UNIVERSITÄT
DES
SAARLANDES

FAKULTÄT FÜR MATHEMATIK UND INFORMATIK

MODULHANDBUCH

Visual Computing MSc

4. Februar 2024

Liste der Modulbereiche und Module

Modulbereich 1

Image Acquisition

Image Acquisition Methods

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

Modulverantwortliche/r	Dr. Pascal Peter
Dozent/inn/en	Dr. Pascal Peter
Zulassungsvoraussetzungen	Undergraduate knowledge in mathematics (e.g. *Mathematik für Informatiker I-III*). Basic knowledge in physics is helpful, but the lecture is designed to be self-contained in this regard.
Leistungskontrollen / Prüfungen	Passing the exam or re-exam. Regular attendance in the weekly assignments which are intended to be solved and discussed during the tutorial session.
Lehrveranstaltungen / SWS	``` 2 h lectures + 2 h tutorial = 4 h (weekly) ``` Homework assignments (theory and programming) and classroom assignments.
Arbeitsaufwand	``` 60 h of classes + 120 h private study = 180 h (= 6 ECTS) ```
Modulnote	The final grade reflects the performance in the exam or the re-exam. The better grade counts.
Sprache	English

Lernziele / Kompetenzen

A broad variety of image acquisition methods is described, including imaging by virtually all sorts of electromagnetic waves, acoustic imaging, magnetic resonance imaging and more. While medical imaging methods play an important role, the overview is not limited to them.

Starting from physical foundations, description of each image acquisition method extends via aspects of technical realisation to mathematical modelling and representation of the data.

Inhalt

1. Introduction and Basic Concepts
2. Imaging by Visible Light 2.1 Electromagnetic Spectrum 2.2 Optics, Sensorics, Photography 2.3 Colour Spaces, Telescopes, Mirrors, Microscopy 2.4 Dual Photography, Depth Imaging, Holography, Light Fields
3. Imaging by Invisible Electromagnetic Radiation 3.1 X-Ray and Gamma-Ray Imaging in 2-D 3.2 Computerised X-Ray Tomography 3.3 Radioastronomy, Radar, Terahertz Radiation, Microwave and Radio Wave Imaging 3.4 Magnetic Resonance Imaging
4. Imaging without Electromagnetic Radiation 4.1 Electron Microscopy 4.2 Acoustic Waves, Sonar, Ultrasound

Literaturhinweise

- B. Jähne, H. Haußecker, P. Geißler, editors, Handbook of Computer Vision and its Applications. Volume 1: Sensors and Imaging. Academic Press, San Diego 1999.
- S. Webb, The Physics of Medical Imaging. Institute of Physics Publishing, Bristol 1988.

- C. L. Epstein, Introduction to the Mathematics of Medical Imaging. Pearson, Upper Saddle River 2003.
- R. Blahut, Theory of Remote Image Formation. Cambridge University Press, 2005.
- A. C. Kak, M. Slaney, Principles of Computerized Tomographic Imaging. SIAM, Philadelphia 2001.
- Articles from journals and conferences.

Physikalische Akustik 1   PhysAk1

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 Eigenstudum (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

Physikalische Akustik 2 — PhysAk2

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 Eigenstudum (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

Ultrasound Imaging   UltraImg

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

Advanced Image Analysis AIA

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

Modulverantwortliche/r	Prof. Dr. Joachim Weickert
Dozent/inn/en	Prof. Dr. Joachim Weickert
Zulassungsvoraussetzungen	Requires undergraduate knowledge in mathematics (e.g. *Mathematik für Informatiker I-III*), and elementary C knowledge. Basic knowledge in image processing and computer vision is recommendable.
Leistungskontrollen / Prüfungen	In order to qualify for the exams, attendance of the tutorials is mandatory. There will be an exam and a re-exam. Further modalities (such as written or oral exam) will be communicated at the beginning of the lecture.

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

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

Modulnote	The grade reflects the performance in the exam or the re-exam. The better grade counts.
Sprache	English

Lernziele / Kompetenzen

In this lecture, we will discuss advanced topics in the fields of image processing and computer vision. Most of the presented methods fuse the information from several images in order to produce an enhanced composite image. Examples for such techniques are super-resolution, high dynamic range (HDR) imaging, tone mapping and gradient domain techniques.

Inhalt

1. Introduction and Overview
2. Finding Correspondences
3. Super-Resolution
4. High Dynamic Range Imaging
5. Tone Mapping
6. Exposure Fusion
7. Alignment of Exposure Series
8. Deghosting and Joint Super-Resolution and HDR
9. Focus Stacking
10. Gradient Domain Techniques

Literaturhinweise

There is no specific book that covers the complete content of this class. Many lectures will be based on articles from journals and conferences. However, the book of R. Szeliski covers some of the topics and additionally summarises most of the intensively studied areas of computer vision research:

- R. Szeliski: Computer Vision: Algorithms and Applications. ISBN: 978-1-84882-934-3, Springer, Berlin, 2011.

Correspondence Problems in Computer Vision

<div align="right">CoPCV</div>

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

Modulverantwortliche/r Prof. Dr. Joachim Weickert

Dozent/inn/en Dr. Pascal Peter

Zulassungsvoraussetzungen Undergraduate mathematics (e.g. "Mathematik für Informatiker I-III") is required, as well as elementary C knowledge (for the programming assignments). Knowledge in image processing or differential equations is useful.

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. 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 corresondence 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
```

Literaturhinweise

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

Differential Equations in Image Processing and Computer Vision   DIC

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	Undergraduate mathematics (e.g. "Mathematik für Informatiker I-III") and some elementary programming knowledge in C is required. Prior participation in "Image Processing and Computer Vision" is useful.
Leistungskontrollen / Prüfungen	• For the homework assignments one can obtain up to 24 points per week. Actively participating in the classroom assignments gives 12 more points per week, regardless of the correctness of the solutions. To qualify for both exams one needs 2/3 of all possible points. • 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)`
	
	Homework assignments (theory and programming) and classroom assignments.

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

Modulnote	Will be determined from the performance in the exam or the re-exam. The better grade counts.
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  Semidiscete Theory
    3.3  Discrete Theory
    3.4  Efficient Sequential and Parallel Algorithms
```

Literaturhinweise

- J. Weickert: Anisotropic Diffusion in Image Processing. Teubner, Stuttgart, 1998.
- G. Aubert and P. Kornprobst: Mathematical Problems in Image Processing: Partial Differential Equations and the Calculus of Variations. Second Edition, Springer, New York, 2006.
- T. F. Chan and J. Shen: Image Processing and Analysis: Variational, PDE, Wavelet, and Stochastic Methods. SIAM, Philadelphia, 2005.
- F. Cao: Geometric Curve Evolutions and Image Processing. Lecture Notes in Mathematics, Vol. 1805, Springer, Berlin, 2003.
- R. Kimmel: The Numerical Geometry of Images. Springer, New York, 2004.
- G. Sapiro: Geometric Partial Differential Equations in Image Analysis. Cambridge University Press, 2001.
- Articles from journals and conferences.

Differential Geometric Aspects of Image Processing — DGAIP

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

Modulverantwortliche/r	Prof. Dr. Joachim Weickert
Dozent/inn/en	Dr. Marcelo Cárdenas
Zulassungsvoraussetzungen	undergraduate mathematics (e.g. *Mathematik für Informatiker I-III*)
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 (= 6 ECTS)`

Modulnote	The final grade reflects the performance in the exam or re-exam.
Sprache	English

Lernziele / Kompetenzen

Students will learn basic concepts from differential geometry and how they can be applied to image analysis problems.

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 (like smoothing methods) as well as feature extraction and segmentation (like locating contours with 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.

High Level Computer Vision HLCV

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

Image Compression   IC

Studiensem.	Regelst.sem.	Turnus	Dauer	SWS	ECTS
1-2	**4**	**occasional**	**1 semester**	**6**	**9**

Modulverantwortliche/r	Dr. Pascal Peter
Dozent/inn/en	Dr. Pascal Peter
Zulassungsvoraussetzungen	Basic mathematics courses (such as *Mathematik für Informatiker I-III*) are required. Image processing lectures such as *Image Processing and Computer Vision* are helpful for some specific topics, but not necessary. For the programming assignments, some elementary knowledge of C is required.
Leistungskontrollen / Prüfungen	Passing of the exam or the re-exam. These are open book written exams. Regular attendance at tutorials is expected. The tutorials include homework assignments as well as classroom assignments. Homework assignments are handed in and graded, while classroom assignements are solved during the tutorials. Homework consists of both theoretical and programming assignments, while classroom assignments are all theoretical. Working together in groups of up to 3 people is permitted and highly encouraged.

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

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

Modulnote	The final grade reflects the performance in the exam or re-exam. The better grade counts.
Sprache	English

Lernziele / Kompetenzen

Motivation: High resolution image data is becoming increasingly popular in research and commercial applications (e.g. entertainment, medical imaging). In addition, there is also a high demand for content distribution via the internet. Due to the resulting increase in storage and bandwidth requirements, image compression is a highly relevant and very active area of research.

Teaching Goals: The course is designed as a supplement for image processing lectures, to be attended before, after or parallel to them. After the lecture, participants should understand the theoretical foundations of image compression and be familiar with a wide range of classical and contemporary compression methods.

Inhalt

The lecture can be seperated into two parts: The first half of the lecture deals with lossless image compression. We discuss the information theoretic background of so-called entropy coders (e.g. Huffman-coding, arithmetic coding, ...), talk about dictionary methods (e.g. LZW), and discuss state-of-the-art approaches like PPM and PAQ. These tools are not limited to compressing image data, but also form core parts of general data compression software such as BZIP2. Knowledge about entropy coding and prediction is key for understanding the classic and contemporary lossless codecs like PNG, gif or JBIG.

The second part of the lecture is dedicated to lossy image compression techniques. We deal with classic transformation based compression (JPEG, JPEG2000), but also with emerging approaches like inpainting-based compression. Furthermore, we consider related topics like human perception, error measurements, and offer a short introduction to video coding.

Literaturhinweise

There is no specific book that covers the complete content of this class. However, each of the following books covers several of the topics discussed in the lecture:

- T. Strutz: Bilddatenkompression. Vieweg+Teubner (in German)
- D. Hankerson, G. A. Harris, and P. D. Johnson, Jr.: Introduction to Information Theory and Data Compression. Chapman & Hall/CRC
- K. Sayood: Introduction to Data Compression. Morgan Kaufmann

Further references will be given during the lecture.

Image Processing and Computer Vision   IPCV

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	Undergraduate mathematics (e.g. Mathematik für Informatiker I-III) and elementary programming knowledge in C
Leistungskontrollen / Prüfungen	• For the homework assignments one can obtain up to 24 points per week. Actively participating in the classroom assignments gives 12 more points per week, regardless of the correctness of the solutions. To qualify for both exams one needs 2/3 of all possible points. • Passing the final exam or the re-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 the exam or the re-exam. The better grade counts.
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. Colour Perception and Colour Spaces
3. Image Transformations
   3.1 Continuous Fourier Transform
   3.2 Discrete Fourier Transform
   3.3 Image Pyramids
   3.4 Wavelet Transform
4. Image Compression
5. Image Interpolation
6. Image Enhancement
   6.1 Point Operations
```

Literaturhinweise

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

Probabilistic Graphical Models and their Applications   PGM

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

Probabilistic Methods in Image Analysis   PMIA

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

Modulverantwortliche/r	Prof. Dr. Joachim Weickert
Dozent/inn/en	Prof. Dr. Joachim Weickert
Zulassungsvoraussetzungen	Undergraduate mathematics such as *Mathematik für Informatiker I-III* is required. Knowledge of probability theory or statistics is helpful but not required
Leistungskontrollen / Prüfungen	The homework assignments are intended to be solved at home and have to be submitted in the lecture break, or earlier. In order to qualify for the exams one must obtain 50% of the possible points on average.

Lehrveranstaltungen / SWS	`  2 h lectures`
	`+ 2 h tutorials`
	`= 2 h (weekly)`

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

Modulnote	The grade reflects the performance in the exam or the re-exam. The better grade counts. The modality of the exam (written or oral) will be communicated in the beginning of the lecture.
Sprache	English

Lernziele / Kompetenzen

Probabilistic techniques are employed quite successfully in the processing and analysis of images, however, they also play a vital role in pattern classification, data mining and learning theory. This lecture introduces to some of the basic approaches.

Inhalt

In this course we will discuss

- basic notions from probability theory and statistics as well as from image processing
- histogram based image analysis and enhancement methods
- the probabilistic background of the Karhunen-Loeve expansion used for data compression, for example
- independent component analysis and applications
- the notion of entropy in image registration
- and, if time permits, we will give an introduction to the basic ideas of Markov random fields and simulated annealing.

Literaturhinweise

Relevant references will be provided in the lecture.

Modulbereich 3

Image Synthesis / Geometric Foundations

Computation and Fabrication

<div align="right">CaF</div>

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.

Computer Graphics   CG

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 beginnning 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 langue, 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.

Geometric Modelling GM

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.

Perception for Computer Graphics PfCG

	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.

Realistic Image Synthesis RIS

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

Litrature 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, at al., Advanced Global Illumition, 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

AI Planning   AP

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.

Artificial Intelligence   AI

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

Zulassungsvoraussetzungen *Programming 1*, *Programming 2*, *Fundamentals of Data Structures and Algorithms*, and *Elements of Machine Learning* or other courses in machine learning are recommended.

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

Search:

- Uninformed- and informed search procedures
- Monte-Carlo tree search

Planning:

- Formalism and complexity
- Critical-path heuristics
- Delete relaxation heuristics
- Abstraction heuristics

Markov decision processes:

- Discounted reward and expected cost
- Value iteration
- Informed search
- Reinforcement learning

Games:

- Adversarial search
- Learning from self-play

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.

Audio/Visual Communication and Networks   AVCN

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.
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*.

Digital Transmission & Signal Processing

<div align="right">DTSP</div>

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*.

Elements of Data Science and Artificial Intelligence ElDSAI

	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

Elements of Machine Learning

<div align="right">EML</div>

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

Modulverantwortliche/r	Prof. Dr. Jilles Vreeken Prof. Dr. Isabel Valera
Dozent/inn/en	Prof. Dr. Jilles Vreeken Prof. Dr. Isabel Valera
Zulassungsvoraussetzungen	The lecture assumes basic knowledge in statistics, linear algebra, and programming. It is advisable to have successfully completed *Mathematics for Computer Scientists 2* and *Statistics Lab*. The exercises use the programming language R. We will give a basic introduction to R in the first tutorial. In addition, for preparation the following materials are useful: *R for Beginners* by Emmanuel Paradis (especially chapters 1, 2, 3 and 6) and *An introduction to R* (Venables/Smith).
Leistungskontrollen / Prüfungen	Prerequisite for admission to the examination is a cumulative 50% of the points of the theoretical and a cumulative 50% of the points of the practical tasks on the exercise sheets. Depending on the number of participants, the examinations are either written or oral. The final modality will be announced in the first two weeks of the lecture.

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.
Sprache	English

Lernziele / Kompetenzen

In this course we will discuss the foundations – the elements – of machine learning. In particular, we will focus on the ability of, given a data set, to choose an appropriate method for analyzing it, to select the appropriate parameters for the model generated by that method and to assess the quality of the resulting model. Both theoretical and practical aspects will be covered. What we cover will be relevant for computer scientists in general as well as for other scientists involved in data analysis and modeling.

Inhalt

The lecture covers basic machine learning methods, in particular the following contents:

- 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
- Clustering
- Visualization

Literaturhinweise

The course broadly follows the book *An Introduction to Statistical Learning with Applications in R*, Springer (2013). In some cases, the course receives additional material from the book *The Elements of Statistical Learning*, Springer (second edition, 2009). The first book is the introductory text, the second covers more advanced topics. Both books are available as free PDFs. Any change of, or additional material will be announced before the start of the course on the course webpage.

Human Computer Interaction HCI

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.

Information Retrieval and Data Mining   IRDM

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 Inhalts 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.

Internet Transport

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	• Motivation for networks and communication • Practical experience (e.g. through *Hands on Networking*) is recommended • Knowledge of the fundamentals of communication (e.g. through *Digital Transmission & Signal Processing*) is recommended
Leistungskontrollen / Prüfungen	• Regular attendance of classes and tutorials • Eligibility for exam through quizzes and assignments • Final Exam • 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	Will be determined from performance in exams, quizzes and assigments. The exact modalities will be announced at the beginning of the module.
Sprache	English

Lernziele / Kompetenzen

Today the majority of all services is available via Internet-connections. Other than in the past this comprises not only data- but also media-services (like Voice Over IP or Video Streaming) and even Cyber-Physical Systems with their networked control loops.

The course introduces the basic characteristics of Internet-based communication (packetization on different layers, packet error detection and correction). It shows how existing protocols like HTTP, TCP and UDP can be shaped and evolved to fulfill the service requirements and how new protocols should be designed to serve the large variety of services.

Inhalt

- Introcudion of *EverythingoverIP* and *IPoverEverything*
- Theory of erasure channels (i.i.d, Gilbert-Elliott, channel capacity, minimum redundancy information)
- Wireless link layers (WiFi, PHY-bursts, Logical Link Control with DCF & EDCA, aggregation and ACK-techniques)
- Frame Check Sums, Cyclic Redundancy Checks
- Time Sensitive Networking
- Transport Layer services (flow control, congestion control, error control, segmentation and reassembly)
- QUIC media transport
- Error Coding under predictable reliability and latency (MDS-codes, binary codes)
- Upper layer protocols (HTTP, RTP/RTSP, DASH)

Literaturhinweise

The course will come with a self-contained interactive manuscript. Complementary material 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 *Future Media Internet* and *Multimedia Transport*.

Machine Learning

<div align="right">

ML

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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.

Neural Networks: Theory and Implementation

NNTI

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

Modulverantwortliche/r	Prof. Dr. Dietrich Klakow
Dozent/inn/en	Prof. Dr. Dietrich Klakow
Zulassungsvoraussetzungen	*Mathemathik für Informatiker I - III* or comparable; good programming skills.
Leistungskontrollen / Prüfungen	Written Exam
Lehrveranstaltungen / SWS	``` 2 h lectures + 2 h tutorial + 2 h project work = 6 h (weekly) ```

Lehrveranstaltungen / SWS

```
  2 h lectures
+ 2 h tutorial
+ 2 h project work
= 6 h (weekly)
```

Arbeitsaufwand

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

Modulnote Written exam and graded projects. 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. To achieve this, there will be theoretical exercises as well as project work.

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

Statistical Natural Language Processing

SNLP

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

Topics in Algorithmic Data Analysis TADA

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.

Zerstörungsfreie Prüfverfahren I

ZFP I

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 Diffaction (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 (Verwchslungsprüfung), 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	Dozent/inn/en der Fachrichtung
Zulassungsvoraussetzungen	Grundlegende Kenntnisse im jeweiligen Teilbereich des Studienganges.
Leistungskontrollen / Prüfungen	• Thematischer Vortrag mit anschließender Diskussion • Aktive Teilnahme an der Diskussion • Gegebenenfalls schriftliche Ausarbeitung oder Projekt
Lehrveranstaltungen / SWS	2 SWS Seminar

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

Modulnote	Wird aus den Leistungen im Vortrag und der schriftlichen Ausarbeitung und/oder dem Seminarprojekt ermittelt. Die genauen Modalitäten werden von dem/der jeweiligen Dozenten/in bekannt gegeben.
Sprache	Deutsch oder Englisch

Lernziele / Kompetenzen

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

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

Inhalt

Weitgehend selbstständiges Erarbeiten des Seminarthemas:

- Lesen und Verstehen wissenschaftlicher Arbeiten
- Analyse und Bewertung wissenschaftlicher Aufsätze
- Diskutieren der Arbeiten in der Gruppe
- Analysieren, Zusammenfassen und Wiedergeben des spezifischen Themas
- Erarbeiten gemeinsamer Standards für wissenschaftliches Arbeit
- Präsentationstechnik

Spezifische Vertiefung in Bezug auf das individuelle Thema des Seminars.

Der typische Ablauf eines Seminars ist üblicherweise wie folgt:

- Vorbereitende Gespräche zur Themenauswahl
- Regelmäßige Treffen mit Diskussion ausgewählter Beiträge
- ggf. Bearbeitung eines themenbegleitenden Projekts
- Vortrag und ggf. Ausarbeitung zu einem der Beiträge

Literaturhinweise

Material wird dem Thema entsprechend ausgewählt.

Weitere Informationen

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

Modulbereich 6

Master Seminar and Thesis

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