



UNIVERSITÄT
DES
SAARLANDES

FAKULTÄT FÜR MATHEMATIK UND INFORMATIK

MODULHANDBUCH

Visual Computing MSc

21. April 2020

Liste der Modulbereiche und Module

1	Image Acquisition	3
1.1	Physikalische Akustik 1	4
1.2	Physikalische Akustik 2	5
1.3	Ultrasound Imaging	6
2	Image Analysis	7
2.1	Correspondence Problems in Computer Vision	8
2.2	Differential Equations in Image Processing and Computer Vision	10
2.3	Differential Geometric Aspects of Image Processing	12
2.4	High Level Computer Vision	14
2.5	Image Processing and Computer Vision	15
2.6	Probabilistic Graphical Models and their Applications	17
3	Image Synthesis / Geometric Foundations	18
3.1	Computation and Fabrication	19
3.2	Computer Graphics	21
3.3	Geometric Modelling	23
3.4	Perception for Computer Graphics	25
3.5	Realistic Image Synthesis	27
4	Image Related Fields	29
4.1	AI Planning	30
4.2	Artificial Intelligence	31
4.3	Audio/Visual Communication and Networks	33
4.4	Digital Transmission & Signal Processing	35
4.5	Elements of Data Science and Artificial Intelligence	37
4.6	Elements of Machine Learning	38
4.7	Human Computer Interaction	40
4.8	Information Retrieval and Data Mining	41
4.9	Machine Learning	42

4.10	Multimedia Transport	43
4.11	Neural Networks: Theory and Implementation	45
4.12	Statistical Natural Language Processing	46
4.13	Topics in Algorithmic Data Analysis	47
4.14	Zerstörungsfreie Prüfverfahren I	48
5	Seminars	50
5.1	Seminar	51
6	Master Seminar and Thesis	53
6.1	Master Seminar (Visual Computing)	54
6.2	Master Thesis	55

Modulbereich 1

Image Acquisition

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4	jedes Sommersemester	1 Semester	2	3

Modulverantwortliche/r Prof. Dr. Ute Rabe

Dozent/inn/en Prof. Dr. Ute Rabe

Zulassungsvoraussetzungen keine

Leistungskontrollen / Prüfungen benotete Klausur (schriftlich oder mündlich)

Lehrveranstaltungen / SWS 2 SWS Vorlesung
= 2 SWS

Arbeitsaufwand 30 h Präsenzstudium
+ 60 h Eigenstudium (Vor- und Nachbereitung, Prüfung)
= 90 h (= 3 ECTS)

Modulnote Wird aus den Leistungen in der Klausur ermittelt. Die genauen Modalitäten werden zu Beginn des Moduls bekannt gegeben.

Sprache Deutsch

Lernziele / Kompetenzen

Die Studierenden erwerben umfangreiche Kenntnisse und Fertigkeiten in:

- Grundkonzepte der physikalischen Akustik
- Einführung in die Materialprüfung mit Ultraschall
- Gerätetechnische Aspekte
- Praxisbezogene Anwendungsbeispiele

Inhalt

- Schwingungen, Schallwellen, Ultraschall
- Anregung und Empfang von Ultraschallwellen, Methoden der Bildgebung (A-B-C-Scan)
- Beugung und Fehlergrößenbestimmung
- Ultraschall-Mikroskopie
- Anwendungsbeispiele

Literaturhinweise

Literaturhinweise werden zu Beginn der Veranstaltung bekannt gegeben.

- A. Ehrhard, Verfahren der zerstörungsfreien Materialprüfung, DVS Media GmbH, Berlin, 2014

Weitere Informationen

Methoden: Powerpoint-Präsentation über Beamer unterstützt durch Overhead-Projektor, Demonstrationsexperimente

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4	jedes Wintersemester	1 Semester	3	4

Modulverantwortliche/r Prof. Dr. Ute Rabe

Dozent/inn/en Priv. Doz. Dr. Martin Spies
und Mitarbeiter des IZFP

Zulassungsvoraussetzungen *Physikalische Akustik 1* (empfohlen)

Leistungskontrollen / Prüfungen benotete Klausur (schriftlich oder mündlich)

Lehrveranstaltungen / SWS 2 SWS Vorlesung
+ 1 SWS Übung
= 3 SWS

Arbeitsaufwand 45 h Präsenzstudium
+ 75 h Eigenstudium (Vor- und Nachbereitung, Prüfung)
= 120 h (= 4 ECTS)

Modulnote Wird aus den Leistungen in der Klausur ermittelt. Die genauen Modalitäten werden zu Beginn des Moduls bekannt gegeben.

Sprache Deutsch

Lernziele / Kompetenzen

Die Studierenden erwerben umfangreiche Kenntnisse und Fertigkeiten in:

- Grundlegende Konzepte der Bildgebung und Rekonstruktion
- Beschreibung der Schallausbreitung in komplexen Werkstoffen
- Grundlagen der Modellierung und Simulation
- Theoretische Grundlagen der Beschreibung der verschiedenen Wellenarten
- Praxisbezogene Anwendungsbeispiele

Inhalt

- Beschreibung der Ultraschallwellen im 3-dimensionalen Medium
- Methoden der Simulation
- Ausbreitung von Ultraschall in elastisch anisotropen Medien
- Phased Array, Total Focusing Method, Synthetic Aperture Focusing Technique (SAFT)
- Anwendungsbeispiele

Literaturhinweise

Literaturhinweise werden zu Beginn der Veranstaltung bekannt gegeben.

- James P. Wolfe, Imaging Phonons, Acoustic Wave Propagation in Solids, Cambridge University Press, 1998
- B.A. Auld, Acoustic Fields and Waves in Solids, Vol I, II, Robert E. Krieger Publishing, 1990

Weitere Informationen

Methoden: Powerpoint-Präsentation über Beamer unterstützt durch Overhead-Projektor, Demonstrationsexperimente, rechnerische Vertiefung der Vorlesungsinhalte im Rahmen der Übung

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4	every winter semester	1 semester	2	4

Modulverantwortliche/r Dr. Marc Fournelle

Dozent/inn/en Dr. Marc Fournelle

Zulassungsvoraussetzungen keine

Leistungskontrollen / Prüfungen

- Regular attendance of classes
- Final exam (oral or written)

Lehrveranstaltungen / SWS 2 h lectures
= 2 h (weekly)

Arbeitsaufwand 30 h of classes
+ 80 h private study
= 120 h (= 4 ECTS)

Modulnote Will be determined from the performance in the final exam. The exact modalities will be announced at the beginning of the course.

Sprache English

Lernziele / Kompetenzen

Understanding of ultrasound physics of technical applications and medical imaging.

Inhalt

The lecture deals with the generation, the detection, the processing and the visualization of ultrasound signals in technical (e.g. sonar, level or flow control) and biomedical applications (medical imaging, navigation, therapy/therapy control):

- Physics and mathematics of ultrasound and ultrasound signal processing
- Description of the entire signal pipeline of an ultrasound system
- Basics of different measurement and imaging methods

Literaturhinweise

Kuttruff - Physik und Technik des Ultraschalls. More will be announced at the beginning of the course.

Weitere Informationen

This module was previously known as *Bildgebende Verfahren: Ultraschall*.

Modulbereich 2

Image Analysis

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4	at least every two years	1 semester	4	6

Modulverantwortliche/r Prof. Dr. Joachim Weickert

Dozent/inn/en Prof. Dr. Joachim Weickert

Zulassungsvoraussetzungen Related core lecture *Computer Vision*,
Mathematik für Informatiker 1 - 3

Leistungskontrollen / Prüfungen

- Regular attendance of lecture and tutorial
- Written or oral exam and the end of the course

Lehrveranstaltungen / SWS 2 h lectures
+ 2 h tutorial
= 4 h (weekly)

Arbeitsaufwand 60 h of classes
+ 120 h private study
= 180 h (= 6 ECTS)

Modulnote Will be determined from performance in exams, exercises and practical tasks. The exact modalities will be announced at the beginning of the module.

Sprache English

Lernziele / Kompetenzen

Correspondence problems are a central topic in computer vision. Thereby, one is interested in identifying and matching corresponding features in different images/views of the same scene. Typical correspondence problems are the estimation of motion information from consecutive frames of an image sequence (optic flow), the reconstruction of a 3-D scene from a stereo image pair and the registration of medical image data from different modalities (e.g. CT and MRT). Central part of this lecture is the discussion of the most important correspondence problems as well as the modelling of suitable algorithms for solving them.

Inhalt

1. Introduction and Overview
2. General Matching Concepts
 - 2.1 Block Matching
 - 2.2 Correlation Techniques
 - 2.3 Interest Points
 - 2.4 Feature-Based Methods
3. Optic Flow I
 - 3.1 Local Differential Methods
 - 3.2 Parameterisation Models
4. Optic Flow II
 - 4.1 Global Differential Methods
 - 4.2 Horn and Schunck
5. Optic Flow III
 - 5.1 Advanced Constancy Assumptions
 - 5.2 Large Motion
6. Optic Flow IV
 - 6.1 Robust Data Terms

- 6.2 Discontinuity-Preserving Smoothness Terms
- 7. Optic Flow V
 - 7.1 High Accuracy Methods
 - 7.2 SOR and Liemar Multigrid
- 8. Stereo Matching I
 - 8.1 Projective Geometry
 - 8.2 Epipolar Geometry
- 9. Stereo Matching II
 - 9.1 Estimation of the Fundamental Matrix
- 10. Stereo Matching III
 - 10.1 Correlation Methods
 - 10.2 Variational Approaches
 - 10.3 Graph Cuts
- 11. Medical Image Registration
 - 11.1 Mutual Information
 - 11.2 Elastic and Curvature Based Registration
 - 11.3 Landmarks
- 12. Particle Image Velocimetry
 - 12.1 Div-Curl-Regularisation
 - 12.2 Incompressible Navier Stokes Prior

Literaturhinweise

Will be announced before the start of the course on the course page on the Internet.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4	at least every two years	1 semester	6	9

Modulverantwortliche/r Prof. Dr. Joachim Weickert

Dozent/inn/en Prof. Dr. Joachim Weickert

Zulassungsvoraussetzungen Related core lecture *Computer Vision*

Leistungskontrollen / Prüfungen

- Regular attendance of lecture and tutorial
- 50% of all possible points from weekly assignments to be eligible for the final exam are needed
- Passing the final exam or the re-exam
- The re-exam takes place during the last two weeks before the start of lectures in the following semester

Lehrveranstaltungen / SWS 4 h lectures
+ 2 h tutorial
= 6 h (weekly)

50% theoretical exercises and 50% practical programming assignments

Arbeitsaufwand 90 h of classes
+ 180 h private study
= 270 h (= 9 ECTS)

Modulnote Will be determined from performance in exams, exercises and practical tasks. The exact modalities will be announced at the beginning of the module.

Sprache English

Lernziele / Kompetenzen

Many modern techniques in image processing and computer vision make use of methods based on partial differential equations (PDEs) and variational calculus. Moreover, many classical methods may be reinterpreted as approximations of PDE-based techniques. In this course the students will get an in-depth insight into these methods. For each of these techniques, they will learn the basic ideas as well as theoretical and algorithmic aspects. Examples from the fields of medical imaging and computer aided quality control will illustrate the various application possibilities.

Inhalt

1. Introduction and Overview
2. Linear Diffusion Filtering
 - 2.1 Basic Concepts
 - 2.2 Numerics
 - 2.3 Limitations and Alternatives
3. Nonlinear Isotropic Diffusion Filtering
 - 3.1 Modeling
 - 3.2 Continuous Theory
 - 3.2 Semidiscrete Theory
 - 3.3 Discrete Theory
 - 3.4 Efficient Sequential and Parallel Algorithms
4. Nonlinear Anisotropic Diffusion Filtering
 - 4.1 Modeling
 - 4.2 Continuous Theory

- 4.3 Discrete Aspects
- 5. Parameter Selection
- 6. Variational Methods
 - 6.1 Basic Ideas
 - 6.2 Discrete Aspects
 - 6.3 TV Denoising, Equivalence Results
 - 6.4 Mumford-Shah Segmentation and Diffusion-Reaction Filters
- 7. Vector- and Matrix-Valued Images
- 8. Image Sequence Analysis
 - 8.1 Global Methods
 - 8.2 Local Methods
 - 8.3 Combined Local-Global Methods
 - 8.4 Numerical Techniques
- 9. Continuous-Scale Morphology
 - 9.1 Basic Ideas
 - 9.2 Applications
- 10. Curvature-Based Morphology
 - 10.1 Basic Ideas
 - 10.2 Applications

Literaturhinweise

Will be announced before the start of the course on the course page on the Internet.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4		1 semester	3	6

Modulverantwortliche/r Prof. Dr. Joachim Weickert

Dozent/inn/en Dr. Martin Welk

Zulassungsvoraussetzungen keine

Leistungskontrollen / Prüfungen

- Written or oral exam at end of course
- A re-exam takes place during the last two weeks before the start of lectures in the following semester.

Lehrveranstaltungen / SWS

3 h lectures
 + 1 h tutorial
 = 4 h (weekly)

Arbeitsaufwand

60 h of classes
 + 120 h private study
 = 180 h (= 9 ECTS)

Modulnote

Sprache English

Lernziele / Kompetenzen

Specialised course in mathematical image analysis.

Participants learn how concepts of differential geometry can be applied in image processing.

Mathematical prerequisites which exceed the basic mathematics courses for Visual Computing students are provided within the lecture.

Inhalt

The course is concerned with modern methods of digital image processing which rely on the differential geometry of curves and surfaces. This includes methods of image enhancement (likesmoothing procedures) as well as feature extraction and segmentation (like locating contours using active contour models).

The course aims at combining theoretical foundation directly with a variety of applications from the above-mentioned fields; the range of topics extends up to recent research problems.

An introduction to the relevant concepts and results from differential geometry will be included in the course.

Topics include:

- curves and surfaces in Euclidean space
- level sets
- curve and surface evolutions
- variational formulations and gradient descents
- diffusion of scalar and non-scalar data
- diffusion on manifolds
- active contours and active regions

Literaturhinweise

- F. Cao, Geometric Curve Evolution and Image Processing. Lecture Notes in Mathematics, vol. 1805, Springer, Berlin 2003.
- R. Kimmel, Numerical Geometry of Images. Springer, Berlin 2004.
- S. Osher, N. Paragios, eds., Geometric Level Set Methods in Imaging, Vision and Graphics. Springer, Berlin 2003.
- G. Sapiro, Geometric Partial Differential Equations and Image Analysis. Cambridge University Press 2001.
- Articles from journals and conferences.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4	at least every two years	1 semester	4	6

Modulverantwortliche/r Prof. Dr. Bernt Schiele

Dozent/inn/en Prof. Dr. Bernt Schiele
Prof. Dr. Mario Fritz

Zulassungsvoraussetzungen keine

Leistungskontrollen / Prüfungen Written or oral exam and the end of the course.

Lehrveranstaltungen / SWS 2 h lectures
+ 2 h tutorial
= 4 h (weekly)

Arbeitsaufwand 60 h of classes
+ 120 h private study
= 180 h (= 6 ECTS)

Modulnote Will be determined from performance in examinations and exercises. The exact modalities will be announced at the beginning of the course.

Sprache English

Lernziele / Kompetenzen

The main goal of the lecture is to develop an understanding of recent and state-of-the-art methods in high level computer vision, which are often based on Deep Neural Networks and Machine Learning.

Inhalt

This course will cover essential techniques for high-level computer vision including deep learning and other modern machine learning methods. These techniques facilitate semantic interpretation of visual data, as it is required for a broad range of applications like robotics, driver assistance, multi-media retrieval, surveillance etc. In this area, the recognition and detection of objects, activities and visual categories have seen dramatic progress over the last decade. We will discuss the methods that have lead to state-of-the-art performance in this area and provide the opportunity to gather hands-on experience with these techniques.

Literaturhinweise

- "Computer Vision: Algorithms and Applications" by Richard Szeliski (in particular chapter on image formation)
- "Pattern recognition and machine learning" by Christopher M. Bishop
- "Computer vision" by David A. Forsyth and Jean Ponce
- Recent Scientific Papers that will be announced during the lecture

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4	at least every two years	1 semester	6	9

Modulverantwortliche/r Prof. Dr. Joachim Weickert

Dozent/inn/en Prof. Dr. Joachim Weickert

Zulassungsvoraussetzungen For graduate students: none

Leistungskontrollen / Prüfungen

- Regular attendance of classes and tutorials.
- At least 50% of all possible points from the weekly assignments have to be gained to qualify for the final exam.
- Passing the final exam
- A re-exam takes place during the last two weeks before the start of lectures in the following semester.

Lehrveranstaltungen / SWS 4 h lectures
+ 2 h tutorial
= 6 h (weekly)

Arbeitsaufwand 90 h of classes
+ 180 h private study
= 270 h (= 9 ECTS)

Modulnote Will be determined from performance in exams, exercises and practical tasks. The exact modalities will be announced at the beginning of the module.

Sprache English

Lernziele / Kompetenzen

Broad introduction to mathematical methods in image processing and computer vision. The lecture qualifies students for a bachelor thesis in this field. Together with the completion of advanced or specialised lectures (9 credits at least) it is the basis for a master thesis in this field.

Inhalt

Inhalt

1. Basics
 - 1.1 Image Types and Discretisation
 - 1.2 Degradations in Digital Images
2. Image Transformations
 - 2.1 Fourier Transform
 - 2.2 Image Pyramids
 - 2.3 Wavelet Transform
3. Colour Perception and Colour Spaces
4. Image Enhancement
 - 4.1 Point Operations
 - 4.2 Linear Filtering
 - 4.3 Wavelet Shrinkage, Median Filtering, M-Smothers
 - 4.4 Mathematical Morphology
 - 4.5 Diffusion Filtering
 - 4.6 Variational Methods

- 4.7 Deblurring
- 5. Feature Extraction
 - 5.1 Edges
 - 5.2 Corners
 - 5.3 Lines and Circles
- 6. Texture Analysis
- 7. Segmentation
 - 7.1 Classical Methods
 - 7.2 Variational Methods
- 8. Image Sequence Analysis
 - 8.1 Local Methods
 - 8.2 Variational Methods
- 9. 3-D Reconstruction
 - 9.1 Camera Geometry
 - 9.2 Stereo
 - 9.3 Shape-from-Shading
- 10. Object Recognition
 - 10.1 Eigenspace Methods
 - 10.2 Moment Invariances

Literaturhinweise

Will be announced before the start of the course on the course page on the Internet.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4	at least every two years	1 semester	4	6

Modulverantwortliche/r Prof. Dr. Bernt Schiele

Dozent/inn/en Prof. Dr. Bernt Schiele

Zulassungsvoraussetzungen keine

Leistungskontrollen / Prüfungen Written or oral exam and the end of the course.

Lehrveranstaltungen / SWS 2 h lectures
+ 2 h tutorial
= 4 h (weekly)

Arbeitsaufwand 60 h of classes
+ 120 h private study
= 180 h (= 6 ECTS)

Modulnote Will be determined from performance in examinations and exercises. The exact modalities will be announced at the beginning of the course.

Sprache English

Lernziele / Kompetenzen

The main goal of the class is to understand the concepts behind graphical models and to give hands-on knowledge such that one is able to design models for computer vision applications but also in other domains. Therefore the lecture is roughly divided in two parts: learning about graphical models and seeing them in action.

Inhalt

This course will introduce the basic concepts of probabilistic graphical models. Graphical Models are a unified framework that allow to express complex probability distributions in a compact way. Many machine learning applications are tackled by the use of these models, in this course we will highlight the possibilities with computer vision applications.

Literaturhinweise

Modulbereich 3

Image Synthesis / Geometric Foundations

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4	At least every two years	1 semester	4	6

Modulverantwortliche/r Prof. Dr. Hans-Peter Seidel

Dozent/inn/en Prof. Dr. Hans-Peter Seidel
Dr. Vahid Babaei

Zulassungsvoraussetzungen Some background in visual computing is recommended but not required.

Leistungskontrollen / Prüfungen Nanoquiz: At the beginning of each lecture, we ask a few questions as a recapitulation of the last class.

Programming Assignment: The assignments give you the opportunity to apply what you have learned in class. It is also a chance for you to let us know about the topics that give you particular difficulty.

Project: You will have the opportunity to see your new learnings applied in a research context. You will start the projects (in groups of two or three) in the middle of the semester and you will present them during the last session and deliver a report.

Exam: There will be an oral exam.

Lehrveranstaltungen / SWS 2 h lectures
+ 2 h tutorial
= 4 h (weekly)

Arbeitsaufwand 60 h of classes
+ 120 h private study
= 180 h (= 6 ECTS)

Modulnote

- Nanoquiz
- Assignments
- Project
- Exam

The exact modalities will be announced at the beginning of the module.

Sprache English

Lernziele / Kompetenzen

After successful completion of this course, you will be able to:

- Explain the fundamental mission of Computational Fabrication, why it is relevant and what is the necessary skill set for successfully applying it to real-world problems.
- Evaluate different representations of geometric models for manufacturing and create easily modifiable shapes.
- Review different manufacturing technologies, with a focus on additive manufacturing (3D printing), and analyze their advantages and disadvantages.
- Analyze the appearance reproduction workflow, including measuring, modeling and fabrication of object's appearance.
- Apply halftoning algorithms to enable printers to approximate continuous inputs, thereby overcoming their inherent binary limitation.
- Understand necessary components for simulating the deformation of solid objects using the finite element method (FEM), including different measures of deformation, constitutive models of materials, and measuring mechanical properties of objects.

Inhalt

- Solid Modeling
- 3D Printing Software Pipeline
- 3D Printing Hardware Pipeline
- Halftoning Algorithms
 - Appearance Printing Pipeline
- Mass Spring Systems
- Continuum Mechanics
- Finite Element Method
- Design Space Exploration

Literaturhinweise

Unfortunately, there is no single textbook covering all materials of this course. We provide reading materials (mostly accessible online) at the end of each lecture.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4	at least every two years	1 semester	6	9

Modulverantwortliche/r Prof. Dr. Philipp Slusallek

Dozent/inn/en Prof. Dr. Philipp Slusallek

Zulassungsvoraussetzungen Solid knowledge of linear algebra is recommended.

Leistungskontrollen / Prüfungen

- Successful completion of weekly exercises (30% of final grade)
- Successful participation in rendering competition (10%)
- Mid-term written exam (20%, final exam prerequisite)
- Final written exam (40%)
- In each of the above a minimum of 50% is required to pass

A re-exam typically takes place during the last two weeks before the start of lectures in the following semester.

Lehrveranstaltungen / SWS 4 h lectures
+ 2 h tutorial
= 6 h (weekly)

Arbeitsaufwand 90 h of classes
+ 180 h private study
= 270 h (= 9 ECTS)

Modulnote The grade is derived from the above assessments. Possible changes will be announced at the beginning of each semester.

Sprache English

Lernziele / Kompetenzen

This course provides the theoretical and practical foundation for computer graphics. It gives a wide overview of topics, techniques, and approaches used in various aspects of computer graphics but has some focus on image synthesis or rendering. The first part of the course uses ray tracing as a driving applications to discuss core topics of computer graphics, from vector algebra all the way to sampling theory, the human visual system, sampling theory, and spline curves and surfaces. A second part then uses rasterization approach as a driving example, introducing the camera transformation, clipping, the OpenGL API and shading language, plus advanced techniques.

As part of the practical exercises the students incrementally build their own ray tracing system. Once the basics have been covered, the students participate in a rendering competition. Here they can implement their favorite advanced algorithm and are asked to generate a high-quality rendered image that shows their techniques in action.

Inhalt

- Introduction
- Overview of Ray Tracing and Intersection Methods
- Spatial Index Structures
- Vector Algebra, Homogeneous Coordinates, and Transformations
- Light Transport Theory, Rendering Equation
- BRDF, Materials Models, and Shading
- Texturing Methods
- Spectral Analysis, Sampling Theory
- Filtering and Anti-Aliasing Methods

- Recursive Ray Tracing & Distribution Ray-Tracing
- Human Visual System & Color Models
- Spline Curves and Surfaces
- Camera Transformations & Clipping
- Rasterization Pipeline
- OpenGL API & GLSL Shading
- Volume Rendering (opt.)

Literaturhinweise

Will be announced in the lecture.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4	at least every two years	1 semester	6	9

Modulverantwortliche/r Prof. Dr. Hans-Peter Seidel

Dozent/inn/en Prof. Dr. Hans-Peter Seidel
Dr. Rhaleb Zayer

Zulassungsvoraussetzungen calculus and basic programming skills

Leistungskontrollen / Prüfungen

- Regular attendance and participation.
- Weekly Assignments (10% bonus towards the course grade; bonus points can only improve the grade; they do not affect passing)
- Passing the written exams (mid-term and final exam).
- The mid-term and the final exam count for 50% each, but 10% bonus from assignments will be added.
- A re-exam takes place at the end of the semester break or early in the next semester.

Lehrveranstaltungen / SWS 4 h lectures
+ 2 h tutorial
= 6 h (weekly)

Practical assignments in groups of 3 students (practice)
Tutorials consists of a mix of theoretical + practical assignments.

Arbeitsaufwand 90 h of classes
+ 180 h private study
= 270 h (= 9 ECTS)

Modulnote Will be based on the performance in exams, exercises and practical tasks. The detailed terms will be announced by the module coordinator.

Sprache English

Lernziele / Kompetenzen

Gaining knowledge of the theoretical aspect of geometric modelling problems, and the practical solutions used for modelling and manipulating curves and surfaces on a computer. From a broader perspective: Learning how to represent and interact with geometric models in a discretized, digital form (geometric representations by functions and samples; design of linear function spaces; finding “good” functions with respect to a geometric modelling task in such spaces).

Inhalt

- Differential geometry Fundamentals
- Interpolation and Approximation
- Polynomial Curves
- Bezier and Rational Bezier Curves
- B-splines, NURBS
- Spline Surfaces
- Subdivision and Multiresolution Modelling
- Mesh processing
- Approximation of differential operators
- Shape Analysis and Geometry Processing

Literaturhinweise

Will be announced before the term begins on the lecture website.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4	at least every two years	1 semester	2	3

Modulverantwortliche/r Dr. Karol Myszkowski

Dozent/inn/en Dr. Karol Myszkowski

Zulassungsvoraussetzungen Computer graphics, image processing, and the related math.

Leistungskontrollen / Prüfungen Regular attendance of lecture. Written exam at the end of the course.

Lehrveranstaltungen / SWS 2 h lectures
= 2 h (weekly)

Arbeitsaufwand 30 h of classes
+ 60 h private study
= 90 h (= 3 ECTS)

Modulnote Will be determined from performance in examinations. The exact modalities will be announced at the beginning of the module.

Sprache English

Lernziele / Kompetenzen

The target audience are students in computer science or related fields. This course covers topics from psychology and physiology that are relevant to computer graphics, and novel perception research and applications in computer graphics and vision. The objective is to transfer knowledge, experience and competencies that are required for doing research in perceptual computer graphics, and that are useful in many related fields, such as experimental psychology, or usability studies in human-computer interaction.

Inhalt

As computer graphics is producing images and videos that are ultimately perceived by a human, it's mandatory to account for how the human visual system (HVS) is processing this information. The HVS is complex, exhibiting many non-linearities as well as feedback and is only partially understood. While this poses a challenge, it can also be seen as an opportunity which can be exploited in image compression, watermarking, denoising, enhancement, upsampling, etc. Computational models which can predict the human response to the distortion of visual content are important when this opportunity is taken. To this end, our course covers the basic theory of perception research, including:

- What is perception?
- Designing experiments,
- Analysis and statistics,

and the practical applications in computer graphics, including:

- Eye physiology and image formation,
- Brightness and contrast,
- Color,
- High dynamic range and tone reproduction,
- Image compression and image quality,
- Depth and shape perception,
- Material perception.

Literaturhinweise

The following list contains the most relevant books for this lecture:

- Vision Science: Photons to Phenomenology, Stephen E. Palmer, The MIT Press, 2002.
- Foundations of Vision, Brian A. Wandell, Sinauer Associates, Inc., 1995.
- Seeing: The Computational Approach to Biological Vision, John P. Frisby and James V. Stone, The MIT Press, 2010.
- Experimental Design: From User Studies to Psychophysics, Douglas W. Cunningham and Christian Wallraven, A K Peters/CRC Press, 2011.
- Seeing in Depth: Basic Mechanics (Vol. 1) and Seeing in Depth: Depth Perception (Vol. 2), Ian P. Howard and Brian J. Rogers, Oxford Psychology Series, 2012.
- Visual Perception from a Computer Graphics Perspective, William Thompson, Roland Fleming, Sarah Creem-Regehr and Jeanine Kelly Stefanucci, A K Peters/CRC Press, 2011.
- High Dynamic Range Imaging: Acquisition, Display, and Image-Based Lighting, Erik Reinhard, Greg Ward, Paul Debevec, Sumanta Pattanaik, Wolfgang Heidrich and Karol Myszkowski, Morgan Kaufmann Publishers, 2nd edition, 2010.
- High Dynamic Range Video, Karol Myszkowski, Rafal Mantiuk and Grzegorz Krawczyk. Synthesis Digital Library of Engineering and Computer Science. Morgan & Claypool Publishers, San Rafael, USA, 2008.
- Color Imaging: Fundamentals and Applications Erik Reinhard, Erum Arif Khan, Ahmet Oguz Akyuz and Garrett M. Johnson, A K Peters, 2007.
- High Dynamic Range Imaging: an article in Wiley Encyclopedia of Electrical and Electronics Engineering 2015.

Further literature will be announced during the course.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	4	at least every two years	1 semester	6	9

Modulverantwortliche/r Prof. Dr. Philipp Slusallek

Dozent/inn/en Prof. Dr. Philipp Slusallek
Dr. Karol Myszkowski
Guprit Singh

Zulassungsvoraussetzungen Related core lecture: *Computer Graphics*.

Leistungskontrollen / Prüfungen

- Theoretical and practical exercises (50% of the final grade)
- Final oral exam (other 50%)
- A minimum of 50% of needs to be achieved in each part to pass.
- A re-exam takes place during the last two weeks before the start of lectures in the following semester.

Lehrveranstaltungen / SWS 4 h lectures
+ 2 h tutorial
= 6 h (weekly)

Arbeitsaufwand 90 h of classes
+ 180 h private study
= 270 h (= 9 ECTS)

Modulnote The final grade is be based on the assessments above. Any changes will be announced at the beginning of the semester.

Sprache English

Lernziele / Kompetenzen

At the core of computer graphics is the requirement to render highly realistic and often even physically-accurate images of virtual 3D scenes. In this lecture students will learn about physically-based lighting simulation techniques to compute the distribution of light even in complex environment. The course also covers issues of perception of images, including also HDR technology, display technology, and related topics.

After this course students should be able to build their own highly realistic but also efficient rendering system.

Inhalt

- Rendering Equation
- Radiosity and Finite-Element Techniques
- Probability Theory
- Monte-Carlo Integration & Importance Sampling
- Variance Reduction & Advanced Sampling Techniques
- BRDFs and Inversion Methods
- Path Tracing & * Bidirectional Path Tracing
- Virtual Point-Light Techniques
- Density Estimation & Photon Mapping
- Vertex Connection & Merging
- Path Guiding
- Spatio-Temporal Sampling & Reconstruction
- Approaches for Interactive Global Illumination
- Machine Learning Techniques in Rendering

- Human Perception
- HDR & Tone-Mapping
- Modern Display Technology
- Perception-Based Rendering

Literaturhinweise

Literature will be announced in the first lecture of the semester.

But here are some relevant text books:

- Pharr, Jakob, Humphreys, Physically Based Rendering : From Theory to Implementation, Morgan Kaufmann
- Shirley et al., Realistic Ray Tracing, 2. Ed., AK. Peters, 2003
- Jensen, Realistic Image Synthesis Using Photon Mapping, AK. Peters, 2001
- Dutre, et al., Advanced Global Illumination, AK. Peters, 2003
- Cohen, Wallace, Radiosity and Realistic Image Synthesis, Academic Press, 1993
- Apodaca, Gritz, Advanced Renderman: Creating CGI for the Motion Pictures, Morgan Kaufmann, 1999
- Ebert, Musgrave, et al., Texturing and Modeling, 3. Ed., Morgan Kaufmann, 2003
- Reinhard, Ward, Pattanaik, Debevec, Heidrich, Myszkowski, High Dynamic Range Imaging, Morgan Kaufmann Publishers, 2nd edition, 2010.
- Myszkowski, Mantiuk, Krawczyk. High Dynamic Range Video. Synthesis Digital Library of Engineering and Computer Science. Morgan & Claypool Publishers, San Rafael, USA, 2008.
- Glassner, Principles of Digital Image Synthesis, 2 volumes, Morgan Kaufman, 1995

Modulbereich 4

Image Related Fields

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	winter semester	1 semester	6	9

Modulverantwortliche/r Prof. Dr. Jörg Hoffmann

Dozent/inn/en Prof. Dr. Jörg Hoffmann

Zulassungsvoraussetzungen For graduate students: none

Leistungskontrollen / Prüfungen Regular attendance of classes and tutorial
Paper as well as programming exercises for exam qualification
Final exam
A re-exam takes place before the start of lectures in the following semester.

Lehrveranstaltungen / SWS 4 h lectures
+ 2 h tutorial
= 6 h (weekly)

Arbeitsaufwand 90 h of classes
+ 180 h private study
= 270 h (= 9 ECTS)

Modulnote Will be determined from performance in exams, exercises and practical tasks. The exact modalities will be announced at the beginning of the module.

Sprache English

Lernziele / Kompetenzen

The students will gain a deep understanding of algorithms used in Automatic Planning for the efficient exploration of large state spaces, from both a theoretical and practical point of view. The programming exercises will familiarize them with the main implementation basis in Automatic Planning. The search algorithms are generic and are relevant also in other CS sub-areas in which large transition systems need to be analyzed.

Inhalt

Automatic Planning is one of the fundamental sub-areas of Artificial Intelligence, concerned with algorithms that can generate strategies of action for arbitrary autonomous agents in arbitrary environments. The course examines the technical core of the current research on solving this kind of problem, consisting of paradigms for automatically generating heuristic functions (lower bound solution cost estimators), as well as optimality-preserving pruning methods. Apart from understanding these techniques themselves, the course explains how to analyze, combine, and compare them.

Starting from an implementation basis provided, students implement their own planning system as part of the course. The course is concluded by a competition between these student systems.

Literaturhinweise

Will be announced before the start of the course on the course page on the Internet.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	at least every two years	1 semester	6	9

Modulverantwortliche/r Prof. Dr. Jörg Hoffmann

Dozent/inn/en Prof. Dr. Jörg Hoffmann
Prof. Dr. Jana Köhler

Zulassungsvoraussetzungen For graduate students: none

Leistungskontrollen / Prüfungen

- Regular attendance of classes and tutorials
- Solving of weekly assignments
- Passing the final written exam
- A re-exam takes place during the last two weeks before the start of lectures in the following semester.

Lehrveranstaltungen / SWS 4 h lectures
+ 2 h tutorial
= 6 h (weekly)

Arbeitsaufwand 90 h of classes
+ 180 h private study
= 270 h (= 9 ECTS)

Modulnote Will be determined from the performance in exams. The exact modalities will be announced at the beginning of the module.

Sprache English

Lernziele / Kompetenzen

Knowledge about basic methods in Artificial Intelligence

Inhalt

Problem-solving:

- Uninformed- and informed search procedures
- Adversarial search

Knowledge and reasoning:

- Propositional logic
- SAT
- First-order logic, Inference in first-order logic
- Knowledge representation, Semantic Web
- Default logic, rule-based mechanisms

Planning:

- STRIPS formalism and complexity
- Delete relaxation heuristics

Probabilistic reasoning:

- Basic probabilistic methods
- Bayesian networks

Literaturhinweise

Russel & Norvig Artificial Intelligence: A Modern Approach;
further reading will be announced before the start of the course on the course page on the Internet.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	at least every two years	1 semester	6	9

Modulverantwortliche/r Prof. Dr.-Ing. Thorsten Herfet

Dozent/inn/en Prof. Dr.-Ing. Thorsten Herfet

Zulassungsvoraussetzungen Solid foundation of mathematics (differential and integral calculus) and probability theory. The course will build on the mathematical concepts and tools taught in TC I while trying to enable everyone to follow and to fill gaps by an accelerated study of the accompanying literature. *Signals and Systems* as well as *Digital Transmission and Signal Processing (TC I)* are strongly recommended but not required. Related core lecture *Digital Transmission and Signal Processing (TC I)*

Leistungskontrollen / Prüfungen Regular attendance of classes and tutorials Passing the final exam
Oral exam directly succeeding the course. Eligibility: Weekly excersises / task sheets, grouped into two blocks corresponding to first and second half of the lecture. Students must provide min. 50% grade in each of the two blocks to be eligible for the exam.

Lehrveranstaltungen / SWS 4 h lectures
+ 2 h tutorial
= 6 h (weekly)

Arbeitsaufwand 90 h of classes
+ 180 h private study
= 270 h (= 9 ECTS)

Modulnote Final Exam Mark

Sprache English

Lernziele / Kompetenzen

AVCN will deepen the students' knowledge on modern communications systems and will focus on wireless systems.

Since from a telecommunications perspective the combination of audio/visual data – meaning inherently high data rate and putting high requirements on the realtime capabilities of the underlying network – and wireless transmission – that is unreliable and highly dynamic with respect to the channel characteristics and its capacity – is the most demanding application domain.

Inhalt

As the basic principle the course will study and introduce the building blocks of wireless communication systems. Multiple access schemes like TDMA, FDMA, CDMA and SDMA are introduced, antennas and propagation incl. link budget calculations are dealt with and more advanced channel models like MIMO are investigated. Modulation and error correction technologies presented in Telecommunications I will be expanded by e.g. turbo coding and receiver architectures like RAKE and BLAST will be introduced. A noticeable portion of the lecture will present existing and future wireless networks and their extensions for audio/visual data. Examples include 802.11n and the terrestrial DVB system (DVB-T2).

Literaturhinweise

Will be announced before the start of the course on the course page on the Internet.

Weitere Informationen

This module was formerly also known as *Telecommunications II*.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	at least every two years	1 semester	6	9

Modulverantwortliche/r Prof. Dr.-Ing. Thorsten Herfet

Dozent/inn/en Prof. Dr.-Ing. Thorsten Herfet

Zulassungsvoraussetzungen The lecture requires a solid foundation of mathematics (differential and integral calculus) and probability theory. The course will, however, refresh those areas indispensably necessary for telecommunications and potential intensification courses and by this open this potential field of intensification to everyone of you.

Leistungskontrollen / Prüfungen Regular attendance of classes and tutorials
 Passing the final exam in the 2nd week after the end of courses.
 Eligibility: Weekly exercises / task sheets, grouped into two blocks corresponding to first and second half of the lecture. Students must provide min. 50% grade in each of the two blocks to be eligible for the exam.

Lehrveranstaltungen / SWS 4 h lectures
 + 2 h tutorial
 = 6 h (weekly)

Arbeitsaufwand 90 h of classes
 + 180 h private study
 = 270 h (= 9 ECTS)

Modulnote Final exam mark

Sprache English

Lernziele / Kompetenzen

Digital Signal Transmission and Signal Processing refreshes the foundation laid in "Signals and Systems" [Modulkennung]. Including, however, the respective basics so that the various facets of the introductory study period (Bachelor in Computer Science, Vordiplom Computer- und Kommunikationstechnik, Elektrotechnik or Mechatronik) and the potential main study period (Master in Computer Science, Diplom-Ingenieur Computer- und Kommunikationstechnik or Mechatronik) will be paid respect to.

Inhalt

As the basic principle, the course will give an introduction into the various building blocks that modern telecommunication systems do incorporate. Sources, sinks, source and channel coding, modulation and multiplexing are the major keywords, but we will also deal with dedicated pieces like A/D- and D/A-converters and quantizers in a little bit more depth.

The course will refresh the basic transformations (Fourier, Laplace) that give access to system analysis in the frequency domain, it will introduce derived transformations (z, Hilbert) for the analysis of discrete systems and modulation schemes and it will briefly introduce algebra on finite fields to systematically deal with error correction schemes that play an important role in modern communication systems.

Literaturhinweise

Will be announced before the start of the course on the course page on the Internet.

Weitere Informationen

This module was formerly also known as *Telecommunications I*.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	every winter semester	1 semester	6	9

Modulverantwortliche/r Prof. Dr. Jörg Hoffmann
 Prof. Dr. Jens Dittrich
 Prof. Dr. Bernt Schiele
 Prof. Dr. Vera Demberg

Dozent/inn/en Prof. Dr. Jörg Hoffmann
 Prof. Dr. Jens Dittrich
 Prof. Dr. Bernt Schiele
 Prof. Dr. Vera Demberg

Zulassungsvoraussetzungen keine

Leistungskontrollen / Prüfungen Weekly assignments,
 Exam (qualification for exam depends on performance in assignments)

Lehrveranstaltungen / SWS 4 h lectures
 + 2 h tutorial
 = 6 h (weekly)

Arbeitsaufwand 90 h of classes
 + 180 h private study
 = 270 h (= 9 ECTS)

Modulnote Based on exam. The exact modalities are specified by the lecturers.

Sprache English

Lernziele / Kompetenzen

Overview of challenges and methods in Data Science and AI. Basic knowledge of key concepts and algorithms.

Inhalt

Introduction to history and concepts of Data Science and AI

- Machine Learning (supervised, unsupervised, reinforcement, neural networks)
- (adversarial) Search, Planning
- Reasoning
- Modeling and Simulation
- Data Management, Big Data Engineering, and Analytics

The methods will be covered in the context of applications, such as Game Playing, Computer Vision, Autonomous Driving, Language Processing, Social Networks.

The exercises will cover methodological, algorithmic, as well as practical aspects. Where basic programming or scripting skills are required, the lecture and exercises will introduce these skills.

Literaturhinweise

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	jedes Wintersemester	1 Semester	4	6

Modulverantwortliche/r Prof. Dr. Tobias Marschall

Dozent/inn/en Prof. Dr. Tobias Marschall
Prof. Dr. Bernt Schiele
Prof. Dr. Jilles Vreeken

Zulassungsvoraussetzungen Die Vorlesung setzt grundlegende Kenntnisse in Statistik und linearer Algebra voraus. Ist deshalb ratsam, MfI2 und das Statistics Lab erfolgreich abgeschlossen zu haben. Die Übungen verwenden die Programmiersprache R und grundlegende Kenntnisse sind hilfreich. Zur Vorbereitung sind die folgenden Materialien nützlich: „R for Beginners“ von Emmanuel Paradis (insbesondere Kapitel 1, 2, 3 und 6) und „An introduction to R“ (Venables/Smith).

Leistungskontrollen / Prüfungen Voraussetzung zur Zulassung zur Prüfung sind 50% der Punkte der theoretischen und praktischen Aufgaben auf den Übungsblättern. Die Prüfungen finden, je nach Teilnehmerzahl, schriftlich oder mündlich statt. Die genauen Modalitäten werden in den ersten zwei Wochen der Vorlesung bekannt gegeben.

Lehrveranstaltungen / SWS 2 SWS Vorlesung
+ 2 SWS Übung
= 4 SWS

Arbeitsaufwand 60 h Präsenzstudium
+ 120 h Eigenstudium
= 180 h (= 6 ECTS)

Modulnote Siehe "Leistungskontrollen/Prüfungen"

Sprache English

Lernziele / Kompetenzen

In diesem Kurs werden grundlegende Konzepte des maschinellen Lernens behandelt, wobei der Schwerpunkt auf statistischen Methoden liegt. Der Kurs vermittelt die nötigen Fähigkeiten um für einen gegebenen Datensatz geeignete statistische Methoden für dessen Analyse auszuwählen, anzuwenden, und die Qualität der Resultate zu bewerten. Der Kurs behandelt sowohl theoretische als auch praktische Aspekte des maschinellen Lernens, legt den Fokus jedoch auf praktische Aspekte.

Die Vorlesung folgt im Großen und Ganzen dem Buch "An Introduction to Statistical Learning with Applications in R (2013)". In einigen Fällen erhält der Kurs zusätzliches Material aus dem Buch The Elements of Statistical Learning, Springer (second edition, 2009). Das erste Buch ist der einleitende Text, das zweite behandelt fortgeschrittenere Themen. Beide Bücher sind als kostenlose PDFs erhältlich. Es wird durchschnittlich eine Vorlesung pro Woche (90 Minuten) und alle zwei Wochen (90 Minuten) ein Tutorium angeboten.

Inhalt

Die Vorlesung behandelt grundlegende Methoden des maschinellen Lernens, insbesondere folgende Inhalte:

- Introduction to statistical learning
- Overview over Supervised Learning
- Linear Regression
- Linear Classification

- Splines
- Model selection and estimation of the test errors
- Maximum-Likelihood Methods
- Additive Models
- Decision trees
- Boosting
- Dimensionality reduction
- Unsupervised learning

Literaturhinweise

Weitere Informationen

Die Inhalte sind größtenteils identisch mit der Vorlesung, die in der Vergangenheit unter dem Namen *Elements of Statistical Learning* angeboten wurde.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	at least every two years	1 semester	6	9

Modulverantwortliche/r Prof. Dr. Jürgen Steimle

Dozent/inn/en Prof. Dr. Jürgen Steimle

Zulassungsvoraussetzungen undergraduate students: *Programmierung 1* and *2*
graduate students: none

Leistungskontrollen / Prüfungen Regular attendance of classes and tutorials
Successful completion of exercises and course project
Final exam
A re-exam takes place (as written or oral examination).

Lehrveranstaltungen / SWS 4 h lectures
+ 2 h tutorial
= 6 h (weekly)

Arbeitsaufwand 90 h of classes
+ 180 h private study
= 270 h (= 9 ECTS)

Modulnote Will be determined from performance in exams, exercises and practical tasks. The exact modalities will be announced at the beginning of the module.

Sprache English

Lernziele / Kompetenzen

This course teaches the theoretical and practical foundations for human computer interaction. It covers a wide overview of topics, techniques and approaches used for the design and evaluation of modern user interfaces.

The course covers the principles that underlie successful user interfaces, provides an overview of input and output devices and user interface types, and familiarizes students with the methods for designing and evaluating user interfaces. Students learn to critically assess user interfaces, to design user interfaces themselves, and to evaluate them in empirical studies.

Inhalt

- Fundamentals of human-computer interaction
- User interface paradigms, input and output devices
- Desktop & graphical user interfaces
- Mobile user interfaces
- Natural user interfaces
- User-centered interaction design
- Design principles and guidelines
- Prototyping

Literaturhinweise

Will be announced before the start of the course on the course page on the Internet.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	at least every two years	1 semester	6	9

Modulverantwortliche/r Prof. Dr. Gerhard Weikum

Dozent/inn/en Prof. Dr. Gerhard Weikum

Zulassungsvoraussetzungen Good knowledge of undergraduate mathematics (linear algebra, probability theory) and basic algorithms.

Leistungskontrollen / Prüfungen

- Regular attendance of classes and tutor groups
- Presentation of solutions in tutor groups
- Passing 2 of 3 written tests (after each third of the semester)
- Passing the final exam (at the end of the semester)

Lehrveranstaltungen / SWS 4 h lectures
+ 2 h tutorial
= 6 h (weekly)

Arbeitsaufwand 90 h of classes
+ 180 h private study
= 270 h (= 9 ECTS)

Modulnote Will be determined by the performance in written tests, tutor groups, and the final exam. Details will be announced on the course web site.

Sprache English

Lernziele / Kompetenzen

The lecture teaches models and algorithms that form the basis for search engines and for data mining and data analysis tools.

Inhalt

Information Retrieval (IR) and Data Mining (DM) are methodologies for organizing, searching and analyzing digital contents from the web, social media and enterprises as well as multivariate datasets in these contexts. IR models and algorithms include text indexing, query processing, search result ranking, and information extraction for semantic search. DM models and algorithms include pattern mining, rule mining, classification and recommendation. Both fields build on mathematical foundations from the areas of linear algebra, graph theory, and probability and statistics.

Literaturhinweise

Will be announced on the course web site.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	at least every two years	1 semester	6	9

Modulverantwortliche/r Prof. Dr. Isabel Valera

Dozent/inn/en Prof. Dr. Isabel Valera

Zulassungsvoraussetzungen The lecture gives a broad introduction into machine learning methods. After the lecture the students should be able to solve and analyze learning problems.

Leistungskontrollen / Prüfungen

- Regular attendance of classes and tutorials.
- 50% of all points of the exercises have to be obtained in order to qualify for the exam.
- Passing 1 out of 2 exams (final, re-exam).

Lehrveranstaltungen / SWS 4 h lectures
+ 2 h tutorial
= 6 h (weekly)

Arbeitsaufwand 90 h of classes
+ 180 h private study
= 270 h (= 9 ECTS)

Modulnote Determined from the results of the exams, exercises and potential projects. The exact grading modalities are announced at the beginning of the course.

Sprache English

Lernziele / Kompetenzen

The lecture gives a broad introduction into machine learning methods. After the lecture the students should be able to solve and analyze learning problems.

Inhalt

- Bayesian decision theory
- Linear classification and regression
- Kernel methods
- Bayesian learning
- Semi-supervised learning
- Unsupervised learning
- Model selection and evaluation of learning methods
- Statistical learning theory
- Other current research topics

Literaturhinweise

Will be announced before the start of the course on the course page on the Internet.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	winter semester	1 semester	4	9

Modulverantwortliche/r Prof. Dr.-Ing. Thorsten Herfet

Dozent/inn/en Prof. Dr.-Ing. Thorsten Herfet

Zulassungsvoraussetzungen For graduate students: none

Leistungskontrollen / Prüfungen Regular attendance of classes and tutorial.
Paper as well as programming exercises for exam qualification
Final exam
A re-exam takes place before the start of lectures in the following semester

Lehrveranstaltungen / SWS 3 h lectures
+ 1 h tutorial
= 4 h (weekly)

Arbeitsaufwand 60 h of classes
+ 90 h private study
+ 120 h programming exercise
= 270 h (= 9 ECTS)

Modulnote Graded absolute 1.0-n.b. and relative A-F

Sprache English

Lernziele / Kompetenzen

The course deals with Media Transport over the Internet. After the course students know how data- and mediatransport is solved in today's Internet and have a good understanding of so called erasure channels.

Besides the pure transport protocol design the course complements the fundamentals laid in TCI and TCII by introducing state-of-the-art error codes (Van-der-Monde-Codes, Fountain Codes) and by engineering tasks like the design of a Digital PLL.

Inhalt

The course introduces media transmission over packet channels, specifically the Internet. After establishing a Quality of Service framework built on ITU requirements the course models erasure channels without and with memory. Key characteristics like the channel capacity and the minimum redundancy information are derived.

The second part of the course introduces current media transport protocol suites (TCP, UDP, RTP, RTSP) and middleware (ISMA, DLNA, UPnP, DVB-IPI).

In the second half of the course audiovisual coders used in the Internet are introduced (H.264, AAC), state-of-the-art forward error coding schemes (Van-der-Monde-Codes, Fountain Codes) are explained and essential elements like a Digital Phase-locked Loop are developed.

Literaturhinweise

The course will come with a self contained manuscript. The most essential monographs used for and referenced within the manuscript are available in the Computer Science Library of Saarland University.

Weitere Informationen

This module was formerly also known as *Future Media Internet*.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	every winter semester	1 semester	4	6

Modulverantwortliche/r Prof. Dr. Dietrich Klakow

Dozent/inn/en Prof. Dr. Dietrich Klakow

Zulassungsvoraussetzungen *Mathematik für Informatiker I - III* or comparable; good programming skills.

Leistungskontrollen / Prüfungen Written Exam

Lehrveranstaltungen / SWS 2 h lectures
+ 2 h tutorial
= 4 h (weekly)

Arbeitsaufwand 60 h of classes
+ 120 h private study
= 180 h (= 6 ECTS)

Modulnote Based on written exam. Exact details will be announced in the first lecture.

Sprache English

Lernziele / Kompetenzen

The participants will be introduced to the key ideas of basic classification algorithms and in particular neural networks. A focus is also the implementation and applications to relevant problems.

Inhalt

- Classification
- Regression
- Linear Classifiers
- Perceptron
- Support Vector Machines
- Multy-Layer Perceptrons
- Deep Learning Software
- Autoencoders
- LSTMs
- Recurrent Neural Networks
- Sequence-to-sequence learning

Literaturhinweise

Ian Goodfellow and Yoshua Bengio and Aaron Courville
Deep Learning
MIT Press, 2016
<http://www.deeplearningbook.org>

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	every summer semester	1 semester	4	6

Modulverantwortliche/r Prof. Dr. Dietrich Klakow

Dozent/inn/en Prof. Dr. Dietrich Klakow

Zulassungsvoraussetzungen For graduate students: none

Leistungskontrollen / Prüfungen Written Exam

Lehrveranstaltungen / SWS 2 h lectures
+ 2 h tutorial
= 4 h (weekly)

Arbeitsaufwand 60 h of classes
+ 120 h problem solving and private study
= 180 h (= 6 ECTS)

Modulnote Final Exam Mark

Sprache English

Lernziele / Kompetenzen

Acquire core competencies in the mathematical basics of language processing and practice the implementation of essential methods.

Inhalt

- language processing: basic terms
- mathematical foundations
- word sense disambiguation
- part-of-speech tagging
- named-entity recognition
- information retrieval
- text classification

Literaturhinweise

Chris Manning and Hinrich Schütze
Foundations of Statistical Natural Language Processing

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	every summer semester	1 semester	2	6

Modulverantwortliche/r Prof. Dr. Jilles Vreeken

Dozent/inn/en Prof. Dr. Jilles Vreeken

Zulassungsvoraussetzungen a background in statistics, machine learning, and/or data mining is strongly recommended (e.g. *Elements of Machine Learning*, *Elements of Statistical Learning*, *Machine Learning*, or *Information Retrieval and Data Mining*)

Leistungskontrollen / Prüfungen oral exam and written assignments

Lehrveranstaltungen / SWS 2 h lectures
= 2 h (weekly)

Arbeitsaufwand 30 h of classes
+ 150 h private study
= 180 h (= 6 ECTS)

Modulnote Will be determined from performance in examinations and exercises. The exact modalities will be announced at the beginning of the module.

Sprache English

Lernziele / Kompetenzen

- Thorough understanding of selected advanced topics in data analysis.
- Ability to quickly understand the main gist in scientific literature, without getting lost in details, critically assessing claims, seeing through the hype.
- Ability to comparatively analyse and reason about (seemingly disparate) concepts and methods, quickly developing meta-level understanding of advanced topics.

Inhalt

During the course we consider hot topics in machine learning and data mining that are also important to understand deeply. The exact topics we will cover will differ per year, but for example often include aspects of Pattern Discovery, Dependency Discovery, Causal Inference, and Fairness.

Literaturhinweise

Recent scientific publications from the top venues in machine learning and data mining.

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	jedes Sommersemester	1 Semester	2	3

Modulverantwortliche/r Prof. Dr. Christian Boller

Dozent/inn/en Prof. Dr. Christian Boller

Zulassungsvoraussetzungen keine

Leistungskontrollen / Prüfungen Schriftliche Klausur am Ende des Moduls (Dauer 2 Stunden)

Lehrveranstaltungen / SWS 2 SWS Vorlesung
= 2 SWS

Arbeitsaufwand 30 h Präsenzstudium
+ 60 h Eigenstudium
= 90 h (= 3 ECTS)

Modulnote Wird aus Leistungen in Klausur primär ermittelt. Praktische Übungsaufgaben können bis zu 20% ergänzend einfließen. Die genauen Modalitäten werden zu Beginn der Veranstaltung bekannt gegeben.

Sprache Deutsch

Lernziele / Kompetenzen

Erlernen und verstehen akustischer (mechanischer) und elektromagnetischer Prüfverfahren

Inhalt

Einführung:

Was ist zerstörungsfreie Prüfung? Warum ZfP? Qualitätssicherung, Schadenstolerantes Bauen

Schwingungen:

Harmonische ungedämpfte Schwingung einer federnd gelagerten Masse; Periodische Funktionen und Fourier-Analyse; Nutzung der harmonischen Schwingungen zur Schadensanalyse (elementare Modalanalyse) durch Ableitung der Verformungsgleichungen am Biegebalken; Modalanalyse am delaminierten Biegebalken; Gekoppelte Schwingungen; Steifigkeitsmatritzen; Viskos gedämpfte Schwingung und Dämpfung als Parameter; Anwendungen der Modalanalyse; Freie Seilschwingungen; Wellengleichung und Wellenausbreitung; Seilschwingungen auf elastischer Basis; Wellenausbreitung auf elastischer Basis und Dispersion; Phasengeschwindigkeit und Gruppengeschwindigkeit.

Akustik und Ultraschall:

Elementare Wellenformen: Longitudinalwellen, Transversalwellen, Oberflächenwellen, Volumenwellen; Parameter der Wellenausbreitung (Amplitude, Frequenz, Phase, Geschwindigkeit, etc.); Eindimensionale Wellenausbreitung; Wellenausbreitung und Steifigkeit; Akustische Impedanz; Räumliche Wellenausbreitung; Reflexion und Transmission; Snellius'sches Brechungsgesetz; Parameter des Schalls (Geschwindigkeit, Intensität, Dämpfung, Temperatur); Schwingungsformen und Frequenzspektrum; Akustische Schwingungen und mechanische Spannungen wie Spannungsanalyse (1D, 2D, 3D), Umwandlung von Spannungen in Dehnungen, Spannungstensoren, Verallgemeinertes Hooke'sches Gesetz, Anisotropie; Geführte Wellen (Oberflächenwellen, Plattenwellen); Piezoelektrischer Effekt zur Schallerzeugung; Piezoelektrische Wandler (Aufbau, Kopplung); Schallausbreitung (Nahfeld, Fernfeld, Abstrahlverhalten); Fehlererkennung (Wellenlänge vs. Fehlergröße); Formen der US-Prüfung (Pitch-Catch vs. Puls-Echo); Bedeutung des Einschallwinkels; Aufbau eines Ultraschallprüfgeräts; Fehlerprüfung (6 dB-Methode, Ersatzfehlergrößen, AVG-Diagramm); Darstellung von US-Ergebnissen (A-, B-, C- und D-Diagramm, 3D-Visualisierung); Prüfung mit Gruppenstrahlern (Phased Array); Synthetic Aperture Focussing Technique (SAFT); Ausbreitung von Ultraschallwellen; Time of Flight Diffraction (TOFD); Detektion von Rissen (Inspektionsstrategien, Fehlermöglichkeiten); Luftultraschall; Laser-induzierter Ultraschall; Elektromagnetisch induzierter Ultraschall (EMUS); Prüfung mit Ultraschall (Beispiele): Schweißnähte,

Schichtdicken (z.B. Härtetiefen), Eisenbahnachsen, Eisenbahnräder, Lichtmaste, Pipelines, Prüfung heißer Rohre, Akustisches Mikroskop; Zukunft des Ultraschalls – Structural Health Monitoring

Magnetik:

Magnete und Magnetfelder; Spulen; Ursachen der Magnetik (Atommodelle); Magnetische Induktion (Permeabilität, Induktivität, Hall-Effekt, Giant Magnetic Resistors (GMR)); Hauptarten des Magnetismus (Ferromagnetismus, Paramagnetismus, Diamagnetismus); Magnetische Hysterese; Erzeugen von Magnetfeldern; Superposition von Magnetfeldern; Messung von Magnetfeldern; Magnetisches Prüfkonzept; Magnetisierung und Mikrostruktur (Domänen, Bloch-Wände, Weiß'sche Bezirke, etc.); Permeabilität; Streufluss; Oberwellenanalyse; Barkhausenrauschen; Wirbelstromimpedanz; 3MA-Konzept und seine Anwendungen: Spannungsmessungen (1D, 2D, Eigenspannungen), Härtemessung, Härtetiefe, Schleifbrand, Restaustenit, Simultane Messungen; Weitere Anwendungsbeispiele: Materialversprödung, Plastische Dehnung; Magnetische Kraftmikroskopie (Magnetik auf der Mikroebene): Schichtdicken, Eigenspannungen.

Wirbelstrom:

Induktivität (Faraday-Regel); Selbstinduktivität; Induzierter Widerstand (Lenz'sche Regel); Elektrische Impedanz; Prinzip des Wirbelstroms; Wirbelstrom in Medien; Eindringtiefe (Skin-Effekt); Impedanzebenen und Interpretation; Messprinzip des Wirbelstroms: Messaufbau, Spulen, Absolut- versus Differenzprüfköpfen, Magnetfeldbeeinflussung, Kalibrieren, Analoggeräte: Anwendungsbeispiele: Werkstoffdetektion (Verwuchslungsprüfung), Dickenprüfung, Kohlefaserverbundprüfung, Charakterisierung von Korrosionszuständen.

Literaturhinweise

www.ndt.net

www.ndt-ed.org

A. Erhard, 2014: Verfahren der zerstörungsfreien Materialprüfung; DGZfP (Hrsg.); DVS Media GmbH

Jiles D.C., 2008: Principles of Materials Evaluation; CRC Press, Taylor & Francis, Boca Raton/FL, USA

Modulbereich 5

Seminars

Seminar

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	jedes Semester	1 Semester	2	7

Modulverantwortliche/r Studiendekan der Fakultät Mathematik und Informatik
Studienbeauftragter der Informatik

Dozent/inn/en Professoren der Fachrichtung

Zulassungsvoraussetzungen Grundlegende Kenntnisse im jeweiligen Teilbereich der Studienganges.

Leistungskontrollen / Prüfungen

- Beiträge zur Diskussion
- Thematischer Vortrag
- Schriftliche Ausarbeitung
- Mündliche Abschlussprüfung über das gesamte Themengebiet

Lehrveranstaltungen / SWS 2 SWS Seminar

Arbeitsaufwand 30 h Präsenzstudium
+ 180 h Eigenstudium
= 210 h (= 7 ECTS)

Modulnote Die Modalitäten der Notenvergabe werden vom verantwortlichen Hochschullehrer festgelegt.

Sprache Deutsch oder Englisch

Lernziele / Kompetenzen

Die Studierenden haben am Ende der Veranstaltung ein tiefes Verständnis aktueller oder fundamentaler Aspekte eines spezifischen Teilbereiches der Informatik erlangt.

Sie haben Kompetenz im eigenständigen wissenschaftlichen Recherchieren, Einordnen, Zusammenfassen, Diskutieren, Kritisieren und Präsentieren von wissenschaftlichen Erkenntnissen gewonnen.

Inhalt

Praktisches Einüben von

- reflektierender wissenschaftlicher Arbeit,
- Analyse und Bewertung wissenschaftlicher Aufsätze,
- Verfassen eigener wissenschaftlicher Zusammenfassungen
- Diskussion der Arbeiten in der Gruppe
- Erarbeiten gemeinsamer Standards für wissenschaftliches Arbeiten
- Präsentationstechnik

Spezifische Vertiefung in Bezug auf das individuelle Thema des Seminars.

Der typische Ablauf eines Seminars ist wie folgt:

- Vorbereitende Gespräche zur Themenauswahl
- Regelmäßige Treffen mit Diskussion ausgewählter Beiträge
- Vortrag und Ausarbeitung zu einem der Beiträge
- Mündliche Prüfung über das erarbeitete Themengebiet

Literaturhinweise

dem Thema entsprechend

Weitere Informationen

Die jeweils zur Verfügung stehenden Seminare werden vor Beginn des Semesters angekündigt und unterscheiden sich je nach Studiengang.

Master Seminar (Visual Computing)

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
3	4	every semester	1 semester	2	7

Modulverantwortliche/r Dean of Studies of the Faculty of Mathematics and Computer Science
Study representative of computer science

Dozent/inn/en Professors of the department

Zulassungsvoraussetzungen Acquisition of at least 30 CP

Leistungskontrollen / Prüfungen

- Preparation of the relevant scientific literature
- Written elaboration of the topic of the master thesis
- Presentation about the planned topic with subsequent discussion
- Active participation in the discussion

Lehrveranstaltungen / SWS 2 h seminar (weekly)

Arbeitsaufwand 30 h seminar
+ 30 h contact with supervisor
+ 150 h private study
= 210 h (= 7 ECTS)

Modulnote graded

Sprache English or German

Lernziele / Kompetenzen

The Master seminar sets the ground for carrying out independent research within the context of an appropriately demanding research area. This area provides sufficient room for developing own scientific ideas.

At the end of the Master seminar, the basics ingredients needed to embark on a successful Master thesis project have been explored and discussed with peers, and the main scientific solution techniques are established.

The Master seminar thus prepares the topic of the Master thesis. It does so while deepening the students' capabilities to perform a scientific discourse. These capabilities are practiced by active participation in a reading group. This reading group explores and discusses scientifically demanding topics of a coherent subject area.

Inhalt

The methods of computer science are systematically applied, on the basis of the "state-of-the-art".

Literaturhinweise

Scientific articles corresponding to the topic area in close consultation with the lecturer.

Master Thesis

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
4	4	every semester	6 months	-	30

Modulverantwortliche/r Dean of Studies of the Faculty of Mathematics and Computer Science
Study representative of computer science

Dozent/inn/en Professors of the department

Zulassungsvoraussetzungen Successful completion of the *Master Seminar*

Leistungskontrollen / Prüfungen Written elaboration in form of a scientific paper. It describes the scientific findings as well as the way leading to these findings. It contains justifications for decisions regarding chosen methods for the thesis and discarded alternatives. The student's own substantial contribution to the achieved results has to be evident. In addition, the student presents his work in a colloquium, in which the scientific quality and the scientific independence of his achievements are evaluated.

Lehrveranstaltungen / SWS none

Arbeitsaufwand 50 h contact with supervisor
+ 850 h private study
= 900 h (= 30 ECTS)

Modulnote Grading of the Master Thesis

Sprache English or German

Lernziele / Kompetenzen

In the master thesis the student demonstrates his ability to perform independent scientific work focusing on an adequately challenging topic prepared in the master seminar.

Inhalt

In the master thesis the student demonstrates his ability to perform independent scientific work focusing on an adequately challenging topic prepared in the master seminar.

Literaturhinweise

According to the topic