circuits. They know and use exemplary code families.
Students use prime fields, extension fields, minimal polynomials and cyclotomic cosets, and spectral representation over finite fields to implement BCH and Reed-Solomon codes using the BCH bound. They understand the foundations of decoding BCH and Reed-Solomon codes, in particular the Berlekamp-Massey algorithm, and how to sketch and explain the channel coding concepts of CDs and DVDs.
Students are able to describe the differences between convolutional codes and block codes, to sketch the respective encoders based on tabulated generator polynomials and to explain them. They are able to explain how optimal decoders (MLSE) work using examples and compare them with symbol-by-symbol decoding (MAPPSE).

Students sketch the foundations of iterative decoding. In particular, they apply methods of information combining to combine different observations. They use and calculate log-likelihood ratios in iterative decoding processes, sketch the basic encoding and decoding structures of turbo codes and the basics of coding using LDPC codes (including decoding using belief propagation).
Students are able to use the English technical terms correctly or know them and are able to express themselves using the respective technical terms in German.

M 2.9 Digital Signal Processing (DSV), 5 ECTS, Walter Kellermann, Michael Bürger, WS 2017/2018

Content:
The course assumes familiarity with basic theory of discrete-time deterministic signals and linear systems and extends this by a discussion of the properties of idealized and causal, realizable systems (e.g., lowpass, Hilbert transformer) and corresponding representations in the time domain, frequency domain, and z-domain. Thereupon, design methods for recursive and nonrecursive digital filters are discussed. Recursive systems with prescribed frequency-domain properties are obtained by using design methods for Butterworth filters, Chebyshev filters, and elliptic filters borrowed from analog filter design. Impulse-invariant transform and the Prony-method are representatives of the considered designs with prescribed time-domain behaviour.For nonrecursive systems, we consider the Fourier approximation in
its original and its modified form introducing a broad selection of windowing functions. Moreover, the equiripple approximation is introduced based on the Remez-exchange algorithm. Another section is dedicated to the Discrete Fourier Transform (DFT) and the algorithms for its fast realizations ('Fast Fourier Transform'). As related transforms we introduce cosine and sine transforms. This is followed by a section on nonparametric spectrum estimation. Multirate systems and their efficient realization as polyphase structures form the basis for describing analysis/synthesis filter banks and discussing their applications.
The last section is dedicated to investigating effects of finite wordlength as they are unavoidable in any realization of digital signal processing systems.
A corresponding lab course on DSP will be offered in the winter term.

M 2.10 Pattern Recognition Deluxe, 7.5 ECTS, Elmar Nöth, Sebastian Käppler, WS 2017/2018

Suggested requirements:
- Well grounded in probability calculus, linear algebra/matrix calculus
- A pattern recognition system consists of the following steps: sensor data acquisition, pre-processing, feature extraction, and classification. Our bachelor course 'Introduction to Pattern Recognition' focuses on the first three steps; this course on the final step of the pipeline, i.e. classification/machine learning. Knowledge about feature extraction is not required for studying the mathematical foundations of machine learning, but it is certainly helpful to get a better understanding of the whole picture.

Content:
- Mathematical foundations of machine learning based on the following classification methods:
- Bayesian classifier

- Logistic Regression
- Naive Bayes classifier
- Discriminant Analysis
- norms and norm dependent linear regression
- Rosenblatt’s Perceptron
- unconstraint and constraint optimization
- Support Vector Machines (SVM)
- kernel methods
- Expectation Maximization (EM) Algorithm and Gaussian Mixture Models (GMMs)
- Independent Component Analysis (ICA)
- Model Assessment
- AdaBoost

Competences:
Students
- understand the structure of machine learning systems for simple patterns
- explain the mathematical foundations of selected machine learning techniques
- apply classification techniques in order to solve given classification tasks
- evaluate various classifiers with respect to their suitability to solve the given problem
- solve classification problems on their own and write their own implementations of classifiers in the programming language Python

M 2.12 Statistical Signal Processing (STASIP), 5 ECTS, Walter Kellermann, Alexander Schmidt, WS 2017/2018

Content:
The course concentrates on fundamental methods of statistical signal processing and their applications.
The main topics are:
Discrete-time stochastic processes in the time and frequency domain Random variables (RVs), probability distributions and densities, expectations of random variables, transformation of RVs, vectors of normally distributed RVs, time-discrete random processes: probability distribution and densities, expectation, stationarity, cyclostationarity, ergodicity, correlation functions and correlation matrices, spectral representations, principal component analysis (PCA), Karhunen-Loève transform (KLT).
Estimation theory estimation criteria, prediction, classical and Bayesian parameter estimation (including MMSE, Maximum Likelihood, and Maximum A Posteriori estimation), Cramer-Rao bound
Linear signal models
Parametric models (cepstral decomposition, Paley-Wiener theorem, spectral flatness), non-parametric models (all-pole, all-zero and pole-zero models, lattice structures, Yule-Walker equations, PARCOR coefficients, cepstral representation)
Signal estimation
Supervised estimation, problem classes, orthogonality principle, MMSE estimation, linear MMSE estimation for normally distributed random processes, optimum FIR filtering, optimum linear filtering for stationary processes, prediction and smoothing, Kalman filters, optimum multichannel filtering (Wiener filter, LCMV, MVDR, GSC)

Adaptive filtering
Gradient methods, LMS, NLMS, APA and RLS algorithms and their convergence behavior

The course concentrates on fundamental methods of statistical signal processing and their applications.
The main topics are:
Discrete-time stochastic processes in the time and frequency domain Estimation theory Non-parametric and parametric signal models (pole/zero models, ARMA models) Optimum linear filters (e.g. for prediction), eigenfilters, Kalman filters Algorithms for optimum linear filter identification (adaptive filters)
Course material
To be kept up to date, please register for the course on StudOn. Extra points for the written exam can be obtained by handing in the homework. Please note: 1.) The
homework is to be prepared in groups of two. 2.) Copying from another group will result in zero points. 3.) All calculations for arriving at an answer must be shown. 4.) If you fail in the exam without extra points, they cannot be taken into account. 5.) The extra points expire for the resit. Number of passed worksheets: Extra points for the written exam: (based on 100 achievable points) 0- 3.5 0 4 - 4.5 4 5 - 5.5 5 6 - 6.5 6

Competences:
The students:
- analyze the statistical properties of random variables, random vectors, and stochastic processes by probability density functions and expectations as well as correlation functions and matrices and their frequency-domain representations
- know the Gaussian distribution and its role to describe the properties of random variables, vectors and processes
- understand the differences between classical and Bayesian estimation, derive and analyze MMSE and ML estimators for specific estimation problems, especially for signal estimation
- analyze and evaluate optimum linear MMSE estimators (single- and multichannel Wiener filter and Kalman filter) for direct and inverse supervised estimation problems
- evaluate adaptive filters for the identification of optimum linear estimators.

M 2.8 Computer Graphics, 7.5 ECTS, Marc Stamminger, WS 2017/2018

Contents:
This lecture covers the following aspects of Computer Graphics:
- graphics pipeline
- clipping
- 3D transformations
- hierarchical display structures
- perspective transformations and projections
- visibility determination
- raster graphics and scan conversion
- color models
- local and global illumination models
- shading models
- ray tracing and radiosity

- shadows and textures

Educational objectives and skills:
Students should be able to
- describe the processing steps in the graphics pipeline
- explain clipping algorithms for lines and polygons
- explain, characterize and compute affine and perspective transformations in 2D and 3D, and provide an intuitive description of the general form of corresponding transformation matrices in homogeneous coordinates
- depict techniques to compute depth, occlusion and visibility
- compare the different color models
- describe data structures to represent 3D virtual models and complex scenes
- explain the algorithms for rasterization and scan conversion
- solve problems with shading and texturing of 3D virtual models
- classify different shadowing techniques
- explain the difference between local and global illumination techniques and formulate algorithms for ray tracing and radiosity

M 2.28 Algorithms of Numerical Linear Algebra, 7.5 ECTS, Ulrich Rüde, WS 2017/2018

Recommended requirements:
Elementary Numerical Mathematics
Engineering Mathematics or Equivalent

Content:
- Vectors
- Matrices
- Vector Spaces
- Matrix Factorizations
- Orthogonalisation
- Singular Value Decomposition
- Eigenvalues
- Krylov Space Methods
- Arnoldi Method
- Lanczos Method
- Multigrid

Competences:
Providing students with a solid theoretical background for the foundations of modern solution techniques in Computational Engineering

M3 Medical Engineering Core Modules (IDP)

Geometry Processing, 5 ECTS, Günther Greiner, SS 2017

- M 3.7 Image and Video Compression, 5 ECTS, André Kaup, Daniela Lanz, SS 2017

Content:

Multi-Dimensional Sampling

Sampling theorem revisited, 2D sampling, spatiotemporal sampling, motion in 3D sampling

Entropy and Lossless Coding

Entropy and information, variable length codes, Huffman coding, unary coding, Golomb coding, arithmetic coding

Statistical Dependency

Joint entropy and statistical dependency, run-length coding, fax compression standards

Quantization

Rate distortion theory, scalar quantization, Lloyd-Max quantization, entropy coded scalar quantization, embedded quantization, adaptive quantization, vector quantization

Predictive Coding

Lossless predictive coding, optimum 2D linear prediction, JPEG-LS lossless compression standard, differential pulse code modulation (DPCM)

Transform Coding

Principle of transform coding, orthonormal transforms, Karhunen-Loève transform, discrete cosine transform, bit allocation, compression artifacts

Subband Coding

Principle of subband coding, perfect reconstruction property, discrete wavelet transform, bit allocation for subband coding

Visual Perception and Color

Anatomy of the human eye, sensitivity of the human eye, color spaces, color sampling formats

Image Coding Standards

JPEG and JPEG2000

Interframe Coding

Interframe prediction, motion compensated prediction, motion estimation, motion compensated hybrid coding

Video Coding Standards

H.261, H.263, MPEG-1, MPEG-2 / H.262, H.264 / MPEG-4 AVC, H.265 / MPEG-H HEVC

Competences:

The students

- visualize multi-dimensional sampling and the influence of motion within the video signal
- differentiate and evaluate different methods for lossless image and video coding
- understand and analyze mutual entropy and statistical dependencies in image and video data
- determine scalar and vector quantization for different optimization criteria (minimum mean square
- error, entropy coding, embedded quantization)
- determine and evaluate optimal one-dimensional and two-dimensional linear predictor
- apply prediction and quantization for a common DPCM system
- understand the principle and effects of transform and subband coding for image data including
- optimal bit allocation
- describe the principles of the human visual system for brightness and color

- analyze block diagrams and the functioning of hybrid coders and decoders for video signals
- know the prevailing international standards of ITU and MPEG for image and video compression.

M 3.5 Computer Architectures for Medical Applications, 5 ECTS, N.N., Gerhard Wellein, SS2017

M 3.8 Wavelet-Transformationen in Image Processing - V+UE, 7.5 ECTS, Volker Strehl, WS 2017/2018

Content:
The classical Fourier analysis represents functions as overlays of trigonometric functions. As such, it primarily focuses on stationary properties of signals. For the analysis of short term ("transient") properties of signals, the substantially younger wavelet analysis is better suited. Wavelets represent functions as overlays of signal building blocks. These blocks are obtained via scaling and translation of a so-called "mother wavelet", and are clearly delimited in time and frequency domain. While there is in principle "just one" Fourier theory, wavelets provide a much wider range of possibilities. However, constructing wavelets with good properties is nevertheless a challenging task. The lecture consists of theoretical and practical aspects. On the theoretical side, the lecture presents the principles of continuous and discrete wavelet analysis, multiscale analysis, and the construction of compact and smooth wavelets. Surprisingly, it turns out that the Fourier theory plays an important part in this analysis. On the practical side, the lecture applies wavelets on common image processing
tasks (denoising, data compression, edge detection). Participants also implement these methods. Participants do not need to have a particular class passed prior to this lecture. Nevertheless, knowledge about Fourier analysis and basic terms of signal processing and image processing will be useful.
Participants must be willing to actively engage into a good portion of mathematical thinking for this lecture.

Competences:
Lecture and Exercises:

- understand the foundations and explain the most important phenomena of Fourier-based representations and processing of signals in spatial and frequency domain
- illustrate the structure of wavelet transforms and their characteristic properties
- explain the construction of orthogonal and bi-orthogonal filters for wavelet transforms
- discuss the mathematical properties of wavelet filters using Fourier methods in the context of multiresolution analysis
- design wavelet-based methods for selected applications in image processing, particularly for denoising, compression, edge detection, and registration
- experimentally explore the basic properties of Fourier series and Fourier transforms using MATLAB
- examine various aspects of multiresolution analysis based on own MATLAB implementations
- develop wavelet-based methods for denoising and compression based on own MATLAB implementations.

Lecture and Theory Supplement:

- understand the foundations and explain the most important phenomena of Fourier-based representations and processing of signals in spatial and frequency domain
- illustrate the structure of wavelet transforms and their characteristic properties
- explain the construction of orthogonal and bi-orthogonal filters for wavelet transforms
- discuss the mathematical properties of wavelet filters using Fourier methods in the context of multiresolution analysis
- design wavelet-based methods for selected applications in image processing, particularly for denoising, compression, edge detection, and registration
- examine in detail the mathematical properties of Fourier series, Fourier transforms and Wavelet transforms
- explore variations of the methods that are discussed in the lecture and the exercises using theoretical quality criteria

M 3.1 Visual Computing in Medicine, 5 ECTS, Peter Hastreiter, Thomas Wittenberg, WS 2017/2018, (course is 2 semesters long).

Content:

The flood and complexity of medical image data as well as the clinical need for accuracy and efficiency require powerful and robust concepts of medical data processing. Due to the diversity of image information and their clinical relevance the transition from imaging to medical analysis and interpretation plays an important role. The visual representation of abstract data allows understanding both technical and medical aspects in a comprehensive and intuitive way. Based on a processing pipeline for medical image data an overview of the characteristics of medical image data as well as fundamental methods and procedures for medical image analysis and visualization is given. Examples of clinical practice show
the relation to the medical application. Based on VCMed1 the lecture VCMed2 discusses practical approaches for the diagnosis and therapy planning of complex diseases. It will be shown how fundamental methods are selected and integrated to practically applicable concepts. Examples demonstrate the relation to strategies and requirements in clinical practice and the industrial development process. Additionally, complex methods of medical image analysis and visualization will be explained.

Competences:

Visual Computing in Medicine I

The students

- get an overview of the basic principles and differences of medical imaging methods,
- acquire profound knowledge about grid structures, data types and formats of medical image data,
- use sample data to recognize and interpret different image data,
- acquire knowledge about methods of preprocessing, filtering and interpolation of medical image data as well as on basic approaches of segmentation,
- learn the principles and methods of explicit and implicit image registration and get an overview of important procedures of rigid registration,
- acquire profound knowledge about all aspects of medical visualization (2D, 3D, 4D) of scalar, vector, tensor data,

- get a first impression of how visualization can be used to control image analysis and medical diagnostics.

Visual Computing in Medicine II

The students

- gain an insight into complex approaches to the treatment of important disease patterns from the point of view of medical application and specific solution strategies
- learn the requirements and the linking of methods of medical image analysis and visualization for the processing of cardiological, neurological, oncological and radiotherapeutic questions
- get an overview of complex disease pictures as a basis for effective and efficient solutions
- acquire advanced knowledge to process multimodal image data using advanced methods
- receive in-depth knowledge on complex and up-to-date topics of medical visualization (including integration procedures, transfer functions, acceleration techniques with graphics hardware)

M 3.2 Diagnostic Medical Image Processing (VHB-Kurs), 5 ECTS, Andreas Maier, WS 2017/2018

Content:

The contents of the lecture comprise basics about medical imaging modalities and acquisition hardware. Furthermore, details on acquisition-dependent preprocessing are covered for image intensifiers, flatpanel detectors, and MR. The fundamentals of 3D reconstruction from parallel-beam to cone-beam reconstruction are also covered. In the last chapter, rigid registration for image fusion is explained. In the exercises, algorithms that were presented in the lecture are implemented in Java.

Competences:

The participants:

- understand the challenges in interdisciplinary work between engineers and medical practitioners.
- develop understanding of algorithms and math for diagnostic medical image processing.
- learn that creative adaptation of known algorithms to new problems is key for their future career.
- develop the ability to adapt algorithms to different problems.
- are able to explain algorithms and concepts of the lecture to other engineers.

M 3.3 Interventional Medical Image Processing (lecture only), 5 ECTS, Andreas Maier, SS 2017

Content:

This lecture focuses on recent developments in image processing driven by medical applications. All algorithms are motivated by practical problems. The mathematical tools required to solve the considered image processing tasks will be introduced. The lecture starts with an overview on preprocessing algorithms such as scatter correction for x-ray images, edge detection, super-resolution and edge-preserving noise reduction. The second chapter describes automatic image analysis using feature descriptors, key point detection, and segmentation using bottom-up algorithms such as the random walker or top-down approaches such as active shape models. Furthermore, the lecture covers geometric calibration algorithms for single view calibration, epipolar geometry, and factorization. The last part of the lecture covers non-rigid registration based on variational methods and motion-compensated image reconstruction.

Competences:
The participants:

- summarize the contents of the lecture.
- apply pre-processing algorithms such as scatter correction and edge-preserving filtering.
- extract information from images automatically by image analysis methods such as key point detectors and segmentation algorithms.
- calibrate projection geometries for single images and image sequences using the described methods.
- develop non-rigid registration methods using variational calculus and different regularizers.
- adopt algorithms to new domains by appropriate modifications.

➢ M 3.4 Biomedical Signal Analysis (BioSig), 5 ECTS, Björn Eskofier, Heike Leutheuser, WS 2017/2018

Content:
The lecture content explains and outlines (a) basics for the generation of important biosignals of the human body, (b) measurement of biosignals, and (c) methods for biosignals analysis. Considered biosignals are among others action potential (AP), electrocardiogram (ECG), electromyogram (EMG), electroencephalogram (EEG), or mechanomyogram (MMG). The focus during the measurement part is for example the measurement technology or the correct sensor and electrode placement. The main part of the lecture is the analysis part. In this part, concepts like filtering for artifact reduction, wavelet analysis, event detection or waveform analysis are covered. In the end, an insight into pattern recognition methods is gained.

Competences:
Students

- reproduce the generation and measurement of important biosignals of the human body
- recognize relations between the generation of biosignals and the measured signal
- understand the importance of biosignal analysis for medical engineering
- analyze and provide solutions to the key causes for artifacts in biosignals
- apply gained knowledge independently to interdisciplinary research questions of medicine and engineering science
- acquire competences between medicine and engineering science
- learn how to reproduce and argumentatively present subject-related content
- understand the structure of systems for automatic classification of simple patterns
- work cooperatively and act responsibly in groups
- implement biosignal processing algorithms in MATLAB
- solve classification problems in MATLAB

- M 3.10 Multidimensional Signals and Systems, 5 ECTS, Rudolf Rabenstein, WS 2017/2018

Content:

Properties of multidimensional signals

- separability, symmetry, etc.

2D signals and systems

- convolution
- delta impulse
- Fourier transformation
- FIR and IIR systems
- state space representation

Wave propagation in 2D and 3D

- wave equation,
- Fourier transformation and decomposition into plane waves and circular and spherical harmonics
- Green's function
- Kirchhoff-Helmholtz integral equation

Applications

- imaging with the pin hole camera model
- principle of computer tomography
- subpixel rendering
- iterative solution of systems of linear equations
- room acoustics
- sound field reproduction with wave field synthesis and Ambisonics

M5 Medical Engineering Specialisation Modules (IDP)

M 5.2 Lasers in Healthcare Engineering, 2.5 ECTS, Ilya Alexeev, WS 2017/2018

Content:

- Physical phenomena applicable in Laser Technology: EM waves, Beam Propagation;
- Laser tissue interaction processes and Monte-Carlo simulation method;
- Introduction to Optical Coherence Technology;
- Lasers for medical applications;
- Lasers for production of medical tools;
- Optical diagnostic and treatment methods in medicine: laser surgery, Raman spectroscopy, optical phantom preparation and characterization;

Competences:

Students...

- Would know the fundamentals of laser tissue-interaction process.
- Will understand principles of tissue / phantom optical properties characterization.
- Will be able to perform characterization of basic optical properties of tissues.

- Will gain basic understanding and practical experience with Optical Coherence Tomography (OCT).
- Will be familiar with potential applications of laser in medicine and healthcare
- Will become familiar with international (English) professional terminology.

M 5.23 Molecular Communications, 5 ECTS, Robert Schober, WS 2017/2018

Content:
Conventional communication systems employ electromagnetic waves for information transmission. This approach is suitable for typical macroscopic applications such as mobile communication. However, newly emerging applications in biology, nanotechnology, and medicine require communication between so-called nano-machines (e.g. nano-robots and nano-sensors) with sizes on the order of nano and micro-meter. For such device sizes electromagnetic waves cannot be used for efficient information transmission. Instead Molecular Communication, an approach that is also widely used in natural biological systems, has to be applied. In Molecular Communication, transmitter and receiver communicate by exchanging information-carrying molecules. The design of molecular communication systems requires a basic understanding of relevant biological processes and systems as well as their communicationtheoretical modelling and analysis. The course is structured as follows: 1) Introduction to Molecular Communication; 2) Biological Nano-Machines; 3) Molecular Communication in Biological Systems; 4) Synthetic Molecular Communication Systems; 5) Mathematical Modelling and Simulation; 6) Communication and Information Theory for Molecular Communication; 7) Design of Molecular Communication Systems; 8) Applications for Molecular Communication Systems.

Competences:
The students learn how to design synthetic molecular communication systems. They develop an understanding of natural communication processes in biological systems and how to harness these natural processes for the construction of man-made molecular communication systems. The students also learn how to analyse, model, and simulate molecular communication systems.

M 5.18 Knowledge Discovery in Databases, 2.5 ECTS, Klaus Meyer-Wegener, SS 2017 187

Content:

- Why data mining?
- What is data mining?
- A multi-dimensional view of data mining
- What kinds of data can be mined?
- What kinds of patterns can be mined?
- What technologies are used?
- What kinds of applications are targeted?
- Major issues in data mining
- A brief history of data mining

M 5.10 Convex Optimization in Communications and Signal Processing, 5 ECTS, Wolfgang Gerstacker, WS 2017/2018

Content:
Convex optimization problems are a special class of mathematical problems which arise in a variety of practical applications. In this course we focus on the theory of convex optimization, corresponding algorithms, and applications in communications and signal processing (e.g. statistical estimation, allocation of resources in communications networks, and filter design). Special attention is paid to recognizing and formulating convex optimization problems and their efficient solution. The course is based on the textbook "Convex Optimization" by Boyd and Vandenberghe and includes a tutorial in which many examples and exercises are discussed.

Competences:
Students
- characterize convex sets and functions,
- recognize, describe and classify convex optimization problems,
- determine the solution of convex optimization problems via the dual function and the KKT conditions,
- apply numerical algorithms in order to solve convex optimization problems,
- apply methods of convex optimization to different problems in communications and signal processing

M 5.6 Test and Analysis Techniques for Software Verification and Validation, 5 ECTS, Francesca Saglietti, WS 2017/2018

Content:
The module starts with approaches aimed at evaluating the relevance of embedded software in complex control systems. Depending on the degree of the underlying safety relevance, several testing and analysis techniques at different levels of rigour are successively introduced; their application helps checking the correctness of the product developed (verification) resp. the appropriateness of the task specified (validation).

Competences:
The students
- analyse the relevance of embedded software in complex control systems by means of fault trees and causal relations;
- distinguish between different testing techniques in terms of their achievement of structural, control flow based resp. data flow based code coverage criteria and their fault detection capabilities;
- evaluate the adequacy of test case sets by means of mutation testing;
- check the correctness of models and programs by means of axiomatic proofs and model checking.

M 5.22 Image, Video, and Multidimensional Signal Processing, 5 ECTS, André Kaup, WS 2017/2018

Content:
Point operations
Histogram equalization, gamma correction
Binary operations

Morphological filters, erosion, dilation, opening, closing
Color spaces
Trichromacy, red-green-blue color spaces, color representation using hue, saturation and value of intensity
Multidimensional signals and systems
Theory of multidimensional signals and systems, impulse response, linear image filtering, power spectrum, Wiener filtering
Interpolation of image signals
Bi-linear interpolation, bi-cubic interpolation, spline interpolation
Image feature detection
Image features, edge detection, Hough transform, Harris corner detector, texture features, co-occurrence matrix
Scale space representation
Laplacian of Gaussian, difference of Gaussian, scale invariant feature transform, speeded-up robust feature transform
Image matching
Projective transforms, block matching, optical flow, feature-based matching using SIFT and SURF, random sample consensus algorithm
Image segmentation
Amplitude thresholding, k-means clustering, Bayes classification, region-based segmentation, combined segmentation and motion estimation, temporal segmentation of video
Transform domain image processing
Unitary transform, Karhunen-Loeve transform, separable transform, Haar and Hadamard transform, DFT, DCT

Competences:
The students

- understand point operations for image data and gamma correction
- test the effects of rank order and median filters for image data
- evaluate and differentiate between different color spaces for image data
- explain the principle of two-dimensional linear filtering for image signals
- calculate and evaluate the two-dimensional discrete Fourier transform of an image signal
- determine enlarged discrete image signals by bi-linear and spline interpolation
- verify image data for selected texture, edge and motion features
- analyze image and video data for features in different scale spaces
- explain and evaluate methods for the matching of image data
- segment image data by implementing basic classification and clustering methods
- understand the principle of transformations on image data and apply them exemplarily

Branch of study Medical Electronics

M2 Engineering Core Modules (MEL)

M 2.9 Digital Signal Processing (DSV), 5 ECTS, Walter Kellermann, Michael Bürger, WS 2017/2018

Content:
The course assumes familiarity with basic theory of discrete-time deterministic signals and linear systems and extends this by a discussion of the properties of idealized and causal, realizable systems (e.g., lowpass, Hilbert transformer) and corresponding representations in the time domain, frequency domain, and z-domain. Thereupon, design methods for recursive and nonrecursive digital filters are discussed. Recursive systems with prescribed frequency-domain properties are obtained by using design methods for Butterworth filters, Chebyshev filters, and elliptic filters borrowed from analog filter design. Impulse-invariant transform and the Prony-method are representatives of the considered designs with prescribed time-domain behaviour.For nonrecursive systems, we consider the Fourier approximation in its original and its modified form introducing a broad selection of windowing functions. Moreover, the equiripple approximation is introduced based on the Remez-exchange algorithm. Another section is dedicated to the Discrete Fourier Transform (DFT) and the algorithms for its fast realizations ('Fast Fourier Transform'). As related transforms we introduce cosine and sine transforms. This is followed by a section on nonparametric spectrum estimation. Multirate systems and their efficient realization as polyphase structures form the basis for describing analysis/synthesis filter banks and discussing their applications.
The last section is dedicated to investigating effects of finite wordlength as they are unavoidable in any realization of digital signal processing systems.
A corresponding lab course on DSP will be offered in the winter term.

M3 Medical Engineering Core Modules (MEL)

M 3.4 Biomedical Signal Analysis, 5 ECTS, Björn Eskofier, Heike Leutheuser, WS 2017/2018

Content:
The lecture content explains and outlines (a) basics for the generation of important biosignals of the human body, (b) measurement of biosignals, and (c) methods for biosignals analysis.
Considered biosignals are among others action potential (AP), electrocardiogram (ECG), electromyogram (EMG), electroencephalogram (EEG), or mechanomyogram (MMG). The focus during the measurement part is for example the measurement technology or the correct sensor and electrode placement.The main part of the lecture is the analysis part. In this part, concepts like filtering for artifact reduction, wavelet analysis, event detection or waveform analysis are covered. In the end, an insight into pattern recognition methods is gained.

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- recognize relations between the generation of biosignals and the measured signal
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- apply gained knowledge independently to interdisciplinary research questions of medicine and engineering science
- acquire competences between medicine and engineering science
- learn how to reproduce and argumentatively present subject-related content
- understand the structure of systems for automatic classification of simple patterns

- work cooperatively and act responsibly in groups
- implement biosignal processing algorithms in MATLAB
- solve classification problems in MATLAB

M 3.7 Image and Video Compression, 5 ECTS, André Kaup, Daniela Lanz, SS 2017

<u>Content:</u>
Multi-Dimensional Sampling
Sampling theorem revisited, 2D sampling, spatiotemporal sampling, motion in 3D sampling
Entropy and Lossless Coding
Entropy and information, variable length codes, Huffman coding, unary coding, Golomb coding, arithmetic coding
Statistical Dependency
Joint entropy and statistical dependency, run-length coding, fax compression standards
Quantization
Rate distortion theory, scalar quantization, Lloyd-Max quantization, entropy coded scalar quantization, embedded quantization, adaptive quantization, vector quantization
Predictive Coding
Lossless predictive coding, optimum 2D linear prediction, JPEG-LS lossless compression standard, differential pulse code modulation (DPCM)
Transform Coding
Principle of transform coding, orthonormal transforms, Karhunen-Loève transform, discrete cosine transform, bit allocation, compression artifacts
Subband Coding
Principle of subband coding, perfect reconstruction property, discrete wavelet transform, bit allocation for subband coding
Visual Perception and Color
Anatomy of the human eye, sensitivity of the human eye, color spaces, color sampling formats
Image Coding Standards
JPEG and JPEG2000
Interframe Coding
Interframe prediction, motion compensated prediction, motion estimation, motion compensated hybrid coding
Video Coding Standards
H.261, H.263, MPEG-1, MPEG-2 / H.262, H.264 / MPEG-4 AVC, H.265 / MPEG-H HEVC
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<u>Competences:</u>
The students

- visualize multi-dimensional sampling and the influence of motion within the video signal
- differentiate and evaluate different methods for lossless image and video coding
- understand and analyze mutual entropy and statistical dependencies in image and video data
- determine scalar and vector quantization for different optimization criteria (minimum mean square error, entropy coding, embedded quantization)
- determine and evaluate optimal one-dimensional and two-dimensional linear predictor
- apply prediction and quantization for a common DPCM system
- understand the principle and effects of transform and subband coding for image data including optimal bit allocation

- describe the principles of the human visual system for brightness and color
- analyze block diagrams and the functioning of hybrid coders and decoders for video signals
- know the prevailing international standards of ITU and MPEG for image and video compression.

Medizinelektronik/Medical Electronics, 5 ECTS, Georg Fischer, SS 2017

Content:
The Lecture and exercise deals with the following topics:

- Implications of MPG (Medizinproduktegesetz) on circuit design
- Electronics for medical diagnostics and therapy
- Circuit design of standard medical equipment ECG, EEG, EMG, SpO2
- Circuit technology for vital sensors
- Circuit technology for impedance spectroscopy
- Circuit technology for impedance tomography
- Circuit technology for microwave/mm-wave spectroscopic sensors
- Electronic Systems for AAL (Ambient Assisted Living)
- Electronic Systems including MEMS (Micro ElectroMechanical Systems) components
- Circuit technology around MEMS "Lab-on-chip"
- Circuit technology for implants
- Electronic circuits around „Smart Textiles"
- Body near energy harvesting

Competences:

- Substantial knowledge on principles for the circuit design of medical electronic devices
- Ability to analyze circuit diagrams of medical electronic devices
- Ability to separate medical electronic devices into its subfunctions
- Ability to analyze energy budget of medical sensors and circuits with body near electronics
- Basic ability to design electronic circuits to comply with obligations by MPG
- Substantial knowledge on circuit design for standard medical devices, e.g. ECG, EEG, EMG
- Substantial knowledge on wireless Body Area Networks (BAN)
- Substantial knowledge on circuit design rules for micro/mmwave medical sensors
- Substantial knowledge on circuits including microsystem (MEMS) components for health assistance systems

M5 Medical Engineering Specialisation Modules (MEL)

M 5.17 Body Area Communications, 2.5 ECTS, N.N., WS 2017/2018

Content:

- The Lecture and exercise deals with the following topics:
- Introduction to Body Area Communications
- Electromagnetic Characteristics of Human Body
- Electromagnetic Analysis Methods

- Body Area Channel Modeling
- Modulation/Demodulation
- Body Area Communication Performance
- Electromagnetic Compatibility Consideration

Competences:

- Students understand the challenges in designing Body Area Communication (BAC) systems
- Students can conduct basic design decisions with BAC systems, like frequency and modulation selection
- Students understand electromagnetic wave propagation in bodies
- Students understand the frequency dependent loss and propagation behavior of electromagnetic waves
- Students can analyze the communication performance of a BAC system
- Students can evaluate Electromagnetic Compatibility of a BAC system
- Students can assess the field strength inside body and relate it to regulatory limits like SAR (Specific Absorption rate), frequency dependent maximum electrical and magnetic field strength
- Students can sketch block diagrams of BAC systems
- Students can derive channel models for BAC

Architectures for Digital Signal Processing, 5 ECTS, Jens Kirchner, WS 2017/2018

Content:

- Basic algorithms of signal processing (FFT, windowing, digital FIR and IIR-filters)
- Non-idealities of digital filters (quantization of filter coefficients, fixed-point arthmetic)
- CORDIC-architectures
- Architectures of systems with multiple sampling rates (conversion between different sampling rates)
- Digital signal generation
- Measures of performance improvement (pipelining)
- Architecture of digital signal processors
- Applications

- ➢ Medical Imaging System Technology, 5 ECTS, Wilhelm Dürr, SS 2017

- ➢ M 5.22 Image, Video, and Multidimensional Signal Processing, 5 ECTS, André Kaup, WS2017/2018

Content:

Point operations

Histogram equalization, gamma correction

Binary operations

Morphological filters, erosion, dilation, opening, closing

Color spaces

Trichromacy, red-green-blue color spaces, color representation using hue, saturation and value of intensity

Multidimensional signals and systems

Theory of multidimensional signals and systems, impulse response, linear image filtering, power spectrum, Wiener filtering

Interpolation of image signals

Bi-linear interpolation, bi-cubic interpolation, spline interpolation

Image feature detection

Image features, edge detection, Hough transform, Harris corner detector, texture features, co-occurrence matrix

Scale space representation

Laplacian of Gaussian, difference of Gaussian, scale invariant feature transform, speeded-up robust feature transform

Image matching

Projective transforms, block matching, optical flow, feature-based matching using SIFT and SURF, random sample consensus algorithm

Image segmentation

Amplitude thresholding, k-means clustering, Bayes classification, region-based segmentation, combined segmentation and motion estimation, temporal segmentation of video

Transform domain image processing

Unitary transform, Karhunen-Loeve transform, separable transform, Haar and Hadamard transform, DFT, DCT

Competences:

The students

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- analyze image and video data for features in different scale spaces
- explain and evaluate methods for the matching of image data
- segment image data by implementing basic classification and clustering methods
- understand the principle of transformations on image data and apply them exemplarily

Branch of study Medical Production Technology, Device Engineering and Prosthetics

M2 Engineering Core Modules (Medical Production Technology, Device Engineering and Prosthetics)

Nonlinear Continuum Mechanics, 5 ECTS, Paul Steinmann,Jan Friederich, SS 2017

Content:
Kinematics
- Displacement and deformation gradient
- Field variables and material (time) derivatives
- Lagrangian and Eulerian framework

Balance equations
- Stress tensors in the reference and the current configuration
- Derivation of balance equations

Constitutive equations
- Basic requirements, frame indifference
- Elastic material behavious, Neo-Hooke

Variational formulation and solution by the finite element method
- Linearization
- Discretization
- Newton method

Objectives:
The students
- obtain profound knowledge on the description of field variables in non-linear continuum theory
- know the relation/transformation between the Lagrangian and the Eulerian framework
- are able to derive constitutive equations for elastic materials on the basis of thermodynamic assumptions
- are familiar with the basic concept of variational formulations and how to solve them within a finite element framework

Linear Continuum Mechanics, 5 ECTS, Paul Steinmann, Jan Friederich, WS 2017/2018

Content:
- Basic concepts in linear continuum mechanics
- Kinematics
- Stress tensor
- Balance equations
- Application in elasticity theory
- Constitutive equations
- Variational formulation

Objectives:
Continuum mechanics is a key discipline in the field of engineering mechanics and conveys a basic understanding on the strength of materials when designing structural components. Therefore, the lecture aims to clarify the fundamentals of linear continuum mechanics following a modern approach based on the use of tensor analysis and algebra. This lecture is a sequel to the basic knowledge acquired in lecture sessions of 'Engineering statics (Technische Mechanik)' and serves as an ideal addendum for a first course in the finite element method.

Nichtlineare Finite Elemente / Nonlinear Finite Elements, 5 ECTS, Sebastian Pfaller, Dominic Soldner, WS 2017/2018

Content:
- Basic concepts in nonlinear continuum mechanics
- Geometric and material nonlinearities
- Derivation and discretization of the weak form in the material and spatial configuration
- Consistent linearization
- Iterative solution methods for nonlinear problems
- Solution methods for transient problems
- Discontinous finite elements

Objectives
The students
- are familiar with the basic concept of the finite element method
- are able to model nonlinear problems in continuum mechanics
- are familiar with solution algorithms for nonlinear problems
- are familiar with solution methods for transient problems

Computational Dynamics, 5 ECTS, Denis Davydov, WS 2017/2018

Content:
- Introduction to the Finite Element Method
- Balance equations for dynamic analyses
- Direct integral methods
- Mode superposition
- Analysis of direct integral methods
- Solution of nonlinear equations
- Solution of nonstructural problems

Objectives
The students
- are familiar with the basic idea of the linear finite element method
- know how to derive the weak and the discretized form of a given time-dependent differential equation
- know how to derive the equations of motion
- know how to formulate thermal problems
- know how to formulate continuum mechanical problems
- are familiar with direct time integration methods
- are familiar with eigenvalue problems and stability analysis of various time integration methods
- know how to solve time-dependent differential equations

M3 Medical Engineering Core Modules (Medical Production Technology, Device Engineering and Prosthetics)

Cell-Material-Interaction (Medizintechnik), 2.5 ECTS, Aldo R. Boccaccini, Rainer Detsch, WS 2017/2018

M5 Medical Engineering Specialization Modules (Medical Production Technology, Device Engineering and Prosthetics)

Biomaterials for Tissue Engineering-MT, 2.5 ECTS, Aldo R. Boccaccini, SS 2017

Integrated Production Systems (Lean Management), 5 ECTS, Jörg Franke, SS 2017

Optical Technologies in Life Science, 5 ECTS, Sebastian Schürmann, Oliver Friedrich,Daniel Gilbert, Maximilian Waldner, WS 2017/2018

Content:

- Microscopy: Basic Concepts and Contrast Techniques, Resolution and Limits, Construction and components of light microscopes, fluorescence microscopy
- Applications of fluorescence microscopy in the life science field, method for labeling biological Structures and processes in cells
- Epifluorescence, confocal, multiphoton microscopy, concepts and application examples
- Optical endoscopy and endomicroscopy in research and clinic
- Super-Resolution Microscopy, concepts and application examples for optical imaging beyond
- the diffraction-related resolution limit
- High Throughput Screening, Optical Methods for Quickly Reviewing the Response of Cells
- on active ingredients

Competences:

- Learning objectives of the lecture are on the one hand, the understanding of the basic concepts and their technical implementation, and on the other hand, the targeted application of optical technologies for Life Sciences and Medicine.
- In addition, advantages and disadvantages of individual technologies and their limitations in implementation will be worked out.
- Students should be enabled to use optical methods to answer specific questions in the Life Sciences and planning experiments under consideration of technical strengths and limitations.
- The students themselves deepen a selected topic based on scientific primary literature and present the topic in a lecture as part of the exercise. Another goal in addition to the substantive deepening here is the teaching of soft skills for the preparation of a presentation in English, such as filtering and structuring the essential information, the presentation planning, design of the slides and improvement of the presentation skills.

M 5.2 Lasers in Healthcare Engineering, 2.5 ECTS, Ilya Alexeev, WS 2017/2018

Content:

- Physical phenomena applicable in Laser Technology: EM waves, Beam Propagation;
- Laser tissue interaction processes and Monte-Carlo simulation method;
- Introduction to Optical Coherence Technology;
- Lasers for medical applications;

- Lasers for production of medical tools;
- Optical diagnostic and treatment methods in medicine: laser surgery, Raman spectroscopy, optical phantom preparation and characterization;

Competences:

Students...

- Would know the fundamentals of laser tissue-interaction process.
- Will understand principles of tissue / phantom optical properties characterization.
- Will be able to perform characterization of basic optical properties of tissues.
- Will gain basic understanding and practical experience with Optical Coherence Tomography (OCT).
- Will be familiar with potential applications of laser in medicine and healthcare
- Will become familiar with international (English) professional terminology.

M 5.23 Molecular Communications, 5 ECTS, Robert Schober, WS 2017/2018

Content:

Conventional communication systems employ electromagnetic waves for information transmission. This approach is suitable for typical macroscopic applications such as mobile communication. However, newly emerging applications in biology, nanotechnology, and medicine require communication between so-called nano-machines (e.g. nano-robots and nano-sensors) with sizes on the order of nanoand micro-meter. For such device sizes electromagnetic waves cannot be used for efficient information transmission. Instead Molecular Communication, an approach that is also widely used in natural biological systems, has to be applied. In Molecular Communication, transmitter and receiver communicate by exchanging information-carrying molecules. The design of molecular communication systems requires a basic understanding of relevant biological processes and systems as well as their communication theoretical modelling and analysis. The course is structured as follows: 1) Introduction to Molecular Communication; 2) Biological Nano-Machines; 3) Molecular Communication in Biological Systems; 4) Synthetic Molecular Communication Systems; 5) Mathematical Modelling and Simulation; 6) Communication and Information Theory for Molecular Communication; 7) Design of Molecular Communication Systems; 8) Applications for Molecular Communication Systems.

Competences:

The students learn how to design synthetic molecular communication systems. They develop an understanding of natural communication processes in biological systems and how to harness these natural processes for the construction of man-made molecular communication systems. The students also learn how to analyse, model, and simulate molecular communication systems.