M.Sc. Computer Science (PO 2023)

Module Handbook
FB 20 - Department of Computer Science
Date: 01.09.2023

TECHNISCHE UNIVERSITÄT DARMSTADT

Informatik

Module Handbook: M.Sc. Computer Science (PO 2023)

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FB 20 - Department of Computer Science

Contents

1 Elective Areas, Specializations and Studium Generale

1.1 Elective Areas and Specializations

1.1.1 Basic Elective Areas

1.1.1.1 Software and Hardware (Practical, Technical and Applied Computer Science)

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Algorithms for Electronic Design Automation Tools</td></tr>
<tr><td>Module nr.
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3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Winter term</td></tr>
<tr><td colspan="3">Language
German/English</td><td colspan="3">Module owner
Prof. Dr.-Ing. Andreas Koch</td></tr>
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<tr><td>Course nr.</td><td>Course name</td><td>Workload (CP)</td><td>Teaching form</td><td>HPW</td></tr>
<tr><td>20-00-0183-vl</td><td>Algorithms for Chip Design Tools</td><td>0</td><td>Lecture</td><td>2</td></tr>
<tr><td>2</td><td colspan="5">Teaching content
- The VLSI design problem
- Fundamental graph representations and algorithms
- Representations for hierarchical circuits
- Fabrication technologies for integrated circuits
- Layout compaction
- Timing analysis
- Heuristical optimization techniques
- Placement problems, algorithms, and cost functions
- Exact optimization techniques
- Partitioning and its use in placement
- Floorplanning problems, representations, and techniques
- Routing problems, algorithms, and cost functions</td></tr>
<tr><td>3</td><td colspan="5">Learning objectives
After successfully attending the course, the students know a number of fabrication technologies for integrated circuits. They are able to deduce from the technologies the requirements on automation tools for the different tasks in the design and realization process. They are familiar with modeling technological problems by formal concepts such as graphs and equation systems. They understand fundamental techniques for solving even hard computational problems and are able to apply these, together with knowledge of representative EDA algorithms, to develop new or refined implementations of design tools.</td></tr>
<tr><td>4</td><td colspan="5">Prerequisite for participation
Recommended:
Participation of lecture “Digitaltechnik", “Algorithmen und Datenstrukturen” and “Funktionale und objektorientierte Programmierung”.</td></tr>
<tr><td>5</td><td colspan="5">Form of examination</td></tr>
</table>

	Course related exam: • [20-00-0183-vl] (Technical examination, Oral/written examination, Default RS)
6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-0183-vl] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
9	**References** Literature reommendations will be updated regularly, an example might be: Gerez: Algorithms for VLSI Design Automation Wang/Chang/Cheng: Electronic Design Automation
10	**Comment**

Module name Ambient Intelligence					
Module nr. 20-00-0390	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0390-iv	Ambient Intelligence	0	Integrated course	4

2 Teaching content

The course will provide an overview of a new vision for Human-Computer-Interaction (HCI) in which people are surrounded by intelligent and intuitive interfaces embedded in the everyday objects around them. In specific the course addresses the emergence of Ambient Mobility and the ubiquitous, pervasive information access, retrieval and display on mobile devices. It will focus on understanding enabling technologies and studying applications and experiments, and, to lesser extent, it will adress the sociocultural impact. Additional topics of the lecture include system architectures for distributed systems, context awareness and management, user models and their implications, sensing and interaction in smart environments. The lecture discusses recent topics and research projects in the domain of Ambient Intelligence.

3 Learning objectives

After successfully attending the lecture, the students will be able to describe technology trends and research results in the domain of Ambient Intelligence. The most important concepts to create smart environments - intelligent networks and objects, technologies for mobile, augmented reality, ubiquitous and pervasive information spaces, nomadic communications, real-time communication and related middle ware, embedded systems, sensor networks and wearable computing - can be discussed and classified. After completing the practical part, students will be able to plan and realize the different project phases required to develop an Ambient-Intelligence solution.

4 Prerequisite for participation

Master-Students
Participation in lecture “Visual Computing“ and „Multimodale Interaktion mit intelligenten Umgebungen“

5 Form of examination

Course related exam:
- [20-00-0390-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0390-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Will be given according to actual topics.
10	**Comment**

Module name Augmented Vision					
Module nr. 20-00-0160	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0160-iv	Virtual and Augmented Reality	0	Integrated course	4

2 Teaching content

This course starts to detail the principal concepts of Augmented and Virtual Reality in relation to Computer Graphics and Computer Vision. Starting from here basic principles, methods, algorithms as well as relevant standards are discussed. This includes

- VR/AR specific requirements and interfaces
- Interaction technologies (e.g. interaction with range camera technologies)
- Rendering technologies (in particular real-time rendering)
- Web-based VR and AR
- Computer-Vision-based Tracking
- Augmented Reality with range camera technologies
- Augmented Reality on smartphone platforms

The technologies will be illustrated and discussed with the results of actual research projects including in application fields „AR-maintenance support“ and „AR/VR based Cultural Heritage presentation“.

3 Learning objectives

After successfully attending the course, students are familiar with the challenges and the requirements of Virtual and Augmented reality applications. They know the standards used for the specification of VR/AR-applications. In particular, the students understand the potential of Computer Vision based tracking and they can decide which methods can be applied in with environment.

4 Prerequisite for participation

Grundlagen der Graphischen Datenverarbeitung (GDV)

5 Form of examination

Course related exam:

- [20-00-0160-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0160-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
9	**References** Dörner, R., Broll, W., Grimm, P., Jung, B. Virtual und Augmented Reality (VR / AR)
10	**Comment**

Module name Image Processing					
Module nr. 20-00-0155	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0155-iv	Image Processing	0	Integrated course	2

2 Teaching content

Fundamentals of image processing:
- Image properties
- Image transformations
- Simple and complex filtering
- Image compression,
- Segmentation
- Classification

3 Learning objectives

After successfully completing the course, students have an overview over the mechanisms used in and the abilities of modern image processing techniques. They are able to solve basic to medium level problems in image processing.

4 Prerequisite for participation

5 Form of examination

Course related exam:
- [20-00-0155-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0155-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

9 References

	- Gonzalez, R.C., Woods, R.E., ""Digital Image Processing"", Addison- Wesley Publishing Company, 1992 - Haberaecker, P., ""Praxis der Digitalen Bildverarbeitung und Mustererkennung"", Carl Hanser Verlag, 1995 - Jaehne, B., ""Digitale Bildverarbeitung"", Springer Verlag, 1997
10	**Comment**

Module name Capturing Reality					
Module nr. 20-00-0489	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Bernt Schiele		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-0489-iv	Capturing Reality	0	Integrated course	4
2	**Teaching content** This course covers a broad range of techniques to capture and model our world with a focus on application in computer graphics and computer vision. This includes: - basic tools and calibration techniques required in capturing applications - capturing and modeling techniques for various object properties (such as geometry and reflectance) - basic set of relevant mathematical modeling and optimization techniques - implementation and practical application of several techniques				
3	**Learning objectives** After successful completion of the course, students are able to analyze digitization and modeling problems for objects and scenes in computer graphics and computer vision as well as the underlying techniques. They are able to develop new setups, perform experiments and evaluate the results.				
4	**Prerequisite for participation** Recommended: Participation in lecture Graphische Datenverarbeitung I or Computer Vision I Basic knowledge in C/C++				
5	**Form of examination** Course related exam: • [20-00-0489-iv] (Technical examination, Oral/written examination, Default RS)				
6	**Prerequisite for the award of credit points** Pass exam (100%)				
7	**Grading** Course related exam: • [20-00-0489-iv] (Technical examination, Oral/written examination, Weighting: 100 %)				
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.				
9	**References**				

	Noriko Kurachi: The Magic of Computer Graphics. A K Peters/CRC Press Richard Szeliski: Algorithms and Applications, Springer Marcus Magnor, Oliver Grau, Olga Sorkine-Hornung, Christian Theobalt: Digital Representations of the Real World: How to Capture, Model, and Render Visual Reality Wolfgang Förstner, Bernhard P. Wrobel: Photogrammetric Computer Vision - Geometry, Orientation and Reconstruction
10	**Comment**

Module name Deep Learning for Medical Imaging					
Module nr. 20-00-1014	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1014-iv	Deep Learning for Medical Imaging	0	Integrated course	3

2 Teaching content

Formulating Medical Image Segmentation, Computer Aided Diagnosis and Surgical Planning as Machine Learning Problems, Deep Learning for Medical Image Segmentation, Deep Learning for Computer Aided Diagnosis, Surgical Planning from pre-surgical images using Deep Learning, Tool presence detection and localization from endoscopic videos using Deep learning, Adversarial Examples for Medical Imaging, Generative Adversarial Networks for Medical Imaging.

3 Learning objectives

After successful completion of the course, students should be able to understand all components of formulating a Medical Image Analysis problem as a Machine Learning problem. They should also be able to make informed decision of choosing a general purpose deep learning paradigm for given medical image analysis problem.

4 Prerequisite for participation

- Programming skills
- Understanding of Algorithmic design
- Linear Algebra
- Image Processing / Computer Vision I
- Statistical Machine Learning

5 Form of examination

Course related exam:
- [20-00-1014-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1014-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Real-Time Systems					
Module nr. 18-su-2020	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
18-su-2020-vl	Real-Time Systems	0	Lecture	3
18-su-2020-ue	Real-Time Systems	0	Practice	1

2 Teaching content

The lecture basically covers a model-driven software engineering process which is specially customized for real-time systems. This process is more deeply explored in the exercise using an automotive example. A focus is laid on object-oriented techniques. In this context, a real-time specific state-of-the-art CASE tool is introduced and used. Furthermore, fundamental characteristics of real-time systems and system architectures are introduced. Scheduling algorithms are discussed to get insights into real-time operating systems. Finally, a comparison between the Java programming language and its expansion for real-time operating systems (RT Java) will conclude the lecture.

3 Learning objectives

After successful completion of the module, students are able to use and evaluate model-based (object-oriented) techniques for the development of embedded real-time systems. This includes a deeper understanding of the following topics:

- classification of real-time systems
- create and analyze executable models
- application of real-time scheduling algorithms
- evaluation and comparison of pros/cons of real-time programming languages as well as real-time operating systems

4 Prerequisite for participation

Recommended: Basic knowledge of software engineering techniques and excellent knowledge of at least one object-oriented programming language (preferably Java)

5 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 15 students register, the examination will be an oral examination (duration: 30 min.). The type of examination will be announced in the beginning of the lecture.

6 Prerequisite for the award of credit points

Passing the final module examination

7 Grading

Module exam:

- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

MSc ETiT, BSc iST, MSc Wi-ETiT, BSc Informatik

9 References

https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/es-v and Moodle

10 Comment

Module name					
Formal Specification and Verification of Software					
Module nr. 20-00-0794	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Dr.-Ing. Michael Eichberg		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0794-iv	Formal Specification and Verification of Software	0	Integrated course	4

2 Teaching content

In this lecture we focus on the formal specification and deductive verification of object-oriented software.

The course covers advanced topics like:
* specification of interfaces and classes using queries, ghost fields and model fields
* the framing problem: static and dynamic framing
* program logic and calculus
* modular verification (e.g., verification of the correctness of specified frames and how to exploit framing properties)
* specification and verification of (recursive) methods, loops
* automated loop invariant/method contract generation

The course focuses on sequential programs, but current approaches on deductive verification of concurrent programs will be discussed as well.

For almost all topics tool support is available and will be demonstrated.

3 Learning objectives

* Students shall be able to formally specify complex object-oriented software in a modular manner
* Students shall be able to choose a specification approach that fits the underlying problem
* Students shall be able to specify recursive methods and loops
* Students shall be able to verify that the software meets their specification

4 Prerequisite for participation

Basic knowledge in first-order logic
Content of the lectures:
Formale Grundlagen der Informatik 2 und 3
(or similar)

5 Form of examination

Course related exam:
- [20-00-0794-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0794-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT M.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References**
10	**Comment**

Module name Advanced Compiler Construction					
Module nr. 20-00-0701	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0701-vl	Advanced Compiler Construction	0	Lecture	3

2 Teaching content

- Compilation and run-time environment for object-oriented programming languages
- Control flow graphs as intermediate representations
- Static dataflow analysis
- Static single-assignment form
- Eliminating total and partial redundancy
- Scalar optimization
- Register allocation
- Scheduling
- Loop optimization
- Structure and organization of real compilers (e.g., phases, intermediate representations, compfile flow)

3 Learning objectives

After successfully attending the course, students understand techniques for the compilation and execution of object-oriented programs at the machine-level. The can apply static dataflow analysis to control flow graphs and are practiced using their SSA form. They are familiar with optimizing techniques for a number of problems as well as fundamental algorithms for register allocation. They know the internal structure of real production-grade compilers.

4 Prerequisite for participation

Successfull participation of “Einführung in den Compilerbau”

5 Form of examination

Course related exam:

- [20-00-0701-vl] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0701-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Literature recommendations will be updated regularly, an example might be: Cooper/Torczon: Engineering a Compiler Muchnick: Advanced Compiler Design and Implementation Aho/Lam/Sethi/Ullman: Compilers - Principles, Techniques, and Tools
10	**Comment**

Module name					
Geometric Methods of CAE/CAD					
Module nr. 20-00-0140	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0140-iv	Geometrical Methods of CAE/CAD	0	Integrated course	3

2 Teaching content

- parametric curve models
- parametric surface models
- topology and volumetric CAD models
- CAD operations on surfaces
- tesselation
- approximation of curves and surfaces
- finite element method and computational fluid dynamics
- various applications from the area of CAD

3 Learning objectives

After successfully attending the course, students understand the foundations of computer-aided methods for geometric modelling and simulation. They understand multiple parametric representations for curves and surfaces and are able to analyze and compare them. They know classical data structures and algorithms from computer aided design (CAD). They can use the presented techniques to model and visualize 3D geometry.

4 Prerequisite for participation

Basic knowledge in Computer Science.

5 Form of examination

Course related exam:

- [20-00-0140-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0140-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

9	**References** Vorlesungsfolien Lee: Principles of CAD / CAM / CAE Systems, Addison-Wesley. Piegl, Tiller: The NURBS Book, Springer Verlag. Farin: Kurven und Flächen im Computer Aided Geometric Design, vieweg Shah, Mäntylä: Parametric and Feature-based CAD/CAM, Wiley & Sons	
10	**Comment**	

<table>
<tr><td colspan="6">Module name
Computer Graphics I</td></tr>
<tr><td>Module nr.
20-00-0040</td><td>Credit points
6 CP</td><td>Workload
180 h</td><td>Self-study
120 h</td><td>Module duration
1 Term</td><td>Module cycle
Every 2. Semester</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. Bernt Schiele</td></tr>
</table>

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0040-iv	Computer Graphics I	0	Integrated course	4

2 Teaching content

Introduction to basic principles of computer graphics, in particular input and output devices, rendering using OpenGL, ray tracing, illumination modelling, ongoing development in computer grapics.

3 Learning objectives

After successful completion of the modul, students are able to understand all components of the graphic pipeline and change variable parts (Vertex-Shader, Fragment-Shader, etc.). They are able to arrange, change and effectively store objects in the 3D-space, as well as appropriately choose the camera and the perspective, and utilize various shading-techniques and lighting-models to adapt all steps on the way to the displayed 2D-Image.

4 Prerequisite for participation

Recommended:
- Programming
- Basic algorithm and data structure
- Linear algebra
- Analysis
- Topics of lecture Visual Computing

5 Form of examination

Course related exam:
- [20-00-0040-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%).

7 Grading

Course related exam:
- [20-00-0040-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B. Sc. Informatik
M. Sc. Informatik
M. Sc. Computer Science
M. Sc. Autonome Systeme und Robotik
M.Sc. IT Sicherheit

May be used in other degree programs.

9	**References** - Real-Time Rendering: Tomas Akenine-Möller, Eric Haines, Naty Hoffman A.K. Peters Ltd., 3rd edition, ISBN 987-1-56881-424-7 - Fundamentals of Computer Graphics: Peter Shirley, Steve Marschner, third edition, ISBN 979-1-56881-469-8 - Additional literature will be given in the lecture.
10	**Comment**

Module name Computer Graphics II					
Module nr. 20-00-0041	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0041-iv	Computer Graphics II	0	Integrated course	4

2 Teaching content

Foundations of the various object- and surface-representations in computer graphics. Curves and surfaces (polynomials, splines, RBF) Interpolation and approximation, display techniques, algorithms: de Casteljau, de Boor, Oslo, etc. Volumes and implicit surfaces. visualization techniques, iso-surfaces, MLS, surface rendering, marching cubes. Meshes, mesh compression, mesh simplication, multiscale expansion, subdivision. Pointclouds: rendering techniques, surface reconstruction, voronoi-diagram and delaunay-triangulation.

3 Learning objectives

After successful completion of the module, students are able to handle various object- and surface-representations, i.e., to use, adapt, display (render), and effectively store these objects. This includes mathematical polynomial representations, iso-surfaces, volume representations, implicite surfaces, meshes, subdivision control meshes and pointclouds.

4 Prerequisite for participation

Recommended:

- Algorithmen und Datenstrukturen
- Grundlagen aus der Höheren Mathematik
- Graphische Datenverarbeitung I
- C / C++

5 Form of examination

Course related exam:

- [20-00-0041-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0041-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B. Sc. Informatik M. Sc. Informatik M. Sc. Computer Science M.Sc. IT Sicherheit May be used in other degree programs.
9	**References** - Real-Time Rendering: Tomas Akenine-Möller, Eric Haines, Naty Hoffman A.K. Peters Ltd., 3rd edition, ISBN 987-1-56881-424-7 - Additional literature will be given in the lecture.
10	**Comment**

Module name Foundations of Robotics					
Module nr. 20-00-0735	**Credit points** 10 CP	**Workload** 300 h	**Self-study** 210 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0735-iv	Foundations of Robotics	0	Integrated course	6

2 Teaching content

This course covers spatial representations and transformations, manipulator kinematics, vehicle kinematics, velocity kinematics, Jacobian matrix, robot dynamcis, robot sensors and actuators, robot control, path planning, localization and navigation of mobile robots, robot autonomy and robot development.

Theoretical and practical assignments as well as programming tasks serve for deepening of the understanding of the course topics.

3 Learning objectives

After successful participation, students possess the basic technical knowledge and methodological skills necessary for fundamental investigations and engineering developments in robotics in the fields of modeling, kinematics, dynamics, control, path planning, navigation, perception and autonomy of robots.

4 Prerequisite for participation

Recommended: basic mathematical knowledge and skills in linear algebra, multi-variable analysis and fundamentals of ordinary differential equations

5 Form of examination

Course related exam:

- [20-00-0735-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0735-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

10	**Comment**

Module name					
Hands-On HCI					
Module nr. 20-00-1116	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Arjan Kuijper		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1116-iv	Hands-On HCI	0	Integrated course	4

2 Teaching content

You might have previously heard of or even tried out virtual/augmented reality, 3D printing, wearable or tangible user interfaces. The area of Human-Computer Interaction covers all these exciting topics and offers an opportunity to build new prototypes and try them out with people in the user studies. If you would like to better connect theory and practice in the area of Human-Computer Interaction (HCI), then the course of Hands-On Human-Computer Interaction (Hands-On HCI) is for you. The goal of the class is to walk you through the whole research cycle in HCI. It can play a great preparation role for your future bachelor/master thesis in HCI or lay a first brick in your academic path after finishing your studies.

3 Learning objectives

After completing the module, students can

- differentiate between and apply three approaches to HCI research.
- distinguish three types of empirical research.
- effectively read a scientific publication.
- differentiate between types of HCI contributions.
- Formulate and define research questions, hypotheses and experimental variables.
- create a suitable study design based on the previously developed research questions.
- conduct a study using quantitative and qualitative methods to collect data.
- Analyze, evaluate and interpret quantitative data on the basis of statistical methods.
- Analyze and interpret qualitative data on the basis of grounded theory.
- Understand the peer review process and write reviews for a scientific publication.
- Understand and apply evaluation techniques with and without users.
- Write the knowledge gained as a scientific publication and present it to a specialist audience.

4 Prerequisite for participation

Recommended: Human-Computer Interaction (TK2)

5 Form of examination

Course related exam:

- [20-00-1116-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1116-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Higher-order Meshing					
Module nr. 20-00-1160	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Arjan Kuijper		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1160-vl	Higher-order Meshing	0	Lecture	2

2 Teaching content

This special course focuses on the recent research and advances in the field of higher-order meshing. We will learn about Bézier curves and triangles, NURBS, de Casteljau algorithm, injectivity/quality checking algorithms, 2D/3D meshing algorithms and their properties/guarantees and finally look into some open problems in this field.

3 Learning objectives

After completing the course, the students will know the basics of higher-order curves and surfaces, algorithms for higher-order mesh generation and quality testing. They will be at par with the current research in the field.

4 Prerequisite for participation

Recommended:
20-00-0040-iv Computer Graphics I

5 Form of examination

Course related exam:
- [20-00-1160-vl] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1160-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Human Computer Interaction					
Module nr. 20-00-0535	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0535-iv	Human Computer Interaction	0	Integrated course	2

2 Teaching content

The course presents fundamental concepts, models, and theories in the area of Human Computer Interaction (HCI). More specifically, it contains the following topics:
- Theoretical foundation on psychology and interaction design as basis for the design of intuitive user interfaces
- Overview of the different types of user interfaces
- Command line interfaces
- Graphical user interfaces (MacOS, Windows, . . .)
- Interactive surfaces (Tabletops, Multitouch, . . .)
- Mobile user interfaces (iOS, Android, . . .)
- Pen-based user interfaces (electronic pens)
- Tangible user interfaces, organic user interfaces
- Speech-based user interfaces
- Evaluation, measurement and assessment of user interfaces
- User studies
- Quantitative evaluation
- Qualitative evaluation
- User-centric software development

3 Learning objectives

After perticipation in this course, students will have
- an understanding of the psychologic foundations of the design of user interfaces
- know methods of the user-centric design process
- aquired an overview on common UI concepts
- learnt to know and how to use techniques for the evaluation of user interfaces

4 Prerequisite for participation

5 Form of examination

Course related exam:
- [20-00-0535-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0535-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Literature recommendations will be updated regularly, an example might be: Selected chapters out of: • Donald Norman: The Design of Everyday Things • Alan Dix, Janet Finlay, Gregory Abowd and Russel Beale: Human-Computer Interaction • Jenny Preece , Yvonne Rogers and Helen Sharp: Interaction Design: Beyond Human-Computer Interaction
10	**Comment**

Module name					
Information Visualization and Visual Analytics					
Module nr. 20-00-0294	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0294-iv	Information Visualization and Visual Analytics	0	Integrated course	4

2 Teaching content

This lecture will give a detailed introduction to the scientific topics of information visualization and Visual Analytics, and will cover current research areas as well as practical application scenarios of Visual Analytics.
- Overview of information visualization and Visual Analytics (definitions, models, history)
- Data representation and data transformation
- Mapping of data to visual structures
- Introduction to human cognition
- Visual representations and interaction for bivariate and multivariate Data, time series, networks and geographic data
- Basic data mining techniques
- Visual Analytics - Analytics reasoning - Data mining - Statistics Analytical techniques and scaling
- Evaluation of Visual Analytics Systems

3 Learning objectives

After successfully attending the course, students will be able to
- use information visualization methods for specific data types
- design interactive visualization systems for data from various application domains
- couple visualization and automated methods to solve large-scale data analysis problems
- apply knowledge about key characteristics of the human visual and cognitive system for information visualization and visual analytics

chose evaluation methods are used for specific situations and scenarios

4 Prerequisite for participation

Interesse an Methoden der Computergrafik und Visualisierung

Die Veranstaltung richtet sich an Informatiker, Wirtschaftsinformatiker, Mathematiker in Bachelor, Master und Diplomstudiengänge und weiteren interessierten Kreisen (z.B. Biologen, Psychologen).

5 Form of examination

Course related exam:
- [20-00-0294-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0294-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
9	**References** Will be announced in lecture, an example might be: C. Ware: Information Visualization: Perception for Design Ellis et al: Mastering the Information Age
10	**Comment**

Module name Interaction in Virtual and Augmented Reality					
Module nr. 20-00-1147	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. Arjan Kuijper		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1147-iv	Interaction in Virtual and Augmented Reality	0	Integrated course	4

2 Teaching content

This course offers an introduction to augmented and virtual realities from a human-centered perspective. The focus is less on computer graphics specific issues (e.g. rendering) but on understanding human-computer interaction specific problems. The course includes an introduction to the basic concepts of AR/VR and introduces methods and techniques to design and implement interactive applications. The material will be presented and reviewed using recent research results from conferences (CHI, UIST, IEEE VR, ISMAR, SIGGRAPH).

The format of the course consists of 2 semester hours of lecture and 2 semester hours of labs. The lecture will focus on the following topics:
- History of AR/VR
- Current technologies in AR/VR
- AR/VR and human perception
- Challenge of input
- Challenge of haptics
- Interaction design for AR/VR
- Application scenarios for AR/VR
- Current research questions and challenges

3 Learning objectives

After attending the course, students will be able to
- Be able to explain and apply the fundamentals of human perception used for AR and VR technology.
- understand which metrics are important in AR and VR applications (e.g., presence, immersion, embodiment, simulator sickness) and how to control them
- be able to evaluate and explain why certain concepts (interaction, haptics, presentation) work well or not so well in AR/VR
- understand which current technologies exist in AR/VR and what they can be used for
- understand current research questions in the field of HCI and AR/VR
- can independently implement and evaluate a VR application in Unity

4 Prerequisite for participation

Recommended: Fundamentals of Human-Computer Interaction (TK2: HCI)
Good programming skills in an object-oriented programming language (e.g. Java, C#)

5 Form of examination

Course related exam:
- [20-00-1147-iv] (Technical examination, Special form, Default RS)

Software development (optional: including documentation and submission of source code), colloquium, portfolio

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

	Course related exam: • [20-00-1147-iv] (Technical examination, Special form, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Concepts of Programming Languages					
Module nr. 20-00-1117	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1117-iv	Concepts of Programming Languages	0	Integrated course	4

2 Teaching content

Brief introduction and history of Programming languages, Criteria to measure Programming languages, Basic concepts like Syntax, semantics, variables, names, bindings, scope, subprograms, expressions, arrays, pointers, abstract types, functional programs.

3 Learning objectives

Students will be able to understand the underlying mechanisms of the main concepts behind programming languages upon completion of the module. Students will have initial experience in building simple programming languages.

4 Prerequisite for participation

5 Form of examination

Course related exam:

- [20-00-1117-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1117-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Medical Image Processing					
Module nr. 20-00-0379	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0379-vl	Medical Image Processing	0	Lecture	2

2 Teaching content

The lecture consists of two parts. The first half of the lecture describes how devices that yield medical image data (CT, NMR, PET, SPECT, Ultrasound) work. The second half of the lecture covers various image processing techniques that are typically applied to medical images.

3 Learning objectives

After successfully completing the course, students have an overview over the mechanisms used in and the abilities of modern medical image processing techniques. They are able to solve basic to medium level problems in medical image processing.

4 Prerequisite for participation

Basics within Mathematics are highly recommended.
Participation in lecture "Bildverarbeitung".

5 Form of examination

Course related exam:
- [20-00-0379-vl] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0379-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

	1) Heinz Handels: Medizinische Bildverarbeitung 2) 2) Gonzalez/Woods: Digital Image Processing (last edition) 3) 3) Bernd Jähne: Digitale Bildverarbeitung. 6. überarbeitete und erweiterte Auflage. Springer, Berlin u. a. 2005, ISBN 3-540-24999-0 4) Kristian Bredies, Dirk Lorenz: Mathematische Bildverarbeitung. Einführung in Grundlagen und moderne Theorie. Vieweg+Teubner, Wiesbaden 2011, ISBN 978-3-8348-1037-3
10	**Comment**

Module name Human and Identity centric Machine Learning					
Module nr. 20-00-1118	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Arjan Kuijper		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1118-iv	Human and Identity centric Machine Learning	0	Integrated course	4

2 Teaching content

Background and concepts of human-centric Machine Learning: the goal of identity and human-centric machine learning. The differences between identity learning and other
mainstream classification. Representation extraction for subject-related data: feature extraction methodology for identity related applications. Hand crafted and Deeply learned features background and
basics.

Deep learning strategies for identity representations: learning identities representations with deep learning. Learning strategies and learning losses. Network architectures and identityspecific components.

Knowledge transfer and distillation: transfer learning and identity-representation. Knowledge distillation concepts and applications.

Efficient machine learning: the relation between resource limitations, Green-AI, and deep learning. Methods to build efficient machine learning solutions.

Synthetic identity: the need of synthetic identity. Synthetic identity as adversarial. Generating synthetic identity-controlled data under different restrictions.

Machine learning biases: analyses of demographic fairness and the roots of the fairness issues. ML-based mitigation of demographic biases.

Learning privacy: analyzing unintentionally learned information. Learning strategies to the targeted suppression of information at different representation levels.

Data utility: understanding the effect of data utility in the training process. Understanding sample utility in operation. ML concepts and strategies of estimating sample utilities.

Sample-level attacks: overview on adversarial, sample manipulation, other attacks on human-centric ML. Deep learning concepts, network blocks, and loss strategies, to detect and mitigate sample-level attacks.

Explainability: overview on the need for explainability in different decision-making processes. Different strategies to provide explainability for decision made in different operations discussed in the previous lectures.

Ethics in identity-centric ML: overview on ethics in AI and AI regulation. AI ethics for human data processing and storage.

3 Learning objectives

	After successfully attending the module, students are familiar with machine learning concepts related to dealing with human and identity related information. They understand fundamental techniques for the subject-specific representation extraction, including related knowledge transfer and distillation concepts. Understanding of demographic-related machine learning biases and function-creep privacy concerns, including their main mitigation concepts. They understand the requirements and techniques to achieve embedded and efficient human-centric machine learning. They are familiar with the effect of data utility in the training process and the main concept to estimate the utility of subject-related data. They will have first hand understanding of explainability methodologies of ML decision based on identity-related data. The students will be introduced to AI ethics and AI regulation concepts related to human data processing and storage. They are able to implement these techniques in order to solve basic identity and human-centric machine learning tasks on realistic problems.
4	**Prerequisite for participation** It is recommended having previously taken Visual Computing. Basics in mathematics and probability theory are required.
5	**Form of examination** Course related exam: • [20-00-1118-iv] (Technical examination, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).
6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-1118-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Model Checking					
Module nr. 20-00-1115	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1115-iv	Model Checking	0	Lecture	4

2 Teaching content

- Temporal logics
  - Linear temporal logic (LTL), Computation tree logic (CTL) und CTL*: syntax, sematics, complexity
- Model checking LTL, CTL und CTL*
- Partial order reduction
- Timed automata

3 Learning objectives

In this module students acquire
- Knowledge of the theoretical foundations of LTL, CTL and CTL*
- Ability to choose a suitable logic for specification and model checking by taking into consideration the system to be modelled and the kind of properties to be checked
- Knowledge about different model checking techniques like model checking using Büchi automata, partial order reduction and more
- Knowledge about characteristics and limitations of model checking
- Knowledge in model checking of timed automata
- Ability to use model checker tools

4 Prerequisite for participation

Recommended is knowledge about
- propositional logic
- deduction systems
- automata theory

5 Form of examination

Course related exam:
- [20-00-1115-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.
Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1115-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Multithreading in C++					
Module nr. 20-00-0953	**Credit points** 10 CP	**Workload** 300 h	**Self-study** 210 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0953-iv	Multithreading in C++	0	Integrated course	6

2 Teaching content

C++ offers one of the most advanced threading interfaces available today. Using this interface as an example, the course teaches how to develop parallel software for shared memory with threads.
- Shared memory architectures
- Managing threads
- Sharing data between threads
- Synchronizing concurrent operations
- Designing lock-based concurrent data structures
- Designing programs for concurrency
- Testing and debugging

3 Learning objectives

Skill of developing parallel programs
- Systematically develop correct and efficient multithreaded programs
- Design and implement parallel data structures

4 Prerequisite for participation

- Knowledge of C/C++

5 Form of examination

Course related exam:
- [20-00-0953-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

Students which passed 20-00-0801 aren't allowed in this lecturen.

7 Grading

Course related exam:
- [20-00-0953-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name Physically based Simulation and Animation					
Module nr. 20-00-0682	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0682-iv	Physically based Simulation and Animation	0	Integrated course	4

2 Teaching content

- Basics of physically based simulation and animation
- Equations of motion and modeling of rigid bodies, mass-spring systems, deformable bodies and fluids
- Approximate numerical methods for the efficient solution of ordinary and partial differential equations
- Parallel computing for physically based simulations
- Collision detection and resolution

3 Learning objectives

After completing the module successfully, the students can
- Describe requirements for methods of physically based simulations for computer animation
- Apply concepts of physically based simulations
- Transfer learned concepts to other simulation applications
- Evaluate the suitability of algorithms and numerical methods for physically based simulation
- Describe open research questions in physics-based simulation and animation

4 Prerequisite for participation

- Basic knowledge of numerical computing, algorithms and data structures, computer graphics

5 Form of examination

Course related exam:
- [20-00-0682-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam of Modul (100%)

7 Grading

Course related exam:
- [20-00-0682-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
Can be used in other degree programs.

9 References

10 Comment

Module name Program Analysis					
Module nr. 20-00-1122	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1122-vl	Program Analysis	0	Lecture and practice	4

2 Teaching content

Static analyses are tools that extract information of computer programs without executing them. Static analyses have a wide range of applications in integrated development environments (IDEs), compilers, and continuous integration (CI) servers. For example, static analyses in IDEs are used to detect bugs and security vulnerabilities, whereas in compilers they are used for type checking and optimizations.

This course gives an overview of the fundamental concepts of static analyses. In particular, we will discuss the trade-off between performance, precision, and correctness of static analyses. Furthermore, you will learn about different types of analyses, such as control-flow, data-flow, points-to, purity, and immutability analyses. Lastly, the course presents several analyses frameworks, such as the monotone framework, big-step abstract interpreters, and IFDS/IDE.

The accompanying exercises practice new analysis concepts by applying them to example programs and extending and designing new static analyses.

3 Learning objectives

The goal of the module is to teach students the fundamental concepts of static analyses. This allows students to make better use and fine-tune existing static analyses in IDEs, compilers, and CI servers. Furthermore, students are able to characterize analyses, such as determining their precision, performance, soundness and completeness

4 Prerequisite for participation

Recommendation:
Although this course as self-contained, we assume good familiarity with the concepts of programming languages, such as assignments, loops, exception handling, objects, and anonymous functions.
Furthermore, the students should be familiar with basic university-level math and logic.

5 Form of examination

Course related exam:
- [20-00-1122-vl] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.
Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1122-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Programming Massively Parallel Processors					
Module nr. 20-00-0419	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0419-iv	Programming Massively Parallel Processors	0	Integrated course	4

2 Teaching content

- foundations of massively parallel processors with a focus on modern accelerator hardware
- parallel algorithms
- efficient programming of massively parallel systems
- practical programming projects co-advised by domain scientists

3 Learning objectives

After successful completion of the course, students are able to analyze problems in the context of massively parallel systems. They can develop novel applications and systematically improve their performance. They understand basic parallel algorithms and are able to independently understand and analyze current literature.

4 Prerequisite for participation

Programming skills in C/C++
Recommended: Systemnahe und Parallele Programmierung

5 Form of examination

Course related exam:
- [20-00-0419-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0419-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

Will be announced in lecture.

10 Comment

Module name Serious Games					
Module nr. 18-de-2050	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** PD Dr.-Ing. Stefan Göbel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
18-de-2050-vl	Serious Games	0	Lecture	3
18-de-2050-ue	Serious Games	0	Practice	1

2 Teaching content

Introduction to the topic of ""Serious Games"": scientific and technical foundations, application areas and trends. Individual lectures include:

- Introduction to Serious Games
- Game Development, Game Design
- Game Technology, Tools and Engines
- Personalization and Adaptation
- Interactive Digital Storytelling
- Authoring and Content Generation
- Multiplayer Games
- Game Interfaces and Sensor Technology
- Effects, Affects and User Experience
- Mobile Games
- Serious Games Application Domains and Best Practice Examples

The exercise consists of theoretical and practical parts. Students are taught how to use a Game Engine.

3 Learning objectives

After successfully completing this course the students are able to explain the concept of “Serious Games” and can transfer it to different application domains (like education or health). They can describe the general approach for developing computer games and can apply basic principles of game design, personalisation / adaptation and interactive digital storytelling. Aside from that students are able to sketch out other current research questions regarding Serious Games as well as their solutions.

4 Prerequisite for participation

5 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 8 students register, the examination will be an oral examination (duration: 30 min.). The type of examination will be announced in the beginning of the lecture.

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Module exam:

- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Will be given in lecture.
10	**Comment**

Module name					
Software-Engineering - Maintenance and Quality Assurance					
Module nr. 18-su-2010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
18-su-2010-vl	Software-Engineering - Maintenance and Quality Assurance	0	Lecture	3
18-su-2010-ue	Software-Engineering - Maintenance and Quality Assurance	0	Practice	1

2 Teaching content

The lecture covers advanced topics in the software engineering field that deal with maintenance and quality assurance of software. Therefore, those areas of the software engineering body of knowledge which are not addressed by the preceding introductory lecture, are in focus. The main topics of interest are: software maintenance and reengineering, configuration management, static programme analysis and metrics, dynamic programme analysis and runtime testing as well as programme transformations (refactoring). During the exercises, the participants analyze, test and restructure different examples.

3 Learning objectives

The lecture uses a single running example to teach basic software maintenance and quality assuring techniques in a practice-oriented style. Upon successful completion of the module, students should be familiar with all activities needed to maintain and evolve a software system of considerable size. Main emphasis is laid on software configuration management and testing activities. Selection and usage of CASE tool play a major role.

4 Prerequisite for participation

Recommended: Introduction to Computer Science for Engineers as well as basic knowledge of Java

5 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

6 Prerequisite for the award of credit points

Passing the final module examination

7 Grading

Module exam:

- Module exam (Technical examination, Examination, Weighting: 100 %)

8 Usability of the module

MSc ETiT, MSc iST, MSc Wi-ETiT, Informatik

9 References

https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/se-ii-v and Moodle

10 Comment

Module name Deep Generative Models					
Module nr. 20-00-1035	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1035-iv	Deep Generative Models	0	Integrated course	4

2 Teaching content

Generative Models, Implicit and Explicit Models, Maximum Likelihood, Variational AutoEncoders, Generative Adversarial networks, Numerical Optimization for Generative models, Applications in medical Imaging

3 Learning objectives

After students have attended the module, they can
- Explain the structure and operation of Deep Generative Models (DGM)
- Critically scrutinize scientific publications on the topic of DGMs and thus assess them professionally
- independently construct / implement basic DTMs in a high-level programming language designed for this purpose
- Transfer the implementation and application of DTMs to different applications

4 Prerequisite for participation

- Python Programming
- Linear Algebra
- Image Processing/Computer Vision I
- Statistical Machine Learning

5 Form of examination

Course related exam:
- [20-00-1035-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1035-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B,Sc, Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

No textbooks as such. Online materials will be made available during the course.

10 Comment

Module name					
User-Centered Design in Visual Computing					
Module nr. 20-00-0793	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0793-iv	User-Centered Design in Visual Computing	0	Integrated course	2

2 Teaching content

Developing user-centered software leads to a more efficient usage and increases the acceptance by the human user. The higher acceptance leads to a better dissemination and exploitation of the developed solutions. The lecture “User Centered Design in Visual Computing” aims at enabling students from the department of computer science to acquire knowledge about models, methods, and techniques for user-centered development of visualizations and interactive visual representations. This course will introduce methods that lead to designing more efficient solutions with higher acceptance. Furthermore, the lecture will explain evaluation methods that allow measuring acceptance and efficiency. User Centered Design introduces the mentioned topics with a special focus on visual computing and graphical user interfaces.

Content:
- Usability
- User experience
- Task analysis
- User interfaces
- Interaction design
- Prototyping
- Graphics design and information visualization
- Evaluation during and after software development
- Applications and examples

3 Learning objectives

After a successful participation, students will be able to:
- Identify and argue about adequate methods for developing user-centered software
- Apply techniques for user-centered visual interfaces
- Identify and choose adequate evaluation methods for the chosen techniques in the different stages of software development
- Recommend improvements for information acquisition and navigation based on studies and evaluations

4 Prerequisite for participation

- Basics of visual computing, as e.g. taught in the introductory course HCS and in the course GDV I

5 Form of examination

Course related exam:
- [20-00-0793-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0793-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT M.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References**
10	**Comment**

Module name
Distributed geometry processing

Module nr.	Credit points	Workload	Self-study	Module duration	Module cycle
20-00-1075	6 CP	180 h	120 h	1 Term	Every 2. Semester

Language	Module owner
German	Prof. Dr. Arjan Kuijper

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1075-iv	Distributed geometry processing	0	Integrated course	4

2 Teaching content
* Foundations and algorithms of geometry processing: smoothing, remeshing, Delaunay triangulation, parameterization, texturization, etc.
* Introduction into Big Data and Cloud Computing
* Indexing massive geometry datasets for faster access: quad trees, R-trees, space-filling curves, etc.
* Distributed and cloud-based data storage
* Architectures for distributed processing pipelines
* Programming models for distributed algorithms (e.g. MapReduce)
* Technologies and frameworks for distributed data processing (e.g. Spark, Vert.x) and geometry processing (Draco, etc.)
* Deployment of distributed applications in the Cloud
* There will be practical and theoretical exercises

3 Learning objectives
After successfully absolving the course, students will have knowledge in geometry processing and distributed, cloud-based processing of large datasets in general. They will be able to develop scalable applications and to deploy them to the cloud in order to increase performance of geometry processing through parallelization.

4 Prerequisite for participation
* Programming skills in Java or other JVM languages
* Basic algorithms and data structures

5 Form of examination
Course related exam:
- [20-00-1075-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points
Pass exam (100%)

7 Grading
Course related exam:
- [20-00-1075-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

1.1.1.2 Theory (Theoretical Computer Science)

Module name Algorithmic Modelling					
Module nr. 20-00-0113	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Heiko Mantel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0113-iv	Algorithmic Modelling	0	Integrated course	4

2 Teaching content

- Algorithmic modeling languages like OPL and eclipse
- modeling problems as (integer) linear programming problems
- modelling as combinatorial optimization problems
- complex case studies: e.g. applications in logistics and manufacturing; deterministic and stochastic scheduling

3 Learning objectives

After successfully attending the course,
- students know modelling strategies for decision, construction, and optimization problems
- students can apply two algorithmic modelling languages
- student can adequately model complex problems

4 Prerequisite for participation

Grundzüge III der Informatik oder vergleichbar (Einführung in Foundations of Computing wäre ebenfalls wünschenswert).

5 Form of examination

Course related exam:
- [20-00-0113-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass Exam (100%)

7 Grading

Course related exam:
- [20-00-0113-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

9 References

	Will be appointed in lecture.
10	**Comment**

Module name Automatic Software Verification					
Module nr. 20-00-1069	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Dr.-Ing. Michael Eichberg		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-1069-iv	Automatic Software Verification	0	Integrated course	4
2	**Teaching content** The course deals with approaches for automatic software verification. Topics of the course are: - operational semantics of sequential programs - configurable program analysis (including configuration of dataflow analyses and model checking) - bounded model checking - k-induction - cooperative verification, especially conditional model checking - witness validation - test-case generation with verifiers				
3	**Learning objectives** After successful participation, students can name a number of techniques for automatic software verification. They can describe and classify the techniques and formally define their foundations. Furthermore, students can apply the techniques to examples and are able to develop new configurable program analyses.				
4	**Prerequisite for participation** Recommendation: Knowledge of the first four semesters of the Bachelor's degree, especially propositional and predicate logic.				
5	**Form of examination** Course related exam: • [20-00-1069-iv] (Technical examination, Oral/written examination, Default RS)				
6	**Prerequisite for the award of credit points** Pass exam (100%)				
7	**Grading** Course related exam: • [20-00-1069-iv] (Technical examination, Oral/written examination, Weighting: 100 %)				
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.				
9	**References**				
10	**Comment**				

Module name Efficient Graph Algorithms					
Module nr. 20-00-0110	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Heiko Mantel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0110-iv	Efficient Graph Algorithms	0	Integrated course	4

2 Teaching content

- Efficient Data- Efficient Algorithms for Graph Scanning and Connectivity
- Optimal Trees and Branchings
- Network Flow Problems
- Matching and Assignment
- Planar Graphs.
- Theory, Generic Approaches, Improvement by means of Speedup Techniques and Structures

3 Learning objectives

After successfully attending the course, students
- know fundamental algorithms
- know techniques to improve efficiency
- can analyse graph algorithms
- know methods to exploit particular characteristics (planarity, sparseness)
- can judge practical efficiency of techniques

4 Prerequisite for participation

5 Form of examination

Course related exam:
- [20-00-0110-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0110-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

9	**References** Will be appointed in lecture
10	**Comment**

Module name					
Introduction to Quantum Computing					
Module nr. 20-00-1136	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1136-iv	Introduction to Quantum Computing	0	Integrated course	4

2 Teaching content

General introduction and motivation
Introduction to Quantum mechanics (states, measurements, evolution, a short review of linear algebra)
Elementary quantum gates and circuit model
Universal quantum computation
Quantum parallelism and Deutsch-Jozsa Algorithm
Simon's Algorithm
The Fourier Transform
Shor's Factoring Algorithm
Hidden Subgroup Problem
Grover's Search Algorithm
Quantum Error-Correction and Fault-Tolerance
Entanglement and Nonlocality
A basic introduction to quantum key distribution
Overview of quantum computing platforms and claims of quantum advantage

3 Learning objectives

After completing the module, students will be familiar with all of the fundamental concepts of quantum information processing and computing and will be able to program them using the quantum programming language Qiskit. They will learn the most important ‘peculiarities' of the quantum world and will be able to connect them to computational and cryptographic tasks. Finally, at the end of the lecture, a summary of the most recent developments in industry and academia will be provided, allowing students to navigate their future interests in the field

4 Prerequisite for participation

Basic knowledge of elementary linear algebra (matrix multiplication, determination of eigenvalues) is recommended.

5 Form of examination

Course related exam:

- [20-00-1136-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

	Course related exam: • [20-00-1136-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name					
Introduction to Computational Physics					
Module nr. 20-00-1186	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Heiko Mantel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1186-vl	Introduction to Computational Physics	0	Lecture	2

2 Teaching content

This course is an introduction to computational physics for students with a background in computer science. The Lagrangian formalism, symmetries and conservation laws, stability and bifurcation, multi-body problems and rigid bodies, linear and nonlinear oscillations, Hamiltonian formalism, canonical transformations and invariances, Liouville's theorem, discrete Lagrangian and Hamiltonian formalisms, Hamilton Jacobi theory, transition to quantum mechanics, relativity, fields are considered.

3 Learning objectives

After successful Completion of the module student are able to

- apply the Euler-Lagrange and the Hamilton formalism for the mathematical description of physical systems in the field of mechanics;
- discretize the underlying differential equations for the purpose of numerical solution;
- critically evaluate different numerical solution schemes;
- and to interpret the results of numerical simulations appropriately.

4 Prerequisite for participation

Recommended:
Basic knowledge of algorithms, calculus, and linear algebra, as well as programming skills in a programming language (C++, Java, Python, or similar).

5 Form of examination

Course related exam:

- [20-00-1186-vl] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.
Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%).

7 Grading

Course related exam:

- [20-00-1186-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Optimization Algorithms					
Module nr. 20-00-0667	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Karsten Weihe		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0667-iv	Optimization Algorithms	0	Integrated course	4

2 Teaching content

Algorithmic standard approaches to complex discrete optimization problems; for example, evolution strategies, dynamic programming, branch-and-bound, etc.

3 Learning objectives

In this course students acquire systematic knowledge of generic algorithmic approaches in discrete optimization and the abitiliy to tackle complex discrete optimization problems algorithmically.

4 Prerequisite for participation

Funktionale und objektorientierte Programmierkonzepte, Algorithmen und Datenstrukturen or similar.

5 Form of examination

Course related exam:

- [20-00-0667-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0667-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

Will be given in lecture.

10 Comment

Module name Quantum Information Science					
Module nr. 20-00-1144	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1144-vl	Quantum Information Science	0	Lecture	4

2 Teaching content

Part 1: Introductory topics
. Introduction to Quantum mechanics (states, measurements, evolution, postulates of quantum mechanics, uncertainty relation, no-cloning theorem)
. Quantum entanglement theory (resource theory of entanglement, multipartite entanglement, mixed state entanglement, entanglement detection/criteria, entanglement measures)
. Quantum channels (Choi-Jamiolkowski isomorphism, Kraus decomposition, quantum instruments)
. Protocols (purification, teleportation, quantum key distribution)
. Quantum error correction (stabilizer formalism, CSS codes, bounds on codes)

Part 2: Quantum Shannon Theory
. Distance Measures
. Classical Information and Entropy
. Quantum Information and Entropy
. Entropic inequalities
. The Information of Quantum Channels

3 Learning objectives

The students will learn how to interpret, process, and measure the amount of information in a quantum experiment. The objective will be achieved by covering all the basic concepts of the quantum information theory in full generality and depth: Noisy quantum state preparation, noisy quantum evolution, and noisy quantum measurements. The topics of the course are complementary to the ones presented in the Introduction to Quantum Computation course

4 Prerequisite for participation

The course is aimed at master's students in computer science, physics, and mathematics and bachelor's students who would like to challenge themselves with advanced topics. The primary prerequisite is elementary linear algebra. Attending the Introduction to QC is a plus but not a strict requirement to take the course.

5 Form of examination

Course related exam:
- [20-00-1144-vl] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1144-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name					
Static and Dynamic Program Analysis					
Module nr. 20-00-0580	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Heiko Mantel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0580-iv	Static and Dynamic Program Analysis	0	Integrated course	4

2 Teaching content

- operational semantics for sequential and parallel programs
- overview of techniques for static and dynamic program analysis
- abstract interpretation
- data flow analysis
- slicing techniques
- type-based program analysis
- concepts of runtime monitoring
- techniques for implementing runtime monitoring
- language-based security
- soundness and precision of program analysis

3 Learning objectives

After successfully participating in this course the students will know a range of different program analyses. The students will understand the functionality of each program analysis and the difference between each of the considered program analyses. Furthermore, the students will be able to judge which program analysis is suitable for a specific problem, and they will be able to apply the different program analyses. The students will also be able to judge the precision and soundness of program analyses. Finally, the students will be able to implement and define the considered program analyses and variants of them.

4 Prerequisite for participation

Knowledge of Computer Science and Mathematics equivalent to the first four semesters in the Computer Science Bachelor program, in particular basic knowledge about logic and the ability to understand formal calculi.

5 Form of examination

Course related exam:

- [20-00-0580-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0580-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Verification of Parallel Programs					
Module nr. 20-00-1079	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Heiko Mantel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1079-iv	Verification of Parallel Programs	0	Integrated course	4

2 Teaching content

The course deals with mostly automatic verification approaches for multi-threaded programs with shared memory. Topics of the course are:
- Semantics of parallel programs, e.g., interleaving semantics, semantics of selected weak memory models
- Static and dynamic approaches for data race detection
- Techniques for deadlock detection
- Verification of program properties (e.g., with sequentialization, bounded model checking, etc.)
- Partial Order Reduction
- Thread-modular verification
- Verification with weak memory guarantees

3 Learning objectives

At the end of the course, students can name a number of techniques for the verification of parallel programs, especially in the area of data race and deadlock detection as well as for verification of safety properties. They should be able to explain the underlying formalisms of the techniques, to describe the work flow of the different techniques, and to apply the techniques on examples. Moreover, the students know the strengths and weaknesses of the techniques.

4 Prerequisite for participation

Knowledge according to the first four bachelor terms in computer science that is ideally supplemented by knowledge of automatic software verification techniques for sequential programs as taught in the course automatic software verification

5 Form of examination

Course related exam:
- [20-00-1079-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1079-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

1.1.2 Specializations

1.1.2.1 Specialization Data Science and Engineering

Elective Areas

1.1.2.2 Foundations of Data Science

Module name Algorithmic Modelling					
Module nr. 20-00-0113	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Heiko Mantel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0113-iv	Algorithmic Modelling	0	Integrated course	4

2 Teaching content

- Algorithmic modeling languages like OPL and eclipse
- modeling problems as (integer) linear programming problems
- modelling as combinatorial optimization problems
- complex case studies: e.g. applications in logistics and manufacturing; deterministic and stochastic scheduling

3 Learning objectives

After successfully attending the course,
- students know modelling strategies for decision, construction, and optimization problems
- students can apply two algorithmic modelling languages
- student can adequately model complex problems

4 Prerequisite for participation

Grundzüge III der Informatik oder vergleichbar (Einführung in Foundations of Computing wäre ebenfalls wünschenswert).

5 Form of examination

Course related exam:
- [20-00-0113-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass Exam (100%)

7 Grading

Course related exam:
- [20-00-0113-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
9	**References** Will be appointed in lecture.
10	**Comment**

Module name Data Mining and Machine Learning					
Module nr. 20-00-0052	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0052-iv	Data Mining and Machine Learning	0	Integrated course	4

2 Teaching content

With the rapid development of information technology bigger and bigger amounts of data are available. These often contain implicit knowledge, which, if it were known, could have significant commercial or scientific value. Data Mining is a research area that is concerned with the search for potentially useful knowledge in large data sets, and machine learning is one of the key techniques in this area.

This course offers an introduction into the area of machine learning from the angle of data mining. Different techniques from various paradigms of machine learning will be introduced with exemplary applications. To operationalize this knowledge, a practical part of the course is concerned with the use of data mining tools in applications.

- Introduction (Foundation, Learning problems, Concepts, Examples, Representation)
- Rule Learning
  - Learning of indicivual rules (generalization vs. specialization, structured hypothesis spaces, version spaces)
  - Learning of rule sets (covering strategy, evaluation measures for rules, pruning, multi-class problems)
- Evaluation and cost-sensitive Learning (Accuracy, X-Val, ROC Curves, Cost-Sensitive Learning)
- Instance-Based Learning (kNN, IBL, NEAR, RISE)
- Decision Tree Learning (ID3, C4.5, etc.)
- Ensemble Methods (Bias/Variance, Bagging, Randomization, Boosting, Stacking, ECOCs)
- Pre-Processing (Feature Subset Selection, Discretization, Sampling, Data Cleaning)
- Clustering and Learning of Association Rules (Apriori)"

3 Learning objectives

After a successful completion of this module, students are in a position to
- understand and explain fundemental techniques of data mining and machine learning
- apply practical data mining systems and understand their strengths and limitations
- critically judge new developments in this area

4 Prerequisite for participation

5 Form of examination

Course related exam:
- [20-00-0052-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7	**Grading** Course related exam: • [20-00-0052-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B. Sc. Informatik M. Sc. Informatik M. Sc. Computer Science M. Sc. Autonome Systeme und Robotik M. Sc. Artificial Intelligence and Machine Learning M. Sc. IT Sicherheit May be used in other degree programs.
9	**References** - Mitchell: Machine Learning, McGraw-Hill, 1997 - Ian H. Witten and Eibe Frank: Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations, Morgan-Kaufmann, 1999
10	**Comment**

Module name Efficient Graph Algorithms					
Module nr. 20-00-0110	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Heiko Mantel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0110-iv	Efficient Graph Algorithms	0	Integrated course	4

2 Teaching content

- Efficient Data- Efficient Algorithms for Graph Scanning and Connectivity
- Optimal Trees and Branchings
- Network Flow Problems
- Matching and Assignment
- Planar Graphs.
- Theory, Generic Approaches, Improvement by means of Speedup Techniques and Structures

3 Learning objectives

After successfully attending the course, students
- know fundamental algorithms
- know techniques to improve efficiency
- can analyse graph algorithms
- know methods to exploit particular characteristics (planarity, sparseness)
- can judge practical efficiency of techniques

4 Prerequisite for participation

5 Form of examination

Course related exam:
- [20-00-0110-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0110-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

9	**References** Will be appointed in lecture
10	**Comment**

<table>
<tr><td colspan="6">Module name
Ethics in Natural Language Processing</td></tr>
<tr><td>Module nr.
20-00-1061</td><td>Credit points
6 CP</td><td>Workload
180 h</td><td>Self-study
120 h</td><td>Module duration
1 Term</td><td>Module cycle
Every 2. Semester</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. techn. Johannes Fürnkranz</td></tr>
</table>

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1061-iv	Ethics in Natural Language Processing	0	Integrated course	4

2 Teaching content

Machine Learning and Natural Language technologies are integrated in more and more aspects of our life. Therefore, the decisions we make about our methods and data are closely tied up with their impact on our world and society. In this course, we present real-world, state-of-the-art applications of natural language processing and their associated ethical questions and consequences. We also discuss philosophical foundations of ethics in research.

Core topics of this course:

- Philosophical foundations: what is ethics, history, medical and psychological experiments, ethical decision making.
- Misrepresentation and bias: algorithms to identify biases in models and data and adversarial approaches to debiasing.
- Privacy: algorithms for demographic inference, personality profiling, and anonymization of demographic and personal traits.
- Civility in communication: techniques to monitor trolling, hate speech, abusive language, cyberbullying, toxic comments.
- Democracy and the language of manipulation: approaches to identify propaganda and manipulation in news, to identify fake news, political framing.
- NLP for Social Good: Low-resource NLP, applications for disaster response and monitoring diseases, medical applications, psychological counseling, interfaces for accessibility.

3 Learning objectives

After completion of the lecture, the students are able to
- explain philosophical and practical aspects of ethics
- show the limits and limitations of machine learning models
- Use techniques to identify and control bias and unfairness in models and data
- Demonstrate and quantify the impact of influencing opinions in data processing and news
- Identify hate speech and online abuse and develop countermeasures

4 Prerequisite for participation

Basic knowledge of algorithms, data structure and programming

5 Form of examination

Course related exam:
- [20-00-1061-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

	Course related exam: • [20-00-1061-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Foundations of Language Technology					
Module nr. 20-00-0546	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0546-iv	Foundations of Language Technology	0	Integrated course	4

2 Teaching content

This lecture provides an introduction into the fundamental perspectives, problems, methods, and techniques of text technology and natural language processing using the example of the Python programming language.

Key topics:

- Natural language processing (NLP)
- Tokenization
- Segmentation
- Part-of-speech tagging
- Corpora
- Statistical analysis
- Machine Learning
- Categorization and classification
- Information extraction
- Introduction to Python
- Data structures
- Structured programming
- Working with files
- Usage of libraries
- NLTK library

The course is based on the Python programming language together with an open-source library called the Natural Language Toolkit (NLTK). NLTK allows explorative and problem-solving learning of theoretical concepts without the requirement of extensive programming knowledge.

3 Learning objectives

After attending this course, students are in a position to
- define the fundamental terminology of the language technology field,
- specify and explain the central questions and challenges of this field,
- explicate and implement simple Python programs,
- transfer the learned techniques and methods to practical application scenarios of text understanding, as well as
- critically assess their merits and limitations.

4 Prerequisite for participation

5 Form of examination

Course related exam:
- [20-00-0546-iv] (Technical examination, Oral/written examination, Default RS)

6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-0546-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Steven Bird, Ewan Klein, Edward Loper: Natural Language Processing with Python, O'Reilly, 2009. ISBN: 978-0596516499. http://www.nltk.org/book/
10	**Comment**

Module name Model Checking					
Module nr. 20-00-1115	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1115-iv	Model Checking	0	Lecture	4

2 Teaching content

- Temporal logics
  - Linear temporal logic (LTL), Computation tree logic (CTL) und CTL*: syntax, sematics, complexity
- Model checking LTL, CTL und CTL*
- Partial order reduction
- Timed automata

3 Learning objectives

In this module students acquire
- Knowledge of the theoretical foundations of LTL, CTL and CTL*
- Ability to choose a suitable logic for specification and model checking by taking into consideration the system to be modelled and the kind of properties to be checked
- Knowledge about different model checking techniques like model checking using Büchi automata, partial order reduction and more
- Knowledge about characteristics and limitations of model checking
- Knowledge in model checking of timed automata
- Ability to use model checker tools

4 Prerequisite for participation

Recommended is knowledge about
- propositional logic
- deduction systems
- automata theory

5 Form of examination

Course related exam:
- [20-00-1115-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.
Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1115-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Optimization Algorithms					
Module nr. 20-00-0667	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Karsten Weihe		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0667-iv	Optimization Algorithms	0	Integrated course	4

2 Teaching content

Algorithmic standard approaches to complex discrete optimization problems; for example, evolution strategies, dynamic programming, branch-and-bound, etc.

3 Learning objectives

In this course students acquire systematic knowledge of generic algorithmic approaches in discrete optimization and the abitiliy to tackle complex discrete optimization problems algorithmically.

4 Prerequisite for participation

Funktionale und objektorientierte Programmierkonzepte, Algorithmen und Datenstrukturen or similar.

5 Form of examination

Course related exam:

- [20-00-0667-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0667-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

Will be given in lecture.

10 Comment

Module name Probabilistic Graphical Models					
Module nr. 20-00-0449	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Ph. D. Stefan Roth		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0449-iv	Probabilistic Graphical Models	0	Integrated course	4

2 Teaching content

- Refresher of probability & Bayesian decision theory
- Directed and undirected models and their properties
- Inference in tree graphs
- Approximate inference in general graphs: Message passing and mean field
- Learning of directed and undirected models
- Sampling methods for learning and inference
- Modeling in example applications, including topic models
- Deep networks
- Semi-supervised learning

3 Learning objectives

After successfully attending the course, students have developed an in-depth understanding of probabilistic graphical models. They describe and analyze properties of graphical models, and formulate suitable models for concrete estimation and learning tasks. They understand inference algorithms, judge their suitability and apply them to graphical models in relevant applications. Moreover, they determine which learning algorithms are suitable to estimate the model parameters from example data, and apply these.

4 Prerequisite for participation

Recommended: Participation in “Statistisches Maschinelles Lernen”.

5 Form of examination

Course related exam:

- [20-00-0449-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0449-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Literature recommendations will be updated regularly, an example might be: - D. Barber: "Bayesian Reasoning and Machine Learning", Cambridge University Press 2012 - D. Koller, N. Friedman: "Probabilistic Graphical Models: Principles and Techniques", MIT Press 2009
10	**Comment**

Module name					
Statistical Relational Artificial Intelligence: Logic, Probability, and Computation					
Module nr. 20-00-1011	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1011-iv	Statistical Relational Artificial Intelligence: Logic, Probability, and Computation	0	Integrated course	4

2 Teaching content

+ Logic programming
+ Inductive logic programming, i.e., learning logical programs from data
+ Probabilistic graphical models: Inference and Learning
+ Statistical relational models such as ProbLog and Markov logic networks
+ Inference within statistical relational models
+ Learning statistical relational models from data
+ Relational linear and quadratic programs

3 Learning objectives

The lecture provides a systematic introduction to the foundations and methods of statistical relational learning and AI: the study and design of intelligent agents that act in worlds composed of individuals (objects, things), where there can be complex relations among the individuals, where the agents can be uncertain about what properties individuals have, what relations are true, what individuals exist, whether different terms denote the same individual, and the dynamics of the world. After the successful completion of the course, students understand the basic concepts and methods of statistical relational AI. They understand the basic challenges posed by relational domains and know the current state of the art to meet tem. They are able to apply the acquired toolbox to novel problems.

4 Prerequisite for participation

The successful completion of "Statistical Machine Learning" and of "Probabilistic Graphical Models" is recommended but not required.

5 Form of examination

Course related exam:

- [20-00-1011-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1011-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

	Pointers to literature will be updated regularly and include: Luc De Raedt, Kristian Kersting, Sriraam Natarajan, David Poole (2016): Statistical Relational Artificial Intelligence: Logic, Probability, and Computation. Synthesis Lectures on Artificial Intelligence and Machine Learning, Morgan & Claypool Publishers, ISBN: 9781627058414.
10	**Comment**

Module name Statistical Machine Learning					
Module nr. 20-00-0358	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Kristian Kersting		

1 Courses of this module

Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
20-00-0358-iv	Statistical Machine Learning	0	Integrated course	4

2 Teaching content

- Statistical Methods for Machine Learning
- Refreshers on Statistics, Optimization and Linear Algebra
- Bayes Decision Theory
- Probability Density Estimation
- Non-Parametric Models
- Mixture Models and EM-Algorithms
- Linear Models for Classification and Regression
- Statistical Learning Theory
- Kernel Methods for Classification and Regression

3 Learning objectives

The lecture gives a systematic introduction to statistical methods for machine learning. Upon successful completion of this lecture, students will understand the most important methods and approaches of statistical machine learning. They can apply machine learning to solve various new problems.

4 Prerequisite for participation

5 Form of examination

Course related exam:

- [20-00-0358-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0358-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9	**References** 1. C.M. Bishop, Pattern Recognition and Machine Learning (2006), Springer 2. K.P. Murphy, Machine Learning: a Probabilistic Perspective (expected 2012), MIT Press 3. D. Barber, Bayesian Reasoning and Machine Learning (2012), Cambridge University Press 4. T. Hastie, R. Tibshirani, and J. Friedman (2003), The Elements of Statistical Learning, Springer Verlag 5. D. MacKay, Information Theory, Inference, and Learning Algorithms (2003), Cambridge University Press 6. R.O. Duda, P.E. Hart, and D.G. Stork, Pattern Classification (2nd ed. 2001), Willey-Interscience 7. T.M. Mitchell, Machine Learning (1997), McGraw-Hill
10	**Comment**

Module name Deep Generative Models					
Module nr. 20-00-1035	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1035-iv	Deep Generative Models	0	Integrated course	4

2 Teaching content

Generative Models, Implicit and Explicit Models, Maximum Likelihood, Variational AutoEncoders, Generative Adversarial networks, Numerical Optimization for Generative models, Applications in medical Imaging

3 Learning objectives

After students have attended the module, they can
- Explain the structure and operation of Deep Generative Models (DGM)
- Critically scrutinize scientific publications on the topic of DGMs and thus assess them professionally
- independently construct / implement basic DTMs in a high-level programming language designed for this purpose
- Transfer the implementation and application of DTMs to different applications

4 Prerequisite for participation

- Python Programming
- Linear Algebra
- Image Processing/Computer Vision I
- Statistical Machine Learning

5 Form of examination

Course related exam:
- [20-00-1035-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1035-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B,Sc, Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

No textbooks as such. Online materials will be made available during the course.

10 Comment

Module name Advanced C++ modern programming					
Module nr. 20-00-1068	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Dr.-Ing. Michael Eichberg		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1068-iv	Advanced C++ modern programming	0	Integrated course	2

2 Teaching content

The teaching will be given in the form of a course on the most recent updates on the C++ programming language including standards ISO/IEC 14882:2011, 14882:2014, and 14882:2017.

The topics included in the course will be:
1. Introduction to modern C++.
2. Improved type system.
3. Uniform initialization.
4. Modern approach to class design and implementation.
5. Improving library development.
6. Modern support to generic programming.
7. Introduction to meta-programming.
8. Simplifying code through utility library standard components.
9. STL: Containers, algorithms and iterators
10. Recent evolution: C++17
11. The future of C++: C++20

3 Learning objectives

+ Students are able to tell the main differences among the several modern versions of C++ standards.
+ Students have improved their understanding of modern generic programming.
+ Students are able to use main new components of the C++ standards library.
+ Students have an understanding of the trade-offs between flexibility and performance in modern C++.
+ Students understand the most likely paths in the evolution of the C++ programming language.

4 Prerequisite for participation

+ Students have a basic knowledge of the C and C++ programming language.
+ Students know the basic concepts of object oriented programming and generic programming.
+ A basic knowledge of functional programming is welcome.

5 Form of examination

Course related exam:
- [20-00-1068-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1068-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Advanced Data Management Systems					
Module nr. 20-00-1039	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1039-iv	Advanced Data Management Systems	0	Integrated course	4

2 Teaching content

This is an advanced course about the design of modern data management systems which has a heavy emphasis on system design and internals. Sample topics include modern hardware for data management, main memory optimisations, parallel and approximate query processing, etc.

The course expects the reading of research papers (SIGMOD, VLDB, etc.) for each class. Programming projects will implement concepts discussed in selected papers. The final grade will be based on the results of the programming projects. There will be no final exam.

3 Learning objectives

Upon successful completion of this course, the student should be able to:
- Understand state-of-the-art techniques for modern data management systems
- Discuss design decision of modern data management systems with emphasis on constructive improvements
- Implement advanced data management techniques and provide experimental evidence for design decisions

4 Prerequisite for participation

Solid Programming skills in C and C++
Scalable Data Management (20-00-1017-iv)
Information Management (20-00-0015-iv)

5 Form of examination

Course related exam:
- [20-00-1039-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1039-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Advanced Multithreading in C++					
Module nr. 20-00-0977	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0977-iv	Advanced Multithreading in C++	0	Integrated course	4

2 Teaching content

C++ offers one of the most modern threading interfaces available today. Using this interface as an example, the course teaches advanced techniques to develop parallel software for shared memory with threads.

Based on the contents of the course Multithreading in C++, this course will cover the following topics:
• C++ memory model and atomic operations
• Designing lock-free concurrent data structures
• Advanced thread management (e.g., thread pools)

3 Learning objectives

After successfully completing the course, the students have advanced skills of developing parallel programs. They are able to
- Systematically develop correct and efficient multithreaded programs
- Design and implement parallel data structures

4 Prerequisite for participation

• Knowledge of C/C++
• Foundations of programming threads in C++ (lock-based synchronization and lock-based concurrent data structures)

5 Form of examination

Course related exam:
- [20-00-0977-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

Students who passed Modul "Fortgeschrittene parallele Programmierung 2" (FPPROG2), 20-00-0938 aren't allowed to pass this Modul.

7 Grading

Course related exam:
- [20-00-0977-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name					
Information Visualization and Visual Analytics					
Module nr. 20-00-0294	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0294-iv	Information Visualization and Visual Analytics	0	Integrated course	4

2 Teaching content

This lecture will give a detailed introduction to the scientific topics of information visualization and Visual Analytics, and will cover current research areas as well as practical application scenarios of Visual Analytics.
• Overview of information visualization and Visual Analytics (definitions, models, history)
• Data representation and data transformation
• Mapping of data to visual structures
• Introduction to human cognition
• Visual representations and interaction for bivariate and multivariate Data, time series, networks and geographic data
• Basic data mining techniques
• Visual Analytics - Analytics reasoning - Data mining - Statistics Analytical techniques and scaling
• Evaluation of Visual Analytics Systems

3 Learning objectives

After successfully attending the course, students will be able to
• use information visualization methods for specific data types
• design interactive visualization systems for data from various application domains
• couple visualization and automated methods to solve large-scale data analysis problems
• apply knowledge about key characteristics of the human visual and cognitive system for information visualization and visual analytics
chose evaluation methods are used for specific situations and scenarios

4 Prerequisite for participation

Interesse an Methoden der Computergrafik und Visualisierung

Die Veranstaltung richtet sich an Informatiker, Wirtschaftsinformatiker, Mathematiker in Bachelor, Master und Diplomstudiengänge und weiteren interessierten Kreisen (z.B. Biologen, Psychologen).

5 Form of examination

Course related exam:
- [20-00-0294-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0294-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
9	**References** Will be announced in lecture, an example might be: C. Ware: Information Visualization: Perception for Design Ellis et al: Mastering the Information Age
10	**Comment**

Module name Concepts of Programming Languages					
Module nr. 20-00-1117	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
20-00-1117-iv	Concepts of Programming Languages	0	Integrated course	4

2 Teaching content

Brief introduction and history of Programming languages, Criteria to measure Programming languages, Basic concepts like Syntax, semantics, variables, names, bindings, scope, subprograms, expressions, arrays, pointers, abstract types, functional programs.

3 Learning objectives

Students will be able to understand the underlying mechanisms of the main concepts behind programming languages upon completion of the module. Students will have initial experience in building simple programming languages.

4 Prerequisite for participation

5 Form of examination

Course related exam:

- [20-00-1117-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1117-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name					
Multithreading in C++					
Module nr. 20-00-0953	**Credit points** 10 CP	**Workload** 300 h	**Self-study** 210 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0953-iv	Multithreading in C++	0	Integrated course	6

2 Teaching content

C++ offers one of the most advanced threading interfaces available today. Using this interface as an example, the course teaches how to develop parallel software for shared memory with threads.

- Shared memory architectures
- Managing threads
- Sharing data between threads
- Synchronizing concurrent operations
- Designing lock-based concurrent data structures
- Designing programs for concurrency
- Testing and debugging

3 Learning objectives

Skill of developing parallel programs

- Systematically develop correct and efficient multithreaded programs
- Design and implement parallel data structures

4 Prerequisite for participation

- Knowledge of C/C++

5 Form of examination

Course related exam:

- [20-00-0953-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

Students which passed 20-00-0801 aren't allowed in this lecturen.

7 Grading

Course related exam:

- [20-00-0953-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name Scalable Data Management Systems					
Module nr. 20-00-1017	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1017-iv	Scalable Data Management Systems	0	Integrated course	4

2 Teaching content

This course introduces the fundamental concepts and computational paradigms of scalable data management systems. The focus of this course is on the systems-oriented aspects and internals of such systems for storing, updating, querying, and analyzing large datasets.

Topics include:

Database Architectures
Parallel and Distributed Databases
Data Warehousing
MapReduce and Hadoop
Spark and its Ecosystem
Optional: NoSQL Databases, Stream Processing, Graph Databases, Scalable Machine Learning

3 Learning objectives

After the course the student will have a good overview of the different concepts, algorithms, and systems aspects of scalable data management. The main goal is that the students will know how to design and implement such systems including hands-on experience with state-of-the-art systems such as Spark.

4 Prerequisite for participation

Programming in C++ and Java
Informationsmanagement (20-00-0015-iv)

Optional:
Foundations of Distributed Systems (20-00-0998-iv)

5 Form of examination

Course related exam:

- [20-00-1017-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1017-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10	**Comment**

Module name					
Software Engineering - Design and Construction					
Module nr. 20-00-0341	**Credit points** 8 CP	**Workload** 240 h	**Self-study** 165 h	**Module duration** 1 Term	**Module cycle** Summer term
Language English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0341-iv	Software Engineering - Design and Construction	0	Integrated course	5

2 Teaching content

The primary goal of the lecture is to teach students how to design modular software to get maintainable, reusable and extensible software systems.

As part of the lecture, the relation between advanced programming language features and software designs is discussed and also the impact of programming languages on the overall design.

The lecture will in particular discuss:
- Class design (principles) using advanced design patterns and advanced programming language features
- Package-level design (principles);
- High-level design using architecture styles;
- Documenting designs;
- Refactoring designs;
- Metrics to evaluate designs.

3 Learning objectives

After the successful completion of the lecture students are able to perform the following tasks:
- They can analyze the design of existing systems with respect to their modularity and can propose refactorings to improve the modular structure.
- They understand the mid- and long-term issues of non-modular systems.
- They know advanced design patterns and can identify them in existing code and can also apply them to solve new design problems.
- They know well-established architectural styles and can apply them in familiar situations.
- They understand that a solution to a design problem may depend on the chosen programming language and to critically question related decisions.

4 Prerequisite for participation

Successful completion of the lecture Software Engineering

5 Form of examination

Course related exam:
- [20-00-0341-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0341-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** - Bass, L.; Clements, P.; Kazman, R. ; Software Architecture in Practice, Addison-Wesley - Booch, G. Object-Oriented Analysis and Design with Applications. Addison-Wesley - Budd, T. Introduction to Object-Oriented Programming. 2nd. ed., Addison-Wesley - Buschmann, F. et al. Pattern-Oriented Software Architecture: A System of Patterns. John Wiley & Sons - Czarnecki, K. and Eisenecker, U. Generative Programming. Addison-Wesley - Garland, D. and Shaw, M. Software Architecture: Perspectives on an Emerging Discipline. Prentice Hall - Gamma, E. et al. Design Patterns: Elements of Reusable Object-Oriented Software. Addison-Wesley - Martin, Robert. Agile Software Development. Principles, Patterns, and Practices. Pearson US Imports & PHIPEs - Riel, A. Object-Oriented Design Heuristics. Addison-Wesley
10	**Comment**

Module name					
Software-Engineering - Maintenance and Quality Assurance					
Module nr. 18-su-2010	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
18-su-2010-vl	Software-Engineering - Maintenance and Quality Assurance	0	Lecture	3
18-su-2010-ue	Software-Engineering - Maintenance and Quality Assurance	0	Practice	1

2 Teaching content

The lecture covers advanced topics in the software engineering field that deal with maintenance and quality assurance of software. Therefore, those areas of the software engineering body of knowledge which are not addressed by the preceding introductory lecture, are in focus. The main topics of interest are: software maintenance and reengineering, configuration management, static programme analysis and metrics, dynamic programme analysis and runtime testing as well as programme transformations (refactoring). During the exercises, the participants analyze, test and restructure different examples.

3 Learning objectives

The lecture uses a single running example to teach basic software maintenance and quality assuring techniques in a practice-oriented style. Upon successful completion of the module, students should be familiar with all activities needed to maintain and evolve a software system of considerable size. Main emphasis is laid on software configuration management and testing activities. Selection and usage of CASE tool play a major role.

4 Prerequisite for participation

Recommended: Introduction to Computer Science for Engineers as well as basic knowledge of Java

5 Form of examination

Module exam:

- Module exam (Technical examination, Examination, Duration: 90 Min., Default RS)

6 Prerequisite for the award of credit points

Passing the final module examination

7 Grading

Module exam:

- Module exam (Technical examination, Examination, Weighting: 100 %)

8 Usability of the module

MSc ETiT, MSc iST, MSc Wi-ETiT, Informatik

9 References

https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/se-ii-v and Moodle

10 Comment

1.1.2.4 Data Science Applications

Module name Computer Vision I					
Module nr. 20-00-0157	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0157-iv	Computer Vision	0	Integrated course	4

2 Teaching content

- Basics of image formation
- Linear and (simple) nonlinear image filtering
- Foundations of multi-view geometry
- Camera calibration and pose estimation
- Foundations of 3D reconstruction
- Foundations of motion estimation from video
- Template and subspace methods for object recognition
- Object classification with bag of words
- Object detection
- Basics of image segmentation

3 Learning objectives

After successfully attending the course, students are familiar with the basics of computer vision. They understand fundamental techniques for the analysis of images and videos, can name their assumptions and mathematical formulations, as well as describe the resulting algorithms. They are able to implement these techniques in order to solve basic image analysis tasks on realistic imagery.

4 Prerequisite for participation

Particiation of lecture Visual Computing is recommended.

5 Form of examination

Course related exam:

- [20-00-0157-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0157-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
9	**References** Literature recommendations will be updated regularly, an example might be: - R. Szeliski, ""Computer Vision: Algorithms and Applications"", Springer 2011 - D. Forsyth, J. Ponce, ""Computer Vision – A Modern Approach"", Prentice Hall, 2002
10	**Comment**

Module name Computer Vision II					
Module nr. 20-00-0401	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0401-iv	Computer Vision II	0	Integrated course	4

2 Teaching content

- Computer vision as (probabilistic) inference
- Robust estimation and modeling
- Foundations of Bayesian networks and Markov random fields
- Basic inference and learning methods in computer vision
- Image restoration
- Stereo
- Optical flow
- Bayesian tracking of (articulated) objects
- Semantic segmentation
- Current research topics

3 Learning objectives

After successfully attending the course, students have developed a more in-depth understanding of computer vision. They formulate image and video analysis tasks as inference problems, taking challenges of real applications into account, e.g. regarding robustness. They solve the inference problem using discrete or continuous inference algorithms, and apply these to realistic imagery. They quantitatively evaluate the application specific results.

4 Prerequisite for participation

Participation of lecture Visual Computing and Computer Vision I is recommended.

5 Form of examination

Course related exam:
- [20-00-0401-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0401-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Literature recommendations will be updated regularly, an example might be: - S. Prince, “Computer Vision: Models, Learning, and Inference”, Cambridge University Press, 2012 - R. Szeliski, ""Computer Vision: Algorithms and Applications"", Springer 2011
10	**Comment**

Module name Deep Learning for Medical Imaging					
Module nr. 20-00-1014	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-1014-iv	Deep Learning for Medical Imaging	0	Integrated course	3

2	**Teaching content** Formulating Medical Image Segmentation, Computer Aided Diagnosis and Surgical Planning as Machine Learning Problems, Deep Learning for Medical Image Segmentation, Deep Learning for Computer Aided Diagnosis, Surgical Planning from pre-surgical images using Deep Learning, Tool presence detection and localization from endoscopic videos using Deep learning, Adversarial Examples for Medical Imaging, Generative Adversarial Networks for Medical Imaging.
3	**Learning objectives** After successful completion of the course, students should be able to understand all components of formulating a Medical Image Analysis problem as a Machine Learning problem. They should also be able to make informed decision of choosing a general purpose deep learning paradigm for given medical image analysis problem.
4	**Prerequisite for participation** - Programming skills - Understanding of Algorithmic design - Linear Algebra - Image Processing / Computer Vision I - Statistical Machine Learning
5	**Form of examination** Course related exam: • [20-00-1014-iv] (Technical examination, Oral/written examination, Default RS)
6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-1014-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Deep Learning for Natural Language Processing					
Module nr. 20-00-0947	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. phil. Iryna Gurevych		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0947-iv	Deep Learning for Natural Language Processing	0	Integrated course	4

2 Teaching content

The lecture provides an introduction to the foundational concepts of deep learning and their application to problems in the area of natural language processing (NLP)
Main content:
- foundations of deep learning (e.g. feed-forward networks, hidden layers, backpropagation, activation functions, loss functions)
- word embeddings: theory, different approaches and models, application as features for machine learning
- different architectures of neuronal networks (e.g. recurrent NN, recursive NN, convolutional NN) and their application for groups of NLP problems such as document classification (e.g. spam detection), sequence labeling (e.g. POS-tagging, Named Entity Recognition) and more complex structure prediction (e.g. Chunking, Parsing, Semantic Role Labeling)

3 Learning objectives

After completion of the lecture, the students are able to
- explain the basic concepts of neural networks and deep learning.
- explain the concept of word embeddings, train word embeddings and use them for solving NLP problems.
- understand and describe neural network architectures that are used to tackle classical NLP problems such as classification, sequence prediction, structure prediction.
- implement neural networks for NLP problems using existing libraries in Python.

4 Prerequisite for participation

Basic knowledge of mathematics and programming

5 Form of examination

Course related exam:
- [20-00-0947-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0947-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name Deep Learning: Architectures & Methods					
Module nr. 20-00-1034	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1034-iv	Deep Learning: Architectures & Methods	0	Integrated course	4

2 Teaching content

- Review of machine learning background
- Deep Feedforward Networks
- Regularization for Deep Learning
- Optimization for Training Deep Models
- Convolutional Networks
- Sequence Modeling: Recurrent and Recursive Nets
- Linear Factor Models
- Autoencoders
- Representation Learning
- Structured Probabilistic Models for Deep Learning
- Monte Carlo Methods
- Approximate Inference
- Deep Generative Models
- Deep Reinforcement Learning
- Deep Learning in Vision
- Deep Learning in NLP

3 Learning objectives

This course provides students with the required advanced background on machine learning the knowledge to independently carry out research projects on the hot topic of deep learning, e.g. within the scope of a Bachelor's or Master's thesis. In particular, this class aims at providing the students with fundamental understanding of deep learning algorithms and the architecture of deep networks.

4 Prerequisite for participation

20-00-0358-iv Statistical Machine Learning
20-00-0052-iv Data Mining and Machine Learning

5 Form of examination

Course related exam:

- [20-00-1034-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1034-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name					
Intelligent Robotic Manipulation: Advanced topics in Robot Perception, Planning and Control					
Module nr. 20-00-1181	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1181-iv	Intelligent Robotic Manipulation: Advanced topics in Robot Perception, Planning and Control	0	Integrated course	4

2 Teaching content

This course introduces fundamental algorithmic approaches for creating robot systems that can autonomously manipulate physical objects in unstructured environments such as homes. We will cover basic principles for endowing autonomous robots with planning, perception, and decision-making capabilities, i.e., topics include perception (including approaches based on deep learning and approaches based on 3D geometry), planning (robot kinematics and trajectory generation, collision-free motion planning, task-and-motion planning, and planning under uncertainty), as well as dynamics and control for adaptive and reactive manipulation.

Tentative list of topics:

- Topology in robotics and rigid body motions
- Refresher on forward, inverse kinematics and dynamics
- Differential kinematics and optimization
- Geometric perception and object pose detection
- Object pose estimation and tracking and multi-sensor fusion
- Grasp generation and grasp evaluation
- Trajectory Optimization
- Search and Sampling-based motion planning
- Force control
- Visuomotor policies and intuitive physics
- Task and motion planning and belief-space planning

Practical exercises will guide understanding fundamental mathematical and algorithmic principles for enabling robotic manipulators to perceive their environment, estimate the current state of the robot itself and the robots or humans in their surroundings, and create a strategy for executing various tasks that involve autonomously manipulating objects in cluttered scenes.

3 Learning objectives

After completeing the module students will have learned the theoretical, algorithmic, and implementation aspects of main techniques for autonomous and intelligent robotic manipulation, in particular modeling & controls, motion planning, perception, estimation, state machines, and decision making.

With this class, the student will:

- have gained a fundamental knowledge of the “intelligence and autonomy stack” behind autonomous robots in general.
- be able to apply such knowledge in applications and research work.
- devise novel methods and algorithms for intelligent robotic manipulation.

4 Prerequisite for participation

	Recommended: The students should have a fundamental knowledge of robotics and linear algebra. Furthermore, Fundamentals of Robotics (20-00-0735-iv Grundlagen der Robotik) is recommended. Experience in Robot Learning (20-00-0629-vl Lernende Roboter) is also a plus. Combining the course with the seminar and project lab will equip the students with a greater understanding and in-depth knowledge of the necessary components and principles to enable robotic autonomous manipulation.
5	**Form of examination** Course related exam: • [20-00-1181-iv] (Technical examination, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).
6	**Prerequisite for the award of credit points** Pass Exam (100%).
7	**Grading** Course related exam: • [20-00-1181-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Robot Learning					
Module nr. 20-00-0629	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner**		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0629-vl	Robot Learning	0	Lecture	4

2 Teaching content

- Foundations from robotics and machine learning for robot learning
- Learning of forward models
- Representation of a policy, hierarchical abstraction wiith movement primitives
- Imitation learning
- Optimal control with learned forward models
- Reinforcement learning and policy search
- Inverse reinforcement learning

3 Learning objectives

Upon successful completion of this course, students are able to understand the relevant foundations of machine learning and robotics. They will be able to use machine learning approaches to empower robots to learn new tasks. They will understand the foundations of optimal decision making and reinforcement learning and can apply reinforcement learning algorithms to let a robot learn from interaction with its environment. Students will understand the difference between Imitation Learning, Reinforcement Learning, Policy Search and Inverse Reinforcement Learning and can apply each of this approaches in the appropriate scenario.

4 Prerequisite for participation

Good programming in Matlab
Lecture Machine Learning 1 - Statistical Approaches is helpful but not mandatory.

5 Form of examination

Course related exam:

- [20-00-0629-vl] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0629-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Deisenroth, M. P.; Neumann, G.; Peters, J. (2013). A Survey on Policy Search for Robotics, Foundations and Trends in Robotics Kober, J; Bagnell, D.; Peters, J. (2013). Reinforcement Learning in Robotics: A Survey, International Journal of Robotics Research C.M. Bishop, Pattern Recognition and Machine Learning (2006), R. Sutton, A. Barto. Reinforcement Learning - an Introduction Nguyen-Tuong, D.; Peters, J. (2011). Model Learning in Robotics: a Survey
10	**Comment**

Module name Natural Language Processing and the Web					
Module nr. 20-00-0433	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0433-iv	Natural Language Processing and the Web	0	Integrated course	4

2 Teaching content

The Web contains more than 10 billion indexable web pages, which can be retrieved via keyword search queries. The lecture will present natural language processing (NLP) methods to automatically process large amounts of unstructured text from the web and analyze the use of web data as a resource for other NLP tasks.

Key topics:

- Processing unstructured web content
- NLP basics: tokenization, part-of-speech tagging, stemming, lemmatization, chunking
- UIMA: principles and applications
- Web contents and their characteristics, incl. diverse genres such as personal web sites, news sites, blogs, forums, wikis
- The web as a corpus - innovative use of the web as a very large, distributed, interlinked, growing, and multilingual corpus
- NLP applications for the web
- Introduction to information retrieval
- Web information retrieval and natural language interfaces
- Web-based question answering
- Mining Web 2.0 sites such as Wikipedia, Wiktionary
- Quality assessment of web contents
- Multilingualism
- Internet of services: service retrieval
- Sentiment analysis and community mining
- Paraphrases, synonyms, semantic relatedness

3 Learning objectives

After attending this course, students are in a position to
- understand and differentiate between methods and approaches for processing unstructured text,
- reconstruct and explicate the principle of operation of web search engines,
- construct and analyze exemplary NLP applications for web data,
- analyze and evaluate the potential of using web contents to enhance NLP applications.

4 Prerequisite for participation

Basic knowledge in Algorithms and Data Structure
Programming in Java

5 Form of examination

Course related exam:
- [20-00-0433-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7	**Grading** Course related exam: • [20-00-0433-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** - Kai-Uwe Carstensen, Christian Ebert, Cornelia Endriss, Susanne Jekat, Ralf Klabunde: Computerlinguistik und Sprachtechnologie. Eine Einführung. 3. Auflage. Heidelberg: Spektrum, 2009. ISBN: 978-3-8274-20123-7. - http://www.linguistics.rub.de/CLBuch/ - T. Götz, O. Suhre: Design and implementation of the UIMA Common Analysis System, IBM Systems Journal 43(3): 476-489, 2004. - Adam Kilgarriff, Gregory Grefenstette: Introduction to the Special Issue on the Web as Corpus, Computational Linguistics 29(3): 333-347, 2003. - Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze: Introduction to Information Retrieval, Cambridge: Cambridge University Press, 2008. ISBN: 978-0-521-86571-5. http://nlp.stanford.edu/IR-book/
10	**Comment**

Module name					
Reinforcement Learning: From Foundations to Deep Approaches					
Module nr. 20-00-1047	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1047-iv	Reinforcement Learning: From Foundations to Deep Approaches	0	Integrated course	4

2 Teaching content

- Review of machine learning background
- Black box Reinforcement Learning
- Modeling as bandit, Markov Decision Processes and Partially Observable Markov Decision Processes
- Optimal control
- System identification
- Learning value functions
- Policy search
- Deep value functions methods
- Deep policy search methods
- Exploration vs exploitation
- Hierarchical reinforcement learning
- Intrinsic motivation

3 Learning objectives

This course provides students with the required basic background on machine learning the knowledge to independently carry out research projects on the hot topic of reinforcement learning, e.g. within the scope of a Bachelor's or Master's thesis. In particular, this class aims at providing the students with fundamental understanding of reinforcement learning algorithms and the application within deep learning.

4 Prerequisite for participation

Good programming in Python.
Lecture Statistical Machine Learning is helpful but not mandatory.

5 Form of examination

Course related exam:

- [20-00-1047-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1047-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Study-related Achievements

1.1.2.5 Seminars

Module name Reinforcement Learning Algorithms and Platforms					
Module nr. 20-00-1050	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1050-se	Reinforcement Learning Algorithms and Platforms	0	Seminar	2

2 Teaching content

This seminar will cover learning methods and their application in intelligent technical systems. In the context of this seminar, students will train the ability to write a scientific article and present its content similar as at scientific conference.

3 Learning objectives

Upon completion of this class, students can follow ongoing work in reinforcement learning and can do a literature review for a research project in this research area.

4 Prerequisite for participation

Simultaneous Participation in "Reinforcement Learning: From Foundations to Deep Approaches" or previous participation in "Robot Learning."

5 Form of examination

Course related exam:

- [20-00-1050-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1050-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Automated Code Genereation					
Module nr. 20-00-0790	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-0790-se	Automated Code Generation	0	Seminar	3
2	**Teaching content** - Examples of Domain Specific Languages (DSL) - Automatic Differentiation - Automated Generation of Code for specific hardware architectures				
3	**Learning objectives** - Basic knowledge of development and use of DSLs. - Knowledge of some frameworks for DSL and for model driven software development (MDSD). - Foundations of automatic differentiation and its implementation				
4	**Prerequisite for participation** - Foundations of Computer Science 3 - Basic knowledge of differential algebra with respect to derivatives (chain rule, gradients, Jacobian)				
5	**Form of examination** Course related exam: • [20-00-0790-se] (Study achievement, Oral/written examination, Default RS)				
6	**Prerequisite for the award of credit points** Pass exam (100%)				
7	**Grading** Course related exam: • [20-00-0790-se] (Study achievement, Oral/written examination, Weighting: 100 %)				
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT M.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.				
9	**References**				
10	**Comment**				

Module name Deep Learning and Digital Humanities					
Module nr. 20-00-1080	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-1080-se	Deep Learning and Digital Humanities	0	Seminar	2
2	**Teaching content** Our focus will be on humanities applications such as Poetry Generation and Analysis, Metaphor Identification, analysis of emotions, and others, and how these can be solved with the help of Deep Learning techniques. Students will read papers and present them during the seminar.				
3	**Learning objectives** After this seminar, students will be able to: * understand problems in the field of digital humanities * understand how Deep Learning can used to solve these problems * implement crowd-sourcing techniques for annotation				
4	**Prerequisite for participation** Lecture Deep Learning is helpful, but not required.				
5	**Form of examination** Course related exam: • [20-00-1080-se] (Study achievement, Oral/written examination, Default RS)				
6	**Prerequisite for the award of credit points** Pass exam (100%)				
7	**Grading** Course related exam: • [20-00-1080-se] (Study achievement, Oral/written examination, Weighting: 100 %)				
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.				
9	**References**				
10	**Comment**				

Module name Design and Implementation of Modern Programming Languages					
Module nr. 20-00-0182	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0182-se	Design and Implementation of Modern Programming Languages	0	Seminar	2

2 Teaching content

3 Learning objectives

Ability for individual work on scientific questions in the area of "Design and Implementation of modern Programming Languages"; Development of understanding about the selected themes; Acquisition of presentation skills

4 Prerequisite for participation

Vordiplom or equivalent qualification (i.e. the technical knowledge of the first 4 semesters of a Bachelor of Computer Science). The seminar can also serve as an skills training for all programs

5 Form of examination

Course related exam:

- [20-00-0182-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0182-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name Extended Seminar - Systems and Machine Learning					
Module nr. 20-00-1057	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1057-se	Extended Seminar - Systems and Machine Learning	0	Seminar	3

2 Teaching content

This seminar serves the purpose of discussing new research papers in the intersection of hardware/software-systems and machine learning. The seminar aims to elicit new connections amongst these fields and discusses important topics regarding systems questions machine learning including topics such as hardware accelerators for ML, distributed scalable ML systems, novel programming paradigms for ML, Automated ML approaches, as well as using ML for systems.

Every participant will present one research paper, which will be subsequently discussed by all participants. In addition, summary papers will be written in groups and submitted to a peer review process. The papers will typically be recent publications in relevant research venues and journals.

The seminar will be offered as a block seminar. Further information can be found at: http://binnig.name

3 Learning objectives

After this seminar, the students should be able to
- understand a new research contribution in the areas of the seminar
- prepare a written report and present the results of such a paper in front of an audience
- participate in a discussion in the areas of the seminar
- to peer-review the results of other students

4 Prerequisite for participation

Basic knowledge in Machine Learning, Data Management, and Hardware-/Software-Systems.

5 Form of examination

Course related exam:
- [20-00-1057-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1057-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B. Sc Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name					
Extended Seminar - AI for Data Management					
Module nr. 20-00-1182	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. phil. Iryna Gurevych		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1182-se	Extended Seminar - AI for Data Management	0	Seminar	3

2 Teaching content

Database management systems (DBMS) in the cloud are the backbone for managing large volumes of data efficiently and thus play a central role in business and science today. For providing high performance, many of the most complex DBMS components such as query optimizers or schedulers involve solving non-trivial problems.

To tackle such problems, very recent work has outlined a new direction of so-called learned DBMS components where AI-based methods are used to replace and enhance core DBMS components which has shown to provide significant performance benefits. This route is in particular interesting since Cloud vendors such as Google, Amazon, and Microsoft are already applying these techniques to optimize the performance their cloud data systems.

Furthermore, AI has also been used for improving many other data management related tasks such as data engineering tasks (e.g., error detection and correction in databases or data transformation and data augmentation) which typically cause high manual overhead and can be automated by the use of AI. Finally, AI has also been used for extending databases by better data access interfaces (e.g., natural languague querying and chatbots for data) or by supporting data beyond structured tabular data (i.e., text and images).

This seminar serves the purpose to understand the basic concepts of how AI can be used for data management. In the first part of the seminar, participants will learn the basics of AI for data management along with implementing a case study themselves. In the second part, every participant will select and present a recent research paper. The papers will typically be recent publications in relevant research venues and journals such as SIGMOD, VLDB or ICML, NeurIPS.

The seminar kick-off will typically be in the first two weeks of the semester where we discuss the organization of the seminar. Further information can be found at: http://tuda.systems

3 Learning objectives

After successfully completeing this module Students are able to
- apply basic concepts of AI to data management
- read and understand a new research contribution in the areas of the seminar
- prepare and present the results of such a paper in front of an audience
- participate in a discussion in the areas of the seminar
- to peer-review the results of other students

4 Prerequisite for participation

Recommended:
Basic knowledge in Machine Learning and programming in Python and ideally C++. Advanced knowledge in Data Management, and Database-Systems by attending courses such as SDMS or ADMS.

5 Form of examination

	Course related exam: • [20-00-1182-se] (Study achievement, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible: Colloquium (optional: including presentation), Term Paper.
6	**Prerequisite for the award of credit points** Pass Exam (100%).
7	**Grading** Course related exam: • [20-00-1182-se] (Study achievement, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name					
Advanced Topics in Computer Vision and Machine Learning					
Module nr. 20-00-0645	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0645-se	Advanced Topics in Computer Vision and Machine Learning	0	Seminar	2

2 Teaching content

- Basics of scientific presentations and reviewing
- Independent familiarization with current publications in computer vision or machine learning (in English)
- Further research on background literature, with help from a mentor
- Preparation of a two-part slide presentation (problem statement and proposed solution) of one publication, with feedback from mentor
- Writing a scientific “mock” review of another publication, with aid from mentor
- Giving the presentation in front of a mixed audience
- Guiding the interactive discussion after both presentation parts
- Active participation in discussions, including feedback to presenters

3 Learning objectives

After successfully completing the seminar, students are able to use recent scientific publications to become acquainted with current topics in computer vision and/or machine learning in an independent fashion. They can recognize the key contributions of the publications and are able to present them to a heterogeneous audience, taking into account good practices of scientific presentation. They can direct a scientific discussion following the presentation. Moreover, they are able to author a scientific review following common standards of the scientific review process.

4 Prerequisite for participation

Teilnehmer sollten Grundkenntnisse in Computer Vision, sowie idealerweise maschinellem Lernen besitzen (z.B. durch Besuch von Computer Vision I, Maschinelles Lernen: Statistische Verfahren I).

5 Form of examination

Course related exam:
- [20-00-0645-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0645-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Actual publications, mostly last year.
10	**Comment**

Module name Foundations of Static Analyses					
Module nr. 20-00-1028	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Dr.-Ing. Michael Eichberg		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1028-se	Foundations of Static Analyses	0	Seminar	2

2 Teaching content

The foundations of static analyses which are required when implementing advanced analyses for the detection of quality and security issues.

Some topics are:
- computing control- and data-dependencies in the presence of infinite loops and irreducible control-flow graphs
- code slicing
- identifying loops in machine code
- call-graph construction
- static analysis frameworks (e.g., IDE, IFDS, Reactive Async)
- self-adaptation of static analyses
- Sound(iness)
- Specification Mining

3 Learning objectives

The students will be familiar with the core foundations of advanced analyses and will be able to assess the suitability of specific techniques and algorithms for specific analysis purposes. The students will also be able to effectively describe and present advanced, technical topics.

4 Prerequisite for participation

This seminar is targeted at advanced bachelor and master level students. Being familiar with compiler techniques (e.g. SSA form) is highly recommended.

5 Form of examination

Course related exam:
- [20-00-1028-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1028-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs-

9 References

10 Comment

Module name					
Parallel Computing					
Module nr. 20-00-0994	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Dr.-Ing. Michael Eichberg		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0994-se	Parallel Computing	0	Seminar	3

2 Teaching content

Current trends in parallel computing, e.g.,
- Emerging applications (e.g., deep learning)
- Emerging parallel programming models
- Developing parallel software for smart phones
- GPUs, manycore architectures
- FPGAs
- Architectures for the post-Moore era
- Parallel I/O
- New parallel algorithms
- Exascale computing
- Cloud computing

3 Learning objectives
- Explore recent advances in parallel computing
- Search and analyze literature
- Write reports that are easy to read
- Design slides that support the intended message
- Speak in front of an audience
- Provide feedback to other participants

4 Prerequisite for participation
- Knowledge of computer architecture, programming, software engineering
- Basic understanding of parallel systems

5 Form of examination

Course related exam:
- [20-00-0994-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0994-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Performance Engineering					
Module nr. 20-00-1038	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1038-se	Performance Engineering	0	Seminar	3

2 Teaching content

- Architecture and properties of shared-memory multiprocessor (SMP) machines
- Measuring and Understanding Performance on SMP Machines
- First Experience in using selected performance analysis tools

3 Learning objectives

- Understanding of factors influencing performance and their indicators: Compute units, memory design, synchronization protocols
- Understanding of the importance of comparable, understandable, and reproducable mesurements

4 Prerequisite for participation

- Basic knowledge of C++ and OpenMP

5 Form of examination

Course related exam:

- [20-00-1038-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1038-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Seminar Data Mining and Machine Learning					
Module nr. 20-00-0102	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0102-se	Seminar Data Mining and Machine Learning	0	Seminar	2

2 Teaching content

This seminar serves the purpose of discussing new research papers in the areas of data mining and machine learning. Every participant will present one paper, which will be subsequently discussed by all participants. Grades are based on the preparation and presentation of the paper, as well as the participation in the discussion, in some cases also a written report.

The papers will typically recent publications in relevant journals such as “Data Mining and Knowledge Discovery”, ""Machine Learning"", as well as ""Journal of Machine Learning Research"". Students may also propose their own topics if they fit the theme of the seminar.

Please note current announcements to this course at http://www.ke.informatik.tu-darmstadt.de/lehre.

3 Learning objectives

After this seminar, students should be able to
- understand an unknown text in the area of machine learning
- work out a presentation for an audience proficient in this field
- make useful contributions in a scientific discussion in the area of machine learning

4 Prerequisite for participation

Basic knowledge in Machine Learning and Data Mining

5 Form of examination

Course related exam:
- [20-00-0102-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0102-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

9	**References**
10	**Comment**

Module name Software Engineering - project seminar					
Module nr. 20-00-0359	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0359-se	Software Engineering - Projectseminar	0	Seminar	2

2 Teaching content

3 Learning objectives

- Experience with independently led software projects of medium size
- Ability to appreciate the various roles within a software project
- To be able to evaluate tools and methods
- To evaluate your own competence in realistic situations
- Training of soft skills, especially teamwork
- Communication with customers
- Presentation skills

4 Prerequisite for participation

Software Engineering - Requirements (parallel)? Software Engineering - Design (parallel)
Software Engineering - Software quality assurance (parallel, recommended)
Practical experience recommended
Team training und presentation skills through HDA

5 Form of examination

Course related exam:

- [20-00-0359-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0359-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Software Engineering for Artificial Intelligence					
Module nr. 20-00-1097	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1097-se	Software Engineering for Artificial Intelligence	0	Seminar	3

2 Teaching content

Data-driven artificial intelligence (AI) solutions are being adopted in many areas, including finance, medicine, cognitive sciences, and biology. Such machine learning (ML) approaches require an accurate domain and requirement analysis, proper software design and development, dedicated testing and debugging, as well as specific techniques that ensure scalability and maintainability. While AI-enabled systems continue to have a tremendous impact on many fields, developers and data scientists still follow methods (scripting, informal/non-written specifications, trial-and-error testing) that do not conform to the state of the art of engineering disciplines. In this context, it is of paramount importance to take advantage of the decades-long developments of software engineering (SE) to systematize the development process of ML solutions.

In this course, each student will be assigned a topic regarding SE for AI. Based on provided resources and personal extending research, each student prepares a presentation with following discussion. These will be conducted in regular appointments. The students not presenting at a particular date, prepare via introductory reading for the respective discussion. Grading will be based on the preparation of the assigned topic and its presentation, as well as on the participation in all the discussions.

For more information and announcements, please consult the course webpage: https://allprojects.github.io/SE4AI/

3 Learning objectives

After successful completion of the module students will have developed a deeper understanding of software engineering for artificial intelligence. This includes the key topics requirements engineering, quality assurance, development processes, and software architecture and design accounting for modularity, reusability, efficiency, scalability, fairness and privacy.

The students learn the preparation and the presentation of scientific contents for an audience with heterogeneous background knowledge. Moreover, students train efficient preparation of and active participation in scientific discussions as well as their moderation.

4 Prerequisite for participation

Recommended: Basic knowledge of software engineering. Interest in artificial intelligence.

5 Form of examination

Course related exam:
- [20-00-1097-se] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible:
Colloquium (optional: including presentation).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

	Course related exam: • [20-00-1097-se] (Study achievement, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Symbolic Execution					
Module nr. 20-00-0702	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Reiner Hähnle		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0702-se	Symbolic Execution	0	Seminar	2

2 Teaching content

Symbolic execution of programs is a fundamental analysis technique that forms the basis of test generation, compiler optimization, verification, visualization, etc. In recent years, major progress was made. In the seminar we review the most important classic as well as recent contributions to symbolic execution.

3 Learning objectives

Understanding the possibilities and the limitations of this fundamental program analysis technique.

4 Prerequisite for participation

5 Form of examination

Course related exam:

- [20-00-0702-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0702-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Text Analytics					
Module nr. 20-00-0596	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. phil. Iryna Gurevych		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0596-se	Text Analytics	0	Seminar	2

2 Teaching content

The seminar introduces current topics in natural language processing. It provides a thorough introduction into state-of-the-art technology in text analytics. The main focus of the seminar changes each semester.

Further information: https://www.ukp.tu-darmstadt.de/teaching/courses/regular-seminar/

3 Learning objectives

After attending this course, students are in a position to
- name and explain state-of-the-art research questions in the area of the seminar,
- understand, critically assess, and discuss scientific publications,
- independently comprehend and work out a research topic and
- present it to the group and react on questions and discussion threads.

4 Prerequisite for participation

5 Form of examination

Course related exam:
- [20-00-0596-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0596-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

Will be given in seminar.

10 Comment

Module name Type Systems of Programming Languages					
Module nr. 20-00-0796	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Dr.-Ing. Michael Eichberg		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0796-se	Type Systems of Programming Languages	0	Seminar	2

2 Teaching content

Type systems are formal methods to ensure that programs exhibit a desired behavior, with respect to some implicit or explicit specification. They have a broad range of applications in software engineering, language design, security, etc. This seminar focuses on current and fundamental topics of type systems, e.g., dependent types, type inference, type checking techniques, constraint-based type systems, etc.

3 Learning objectives

Along with hands-on experience in scientific work practices, students will obtain a deeper understanding of current developments and research challenges in the broad area of type systems.
With this seminar students will learn some techniques of scientific work, such as scientific writing and search for a given topic of the field and do as well scientific review of the other student's work.

4 Prerequisite for participation

Basic knowledge of math and formal methods.
For further information you could refer our website http://www.stg.tu-darmstadt.de/teaching/teaching_iverview.en.jsp

5 Form of examination

Course related exam:
- [20-00-0796-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0796-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
M.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

10 Comment

1.1.2.6 Practical Lab in Teaching

Module name					
Data Management - Teaching Lab					
Module nr. 20-00-1040	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Courses of this module**

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1040-pl	Data Management - Teaching Lab	0	Internship teaching	3

2	**Teaching content** Creation of lab exercises and teaching material
3	**Learning objectives** Experience in the supervision of students on the topic of data management, especially with regard to using the newly created material.
4	**Prerequisite for participation** Information Management (20-00-0015-iv)
5	**Form of examination** Course related exam: • [20-00-1040-pl] (Study achievement, Oral/written examination, Default RS)
6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-1040-pl] (Study achievement, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik
9	**References**
10	**Comment**

Module name					
Teaching Lab - Deep Learning for Natural Language Processing					
Module nr. 20-00-1044	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1044-pl	Teaching Lab - Deep Learning for Natural Language Processing	0	Internship teaching	3

2 Teaching content

Organization of a shared tasks. In a shared task, the students are challenged to solve a current research problem. They will use methods they learned in the lecture to solve a certain problem as good as possible. The different solutions can be evaluated quantitatively to identify the best solution to the task. Your task is to select and prepare an appropriate dataset for the task and to give an introduction to the task. During the shared task, you are responsible to answer questions from the students and provide help if needed. After the submission, your task is to evaluate the submitted systems quantitatively and qualitatively. Besides the shared task, you support the weekly exercises, e.g., by answering student questions or by helping to grade the home exercises.

3 Learning objectives

The students work on problems that have both technical and didactic aspects and are involved in the implementation of the results they have developed.

4 Prerequisite for participation

Deep Learning for Natural Language Processing

5 Form of examination

Course related exam:

- [20-00-1044-pl] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1044-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name Teaching Lab - Foundations of Language Technology (FOLT)					
Module nr. 20-00-1110	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. phil. Iryna Gurevych		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-1110-pl	Teaching Lab - Foundations of Language Technology (FOLT)	0	Internship teaching	3
2	**Teaching content** Preparation, organization and correction of a shared tasks. Offering of office hours. Holding of tutorials and similar tasks in the context of teaching.				
3	**Learning objectives** After completing the course, the students are able to independently hold a tutorial, conduct shared tasks, and pursue similar tasks in the context of teaching.				
4	**Prerequisite for participation** Recommended: participation in previous Foundation of Language Technology (FOLT) courses or similar courses (e.g. Deep Learning for Natural Language Processing (DL4NLP))				
5	**Form of examination** Course related exam: • [20-00-1110-pl] (Study achievement, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Colloquium (optional: including presentation), portfolio, report (optional: including submission of course material).				
6	**Prerequisite for the award of credit points** Pass exam (100%)				
7	**Grading** Course related exam: • [20-00-1110-pl] (Study achievement, Oral/written examination, Weighting: 100 %)				
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.				
9	**References**				
10	**Comment**				

Module name Practical Lab in Teaching - Software Technology					
Module nr. 20-00-0443	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0443-pl	Practical Lab in Teaching - Software Technology	0	Internship teaching	3

2 Teaching content

3 Learning objectives

The ability to create teaching material for Computer Science students should be learnt. You will also evaluate your input on how well the learners are instructed

4 Prerequisite for participation

Vordiplom / Foundation Courses

5 Form of examination

Course related exam:

- [20-00-0443-pl] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0443-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name Practical Lab in Teaching - Statistical Machine Learning					
Module nr. 20-00-1070	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Arjan Kuijper		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1070-pl	Practical Lab in Teaching - Statistical Machine Learning	0	Internship teaching	3

2 Teaching content
Teaching support, such as supervision of exercise groups, consultations, etc.

3 Learning objectives
Preparation for future teachers' own teaching activities.

4 Prerequisite for participation
Successful completion of Statistical Machine Learning or corresponding knowledge.

5 Form of examination
Course related exam:
- [20-00-1070-pl] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points
Pass exam (100%)

7 Grading
Course related exam:
- [20-00-1070-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name					
Practical Lab in Teaching - Parallel Programming					
Module nr. 20-00-1049	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Dr.-Ing. Michael Eichberg		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1049-pl	Practical Lab in Teaching - Parallel Programming	0	Internship teaching	3

2 Teaching content

Conducting and supervising exercises and laboratories of the course “Parallel Programming”.

3 Learning objectives

Students are able to:
- Present and explain the lecture contents in the exercises
- Supervise laboratories
- Measure learning success in a systematic way

4 Prerequisite for participation

- Knowledge of C/C++ and parallel programming
- German

5 Form of examination

Course related exam:
- [20-00-1049-pl] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1049-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik

9 References

10 Comment

1.1.2.7 Labs, Project Labs, Related Courses

Module name Application of Reinforcement Learning Methods					
Module nr. 20-00-1048	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1048-pp	Application of Reinforcement Learning Methods	0	Project	6

2 Teaching content

In this project, students get hands-on experience in reinforcement learning research conducted by a team of students. Small groups of students pursue their own Reinforcement Learning experiment, involving standard platforms (Cartpole, Furuta-Pendel, etc). Starting from a project idea, students are guided by the lecturer through the whole process of developing the experiment, collecting and analyzing data and writing a research report/paper which is ready to publish.

3 Learning objectives

Hands-on introduction into Research, Designing and conducting an Experiment, potentially resulting in a first publication.

4 Prerequisite for participation

Gleichzeitige Belegung der Vorlesung "Reinforcement Learning: Von Grunlagen zu den Tiefen Ansätzen" oder vorhergehende Belegung von "Lernende Roboter."

5 Form of examination

Course related exam:
- [20-00-1048-pp] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1048-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Data Management - Lab					
Module nr. 20-00-1041	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1041-pr	Data Management - Lab	0	Internship	4

2 Teaching content

Participants independently solve alone or in a small group an individually a given problem. The problems are usually programming projects inspired by the research performed at the Data Management Lab.

Possible areas are:
- Scalable Databases & Modern Hardware
- Cloud Databases & Blockchains
- Interactive Data and Text Exploration
- Natural Language Interfaces for Databases
- Scalable Systems for Machine Learning

In this lab the students will realise a project defined by their advisor. Compared to the "Data Management - Lab", the “Data Management - Extended Lab” requires more effort.

3 Learning objectives

After completion of this course the students are able to
- Understand state-of-the-art techniques in modern data management systems
- Apply and implemenation of techniques in individual projects
- Provide experimental evidence for design decisions with benchmarks and/or real workloads

4 Prerequisite for participation

Depending on selected topic.

5 Form of examination

Course related exam:
- [20-00-1041-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1041-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name					
Data Management - Extended Lab					
Module nr. 20-00-1042	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1042-pp	Data Management - Extended Lab	0	Project	6

2 Teaching content

Participants independently solve alone or in a small group an individually a given problem. The problems are usually programming projects inspired by the research performed at the Data Management Lab.

Possible areas are:
- Scalable Databases & Modern Hardware
- Cloud Databases & Blockchains
- Interactive Data and Text Exploration
- Natural Language Interfaces for Databases
- Scalable Systems for Machine Learning

In this lab the students will realise a project defined by their advisor. Compared to the "Data Management - Lab", the “Data Management - Extended Lab” requires more effort.

3 Learning objectives

After completion of this course the students are able to
- Understand state-of-the-art techniques in modern data management systems
- Apply and implemenation of techniques in individual projects
- Provide experimental evidence for design decisions with benchmarks and/or real workloads

4 Prerequisite for participation

Depending on selected topic.

5 Form of examination

Course related exam:
- [20-00-1042-pp] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1042-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Expert Lab on Robot Learning					
Module nr. 20-00-1108	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1108-pp	Expert Lab on Robot Learning	0	Project	6

2 Teaching content

In this project, students perfect their ability at experimental work in an interdisciplinary team and become experts in scientific approaches to Robot Learning. In this project, small groups of students develop a common experiment in Robot Learning based on special robotic platforms, evaluate it and write a research report/paper that reaches the quality of a submission to an international scientific conference or journal.

3 Learning objectives

After completing the module, students can apply the practical skills of an expert in scientific studies on Robot Learning. They are able to analyze and synthesize experiments from the research idea up to the publication.

4 Prerequisite for participation

Recommended: Successful completion of Robot Learning: Integrated Project - Part 1 and Robot Learning: Integrated Project - Part 2.

5 Form of examination

Course related exam:

- [20-00-1108-pp] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Report (optional: including submission of source code), colloquium (optional: including presentation).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1108-pp] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name					
Research Project Knowledge Engineering and Machine Learning					
Module nr. 20-00-0751	**Credit points** 12 CP	**Workload** 360 h	**Self-study** 240 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0751-pj	Research Project in Knowledge Engineering and Machine Learning	0	Project	8

2 Teaching content

Through an individual project, students are tutored to autonomously conduct research in knowledge engineering, artificial intelligence, machine learning or data mining
The research topics will be defined in collaboration with their tutor.

Possible areas:
- Machine Learning and Data Mining
- Inductive Rule Learning
- Learning from Preferences
- Multilabel Classification
- Information Extraction
- Web Mining
- Semantic Web
- Game Playing

Concrete tasks will be assigned on an individual basis. The project can be started at any time.

Students that are interested in such a project, please contact a staff member of the Knowledge Engineering group (http://www.ke.tu-darmstadt.de).

3 Learning objectives

After completion of this project, students should be able to
- autonomously conduct small research projects in the areas knowledge engineering, artificial intelligence, maschine learning and data mining
- document the achieved results in a report
- present them in a scientific talk
- defend them in a critical discussion

4 Prerequisite for participation

Basic knowledge in Knowledge Engineering , Artificial Intelligence and Machine Learning is helpful.
Java or similar is expected.
Self-motivated and highly interested in actual research.

5 Form of examination

Course related exam:
- [20-00-0751-pj] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

	Course related exam: • [20-00-0751-pj] (Study achievement, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References**
10	**Comment**

Module name Implementation of Programming Languages					
Module nr. 20-00-0306	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-0306-pr	Implementation of Programming Languages	0	Internship	4
2	**Teaching content**				
3	**Learning objectives**				
4	**Prerequisite for participation** ...				
5	**Form of examination** Course related exam: • [20-00-0306-pr] (Study achievement, Oral/written examination, Default RS)				
6	**Prerequisite for the award of credit points** Pass exam (100%)				
7	**Grading** Course related exam: • [20-00-0306-pr] (Study achievement, Oral/written examination, Weighting: 100 %)				
8	**Usability of the module**				
9	**References**				
10	**Comment**				

Module name Performance Analysis and Modeling of Software Systems					
Module nr. 20-00-1130	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language English			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1130-pr	Performance Analysis and Modeling of Software Systems	0	Internship	4

2 Teaching content

The goal of this Lab is to:

1. gain experience in designing experiments that measure the performance of complex software systems,
2. process and analyze the results,
3. build models that describe the behavior of the system.

The experimental results and the models will be used to determine the components of the system that are the bottleneck for performance.

The skills acquired in the Lab shall be relevant to a wide variety of career paths: students who will later pursue a PhD in Systems topics, Data Scientists who will have to work with large distributed processing pipelines, Software Engineers and DevOps who will have to work on improving the performance of IT systems.

To achieve the above goals, we will, on the one hand, review the relevant theory (e.g., Statistical methods, Little's Law, Queuing Theory) and, on the other hand, implement a data processing application that will then be benchmarked and modeled in detail.

The Lab concludes with short project presentations, in which students will demonstrate that they have understood the behavior of their implementation and are able to provide ideas for removing bottlenecks based on the experimental data and the models they have built.

3 Learning objectives

After completion of the module, the students are be able to:

- choose between different experiment types to answer performance-related questions about a software system
- build detailed models of a software system
- perform bottleneck analysis on a model
- summarize and present the results of experimentation

4 Prerequisite for participation

Recommended: Students should have taken introductory courses on computer architecture and operating systems, and should be familiar with Java programming.

5 Form of examination

Course related exam:

- [20-00-1130-pr] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Report (optional: including submission of source code), colloquium (optional: including presentation).

6 Prerequisite for the award of credit points

	Pass exam (100%)
7	**Grading** Course related exam: • [20-00-1130-pr] (Study achievement, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Robot Learning: Integrated Project - Part 1					
Module nr. 20-00-0753	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-0753-pj	Robot Learning: Integrated Project - Part 1	0	Project	4

2	**Teaching content** In "Robot Learning: Integrated Project, Part 1", students will pose a current research problem in the domain of robot learning with assistance of their advisor. The students will select a robot learning topic to fit their research interests, on which they will pursue in-depth literature studies. Using these results, they will develop a plan for their project, try out the algorithms of interest and implement a prototype in simulation.
3	**Learning objectives** Upon successful completion of this course, students will be able to independently develop small research projects in the domain of robot learning and test first research ideas in simulation.
4	**Prerequisite for participation** Previous or concurrent participation in the lecture "Robot Learning".
5	**Form of examination** Course related exam: • [20-00-0753-pj] (Study achievement, Oral/written examination, Default RS)
6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-0753-pj] (Study achievement, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References**
10	**Comment**

Module name Robot Learning: Integrated Project - Part 2					
Module nr. 20-00-0754	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0754-pj	Robot Learning: Integrated Project - Part 2	0	Project	4

2 Teaching content

In "Robot Learning: Integrated Project, Part 2", students will complete their approach to the research problem from Part 1 and apply it to a real robot. A scientific article on the research problem, methods and results will be written and potentially submitted to a national or international scientific venue.

3 Learning objectives

Upon successful completion of this course, students will be able to independently develop small research projects in the domain of robot learning and test first research ideas in simulation.

4 Prerequisite for participation

Previous or concurrent participation in the lecture "Robot Learning".

5 Form of examination

Course related exam:
- [20-00-0754-pj] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0754-pj] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

10 Comment

Module name					
Parallel Programming Technology					
Module nr. 20-00-1008	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Dr.-Ing. Michael Eichberg		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1008-pr	Parallel Programming Technology	0	Internship	4

2 Teaching content

In this lab course, participants actively develop and/or apply parallel programming technologies in several areas:

- Parallelism discovery
- Performance analysis and modeling
- Correctness analysis
- Profiling
- Scalable algorithms
- Resource management and scheduling
- Applications (e.g., deep learning)

3 Learning objectives

- Become familiar with and develop and/or apply parallel programming technologies
- Practice software engineering methods
- Work in a team on software projects
- Present project results effectively in reports and presentations

4 Prerequisite for participation

- Knowledge of parallel programming and parallel systems

5 Form of examination

Course related exam:

- [20-00-1008-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1008-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Practical Project Knowledge Engineering and Machine Learning					
Module nr. 20-00-0919	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0919-pp	Practical Project Knowledge Engineering and Machine Learning	0	Project	6

2 Teaching content

In the course of this practical project, students implement a larger, predefined task in the areas of knowledge engineering, artificial intelligence, machine learning or data mining. The topics will be defined in collaboration with their tutor.

Possible areas:
- Machine Learning and Data Mining
- Inductive Rule Learning
- Learning from Preferences
- Multilabel Classification
- Information Extraction
- Web Mining
- Semantic Web
- Game Playing

Concrete tasks will be assigned on an individual basis. The project can be started at any time.

Students that are interested in such a project, please contact a staff member of the Knowledge Engineering group (http://www.ke.tu-darmstadt.de).

3 Learning objectives

After completion of this project, students should be able to
- autonomously program larger research projects in the areas knowledge engineering, artificial intelligence, maschine learning and data mining
- conduct scientific experiments and evaluations using the implemented instruments

4 Prerequisite for participation

Basic knowledge in Knowledge Engineering, Artificial Intelligence, Data Mining and Machine Learning.
Basic knowledge in programming (e.g. Java).
Autonomous work and Interest on actual research.

5 Form of examination

Course related exam:
- [20-00-0919-pp] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0919-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name					
Project Lab Deep Learning in Computer Vision					
Module nr. 20-00-0980	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0980-pp	Project Lab Deep Learning in Computer Vision	0	Internship	6

2 Teaching content

In this project lab groups of students will work on selected topics in deep learning (deep neural networks) for problems in computer vision. This includes the practical implementation with modern deep learning frameworks. Results will be presented in a talk at the end of the lab. Concrete topics follow the current state of the art and change from term to term.

3 Learning objectives

Through their successful participation, students acquire in-depth knowledge on deep neural networks and their applications in computer vision. They are able to analyze, modify, and apply state-of-the-art techniques in this area. Moreover, they practice their abilities for presenting their results and for collaboration in teams.

4 Prerequisite for participation

* Solid programming skills in C/C++ or Python or Lua
* Prior or concurrent registration for "Computer Vision I"

5 Form of examination

Course related exam:

- [20-00-0980-pp] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0980-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name					
Autonomous Driving Lab I					
Module nr. 18-su-2070	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
18-su-2070-pj	Autonomous Driving Lab I	0	Project seminar	3

2 Teaching content

During this module students gain practical experience in software development for embedded systems in the field of autonomous driving using a model car. In teamwork, they learn to cope with an extensive task. In order to solve this task they practice to use the theoretical knowledge available in the group (from other courses such as real-time systems, software engineering - introduction, C++ lab, digital control systems).

- Hands-on programming experience with C++ in the development of embedded software systems for autonomous driving based on a model car
- Application of control methods from the area of autonomous driving
- Application of software engineering techniques (design, documentation, test, ...) of a non-trivial embedded software system with hard real-time requirements and limited resources (memory, ...)
- Use of a given software framework and further libraries including a modular (real-time) operating system
- Hands-on experience using source code management systems, time management and other project management tools
- Presentations of the project results

3 Learning objectives

Students that have successfully participated in this module are able to organize and set-up a non-trivial software project in an interdisciplinary team according to a given problem independently. The participants acquire the following skills in detail:

- Independent familiarization with a given software framework and ready-made libraries
- Transfer of theoretic knowledge into a software system
- Extensive use of tools for version, configuration, and change management
- Realistic time and resource management (project management)
- Development of hardware/software systems with C++ considering important limitations of embedded systems
- Planning and implementation of extensive quality assurance measures
- Collaboration and communication in and between teams

4 Prerequisite for participation

Recommended:

- ETiT/DT, iST, Informatik, WI-ET/DT: Basic software technology knowledge and advanced knowledge of object-oriented programming languages (especially C++)

Additionally desired:

- Basic knowledge of the development of real-time systems or image processing
- ETiT/AUT, MEC: Basic knowledge in control engineering including state space control design, some additional basic knowledge in digital control design may be helpful

5 Form of examination

	Module exam: • Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)
6	**Prerequisite for the award of credit points** Passing the final module examination
7	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
8	**Usability of the module** MSc ETiT, BSc iST
9	**References** https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/ps-af-i and Moodle
10	**Comment**

Module name Software Development Tools					
Module nr. 20-00-0673	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-0673-pr	Software Development Tools	0	Internship	4
2	**Teaching content** The development of tools that facilitate software development.				
3	**Learning objectives** Gain experience in the development of software development tools. Understand the limits of software development tools.				
4	**Prerequisite for participation** Introduction to Software Engineering				
5	**Form of examination** Course related exam: • [20-00-0673-pr] (Study achievement, Oral/written examination, Default RS)				
6	**Prerequisite for the award of credit points** Pass exam (100%)				
7	**Grading** Course related exam: • [20-00-0673-pr] (Study achievement, Oral/written examination, Weighting: 100 %)				
8	**Usability of the module**				
9	**References**				
10	**Comment**				

Module name					
Data Analysis Software Project for Natural Language					
Module nr. 20-00-0948	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. phil. Iryna Gurevych		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0948-pp	Data Analysis Software Project for Natural Language	0	Internship	6

2 Teaching content

Big datasets have turned to highly valuable information sources nowadays. Intelligent data analysis is the key to unlock their actual value. Such analysis can help to obtain new and useful information and support decision making processes. In this project, students will develop own ideas and build novel software systems to extract useful information from a given dataset of natural language text, i.e. textual Big-Data.

The topic of each semester‘s course can be found on the course website at https://www.ukp.tu-darmstadt.de/teaching/courses/software-project/

3 Learning objectives

After completion of the project, the students are able to
- understand practical aspects for natural language processing
- develop own NLP-systems,
- analyze big datasets of natural language text, and
- use state-of-the-art frameworks and technology for natural language processing.

4 Prerequisite for participation

- Programming skills (Scala, Java or Python)
- Interest in working with natural language text

5 Form of examination

Course related exam:
- [20-00-0948-pp] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0948-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

1.1.2.8 Specialization Distributed Computing

Elective Areas

1.1.2.9 Computer Networks and Distributed Systems

Module name Concepts and Technologies for Distributed Systems and Big Data Processing					
Module nr. 20-00-0951	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Dr.-Ing. Michael Eichberg		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-0951-iv	Concepts and Technologies for Distributed Systems and Big Data Processing	0	Integrated course	2
2	**Teaching content** The course provides an overview of recent advances in distributed systems for Big Data processing. The course starts presenting computational models for high throughput batch processing like MapReduce. Next, we will introduce software engineering techniques for distributed systems such as REST and component-based architectures. We will then cover low latency real time stream processing and complex event processing. Finally, we will present advanced topics in distributed data-intensive systems, such as geodistribution and security. The course focuses both on the fundamental concepts as well as on the concrete technologies and applications of the aforementioned techniques to real-world case studies.				
3	**Learning objectives** - The students are familiar with basic concepts and technologies on distributed systems and big data and are able to implement basic cloud based/distributed applications. - The students are familiar with the fundamental computational models behind recent advances in distributed systems, such as models for batch processing of massive data amounts, stream processing and complex event processing. - The students are familiar with selected advanced topics on big data, including security and geolocalization. - The students know about real-world case studies that apply the concepts and the technologies presented during the course.				
4	**Prerequisite for participation** This course is targeted at master students.				
5	**Form of examination**				

	Course related exam: • [20-00-0951-iv] (Technical examination, Oral/written examination, Default RS)
6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-0951-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module**
9	**References**
10	**Comment**

Module name					
Wireless Network for Emergency Response: Fundamentals, Design, and Build-up from Scratch					
Module nr. 20-00-0780	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0780-iv	Wireless Network for Emergency Response: Fundamentals, Design, and Build-up from Scratch	0	Integrated course	3

2 Teaching content

The communication capabilities among the population is of utmost importance to respond to crises. This course will discuss how to build wireless communication systems from scratch, i.e. under the assumption that no communication infrastructure is left intact as a result of the crisis. The course introduces the theoretical basis from the fields of amateur radio as well as communication systems. It deepens these fields with the knowledge to design and build communication networks for times of crisis. The discussed technologies will span from local to global wireless communications without need of further infrastructure.
Theoretical exercises as well as experimentation, the design and building of electrical circuits and the analysis of wireless technology under laboratory conditions deepen the understanding of the subject.

Course contents:
- Signals, signal propagation, antennas, basics of electrical engineering
- Modulation schemes in analog and digital systems (OFDM, ATV/SSTV, Packet Radio, SSB, ...)
- System aspects for communication in times of crisis
- Design and practical realization from scratch of wireless communication systems

3 Learning objectives

After successfully attending the course, students have theoretical and practical knowledge in the area of wireless and infrastructureless communication for emergency response. They understand the most important physical and electrotechnical basics of wireless communications and know wireless transmission mechanisms in theory and practice. They are able to build a wireless communication system from scratch and operate it. The students acquire competences in the area of amateur radio and software defined radio technology.

4 Prerequisite for participation

5 Form of examination

Course related exam:
- [20-00-0780-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0780-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Selected and given in lecture.
10	**Comment**

Module name Mobile Networking					
Module nr. 20-00-0748	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Thorsten Strufe		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0748-iv	Mobile Networking	0	Integrated course	4

2 Teaching content

Mobile communications and wireless networking technology has seen a thriving development in recent years. The integrated course addresses the characteristics/principles of mobile networks in detail, and practical solutions are presented. Hereby our focus is on the network layer, which is often regarded as the glue of communication systems. In addition to describing the state of the art in technology we discuss actual research problems and learn about methodologies to approach such problems systematically. The contents of the course will be deepended by exercises.

Course contents:
- Introduction to mobile and wireless communications: Applications, history, market vision
- Overview of wireless transmission: frequencies & regulations, signals, antennas, signal propagation, multiplexing, modulation, spread spectrum, cellular systems
- Medium access control in the wireless domain: SDMA, FDMA, CDMA TDMA (fixed, Aloha, CSMA, DAMA, PRMA, MACA, collision avoidance, polling)
- Wireless local area networks: IEEE 802.11 standard including physical layer, MAC layer and access schemes, quality of service and power management
- Wireless metropolitan area networks: Wireless mesh networks, IEEE 802.16 standard including modes of operation, medium access control, quality of service and scheduling
- Mobility at network layer: Concepts to support mobility on various layers, Mobile IP
- Ad hoc networks: Terminology, basics and applications, characteristics of ad hoc communication, ad hoc routing paradigms and protocols
- Performance evaluation of mobile networks: Overview of performance evaluation, systematic approach / common mistakes and how to avoid them, experimental design and analysis
- Mobility at transport layer: Variants of TCP (indirect TCP, snoop TCP, mobile TCP, wireless TCP)
- Mobility at application layer. Outlook: Applications for mobile networks and wireless sensor networks

3 Learning objectives

After successfully attending the course, students have an in-deep knowledge on the working of mobile communication networks. They have gained insight into media access control mechanisms dedicated to wireless communication and have a thorough understanding of mechanisms based on the network and the transport layers, with a focus on ad hoc and mesh networks. Moreover, the students have acquired knowledge about the connections between the different protocol layers and are able to apply the acquired knowledge on methodological analysis of real communication systems. The students are therefore be conversant with the characteristics and basic principles of wireless and mobile communications in theory and practice. The exercise-parts of the integrated course deepen the theoretical foundations by means of exercises, which consist of literature, calculation as well as practical implementation/application examples.

4 Prerequisite for participation

Basic courses in Communication Networks are recommended.

5 Form of examination

	Course related exam: • [20-00-0748-iv] (Technical examination, Oral/written examination, Default RS)
6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-0748-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Selected literature, details are given in lecture.
10	**Comment**

Module name Network Security					
Module nr. 20-00-0512	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Dr.-Ing. Michael Kreutzer		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0512-iv	Network Security	0	Integrated course	4

2 Teaching content

The integrated course Network Security covers the principles and practice of computer and telecommunication network security with particular emphasis on Internet security. After transferring the fundamentals of IT security and cryptography to the networking domain, we follow a top-down approach to network security. Starting with the application layer, the course provides a detailed discussion of network security principles and protocols. In addition to well known mechanisms, selected recent developments in the area of network security will be examined.

Course contents:
- Network security: introduction, motivation, and challenges
- Fundamentals: a reference model for network security, security standards for networks and the Internet, security threats, attacks, services, and mechanisms
- Cryptographic foundations for networking security: symmetric crypto and its use in networks, public-key crypto and its use in networks, support functions to implement network security
- Application layer security
- Transport layer security
- Network layer security
- Link layer security
- Physical layer security and physical security
- Operational network security: firewalls, intrusion detection systems
- Selected topics in network security

3 Learning objectives

After successfully attending the course, students have aquired an in-deep knowledge in the domain of communication network security with emphasis on Internet security. Students are able to apply and transfer the most important fundamentals from IT security and cryptography to the field of communication networks. Students are able to distinguish the most important basic techniques for securing communication networks. They have a thorough understanding of security mechanisms on the different network layers (application layer, transport layer, network layer, link layer, physical layer). As a result, they are able to thoroughly discuss the characteristics and principles in the area of network security and exhibit detailed theoretical and practical knowledge in this field. Additionally, students are able to describe recent developments in the area of network security (e.g. peer-to-peer security, mobile network security, etc.). The exercise deepens the theoretical foundations by means of exercises, which consist of literature, calculation as well as practical implementation/application examples.

4 Prerequisite for participation

Knowledge in the area IT Security, Introduction to Cryptography and Communication Networks

5 Form of examination

Course related exam:
- [20-00-0512-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

	Pass exam (100%)
7	**Grading** Course related exam: • [20-00-0512-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Charlie Kaufman, Radia Perlman, Mike Speciner: Network Security - Private Communication in a Public World, 2nd Edition, Prentice Hall, 2002, ISBN: 978-0-14-046019-6; additional texts may be announced
10	**Comment**

Module name Secure Mobile Systems					
Module nr. 20-00-0583	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Matthias Hollick		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0583-vl	Secure Mobile Systems	0	Lecture	2

2 Teaching content

The integrated course Secure Mobile Systems covers the topic area of security in wireless and mobile networks and communication systems. Fundamental topics will be enriched by current research.

Course contents:
- Security analysis and modelling of security threats in mobile and wireless systems
- Selected attacks and security mechanisms specific to mobile and wireless systems
- Security in wireless sensor networks
- Security in wireless mesh networks
- Threats against privacy and privacy-preserving mechanisms in mobile and wireless systems
- Security in cellular networks (GSM, UMTS, LTE)
- Security on the physical layer in mobile and wireless systems
- Selected research topisc in mobile and wireless systems

3 Learning objectives

After successfully attending the course, students have a specialized knowledge in the domain of security with emphasis on mobile, distributed, wireless communication networks. Students are able to apply and transfer the most important fundamentals from IT security, cryptography and traditional network security to the field of mobile systems.
Students obtain a thorough understanding of security mechanisms on the different network layers (application layer, transport layer, network layer, link layer, physical layer). As a result, they are able to thoroughly discuss the characteristics and principles in the area of mobile system security and exhibit detailed theoretical and practical knowledge in this field.

4 Prerequisite for participation

Grundlagen der Netzsicherheit und der Mobilen Netze

5 Form of examination

Course related exam:
- [20-00-0583-vl] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0583-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Levente Buttyan, Jean-Pierre Hubaux: Security and Cooperation in Wireless Networks, Cambridge University Press, 2008, ISBN: 978-0-521-87371-0 (book is available online for download). Ausgewählte Buchkapitel und ausgewählte wissenschaftliche Veröffentlichungen.
10	**Comment**

Module name					
Software Defined Networking					
Module nr. 18-sm-2280	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
18-sm-2280-vl	Software Defined Networking	0	Lecture	2
18-sm-2280-ue	Software Defined Networking	0	Practice	2

2 Teaching content

The course deals with topics in the area of software defined networking:

- SDN Data Plane
- SDN Control Plane
- SDN Application Plane
- Network Function Virtualization
- Network Virtualization and Slicing
- QoS and QoE in Software Defined Networks

3 Learning objectives

Upon completion of the module, students will have gained in-depth insights into Software Defined Networking, as well as basic technologies and applications.

4 Prerequisite for participation

Recommended: Basic courses of the first 4 semesters are required. Knowledge of lectures Communication Networks I and II are recommended.

5 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 15 students register, the examination will be an oral examination (duration: 20 min.). The type of examination will be announced in the beginning of the lecture.

6 Prerequisite for the award of credit points

Passing the final module examination

7 Grading

Module exam:

- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

MSc ETiT, BSc/MSc iST, MSc Wi-ETiT, CS, Wi-CS

9 References

Textbooks as indicated.
Slides and paper copies as necessary.

10 Comment

Module name TK1: Distributed Systems and Algorithms					
Module nr. 20-00-0065	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0065-iv	TK1: Distributed Systems and Algorithms	0	Integrated course	4

2 Teaching content

Objectives:

- Comprehensive overview about the fundamental problems and approaches in distributed computing
- In-depth methodological knowledge of classical distributed algorithms and programming paradigms
- Applicable exemplary knowledge of current developments and standards

Syllabus:

- Introduction
- Refresher and supplement to Chapter 1 of the Net-Centric Computing canon.
- Overview of the lecture
- Distributed Algorithms
  - Elementary algorithms (e.g., global state).
  - Basic algorithms (e.g., exclusion, consensus, cooperation)
  - Formalization (properties and their proof).
- Distributed Programming
  - Push paradigms (e.g., IPC, RPC, DOC)
  - Current approaches (e.g., pull paradigms, object mobility)

3 Learning objectives

After successful completion of the module, students are familiar with the concepts of distributed algorithms and programming. They understand the fundamental issues of distributed systems and the classical distributed algorithms and programming paradigms. They are able to apply these classical and current standards of distributed programming to given problems.

4 Prerequisite for participation

Recommended: Computer Networks and Distributed Systems

5 Form of examination

Course related exam:

- [20-00-0065-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0065-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. Computer Science M.Sc. Autonome Systeme und Robotik M.Sc. IT Sicherheit M.Sc. IT Security May be used in other degree programs.
9	**References** Literature recommendations will be updated regularly, an example might be: - George Coulouris, Jean Dollimore, Tim Kindberg: Distributed Systems. Concepts and Design (Gebundene Ausgabe) 832 Seiten, Addison Wesley; Auflage: 4th (14. Juni 2005), ISBN: 0321263545 - M. Boger: Java in verteilten Systemen, 1999, dpunkt-Verlag, Heidelberg, ISBN: 3932588320 - G. Tel: Introduction to Distributed Algorithms, 2nd Ed 2001, Cambridge University Press, ISBN: 0521794838 - A. Tanenbaum, M.v.Steen, Verteilte Systeme: Grundlagen und Paradigmen, Pearson Studium 2003, ISBN: 3827370574 - A. Tanenbaum: Computernetzwerke. 4te Auflage. Pearson Studium 2003, ISBN-10: 3827370469 - J. Kurose, K. Ross: Computer Networking, 1. Ed. 2000, Adison-Wesley. ISBN: 0201477114 - L. Peterson, B. Davie, Computernetze, 1. Aufl. 2000, dpunkt Heidelberg, ISBN: 393258869X - Hammerschall, U.: Verteilte Systeme und Anwendungen. Pearson, München 2005, ISBN: 3827370965
10	**Comment**

1.1.2.10 Data-Intensive Systems and Heterogenous Hardware

Module name Advanced Data Management Systems					
Module nr. 20-00-1039	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1039-iv	Advanced Data Management Systems	0	Integrated course	4

2 Teaching content

This is an advanced course about the design of modern data management systems which has a heavy emphasis on system design and internals. Sample topics include modern hardware for data management, main memory optimisations, parallel and approximate query processing, etc.

The course expects the reading of research papers (SIGMOD, VLDB, etc.) for each class. Programming projects will implement concepts discussed in selected papers. The final grade will be based on the results of the programming projects. There will be no final exam.

3 Learning objectives

Upon successful completion of this course, the student should be able to:
- Understand state-of-the-art techniques for modern data management systems
- Discuss design decision of modern data management systems with emphasis on constructive improvements
- Implement advanced data management techniques and provide experimental evidence for design decisions

4 Prerequisite for participation

Solid Programming skills in C and C++
Scalable Data Management (20-00-1017-iv)
Information Management (20-00-0015-iv)

5 Form of examination

Course related exam:
- [20-00-1039-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1039-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Algorithms for Electronic Design Automation Tools					
Module nr. 20-00-0183	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0183-vl	Algorithms for Chip Design Tools	0	Lecture	2

2 Teaching content

- The VLSI design problem
- Fundamental graph representations and algorithms
- Representations for hierarchical circuits
- Fabrication technologies for integrated circuits
- Layout compaction
- Timing analysis
- Heuristical optimization techniques
- Placement problems, algorithms, and cost functions
- Exact optimization techniques
- Partitioning and its use in placement
- Floorplanning problems, representations, and techniques
- Routing problems, algorithms, and cost functions

3 Learning objectives

After successfully attending the course, the students know a number of fabrication technologies for integrated circuits. They are able to deduce from the technologies the requirements on automation tools for the different tasks in the design and realization process. They are familiar with modeling technological problems by formal concepts such as graphs and equation systems. They understand fundamental techniques for solving even hard computational problems and are able to apply these, together with knowledge of representative EDA algorithms, to develop new or refined implementations of design tools.

4 Prerequisite for participation

Recommended:
Participation of lecture “Digitaltechnik", “Algorithmen und Datenstrukturen” and “Funktionale und objektorientierte Programmierung”.

5 Form of examination

Course related exam:
- [20-00-0183-vl] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0183-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
9	**References** Literature reommendations will be updated regularly, an example might be: Gerez: Algorithms for VLSI Design Automation Wang/Chang/Cheng: Electronic Design Automation
10	**Comment**

Module name Advanced Compiler Construction					
Module nr. 20-00-0701	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0701-vl	Advanced Compiler Construction	0	Lecture	3

2 Teaching content

- Compilation and run-time environment for object-oriented programming languages
- Control flow graphs as intermediate representations
- Static dataflow analysis
- Static single-assignment form
- Eliminating total and partial redundancy
- Scalar optimization
- Register allocation
- Scheduling
- Loop optimization
- Structure and organization of real compilers (e.g., phases, intermediate representations, compfile flow)

3 Learning objectives

After successfully attending the course, students understand techniques for the compilation and execution of object-oriented programs at the machine-level. The can apply static dataflow analysis to control flow graphs and are practiced using their SSA form. They are familiar with optimizing techniques for a number of problems as well as fundamental algorithms for register allocation. They know the internal structure of real production-grade compilers.

4 Prerequisite for participation

Successfull participation of “Einführung in den Compilerbau”

5 Form of examination

Course related exam:

- [20-00-0701-vl] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0701-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Literature recommendations will be updated regularly, an example might be: Cooper/Torczon: Engineering a Compiler Muchnick: Advanced Compiler Design and Implementation Aho/Lam/Sethi/Ullman: Compilers - Principles, Techniques, and Tools
10	**Comment**

Module name Practical Programming of FPGAs using High-Level Languages					
Module nr. 20-00-1081	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1081-iv	Practical Programming of FPGAs using High-Level Languages	0	Integrated course	2

2 Teaching content

FPGAs have been used very successfully in recent years to implement application-specific accelerators in heterogeneous systems. However, programming with conventional hardware description languages such as Verilog or VHDL is still the norm.

As an alternative, high-level synthesis tools that can also generate hardware from high-level languages such as C/C++ play an increasingly important role in the implementation of such accelerators. During this course you will gain useful background knowledge on the basic algorithms of high-level synthesis as well as knowledge in practical design and optimization of FPGA designs using high-level synthesis tools.

In addition, you will learn relevant techniques for the integration of FPGA-based accelerators into heterogeneous systems. During the practical phase of this course, you will create an FPGA-based accelerator for a given problem and implement it on a typical heterogeneous system in real hardware.

3 Learning objectives

- Understanding the basics of HLS systems

- Understanding of important internals of HLS systems (e.g. optimization, scheduling)

- Ability to design high-level language hardware accelerators and use HLS systems to generate executable FPGA designs

- Experience in troubleshooting and optimization of HLS generated hardware designs

- Experience in the integration of hardware accelerators into heterogeneous computing systems using hardware/software co-design tools.

4 Prerequisite for participation

- Basics of Digital Logic (DT))

- Basics of Computer Architecture (Computer Organization RO, Architecture and Design of Computer Systems (AER)

- Basic knowledge of compilers is dvantageous, but not obligatory

- Using Linux systems and virtual machines

5 Form of examination

Course related exam:

- [20-00-1081-iv] (Technical examination, Oral/written examination, Default RS)

6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-1081-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Programming Massively Parallel Processors					
Module nr. 20-00-0419	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0419-iv	Programming Massively Parallel Processors	0	Integrated course	4

2 Teaching content

- foundations of massively parallel processors with a focus on modern accelerator hardware
- parallel algorithms
- efficient programming of massively parallel systems
- practical programming projects co-advised by domain scientists

3 Learning objectives

After successful completion of the course, students are able to analyze problems in the context of massively parallel systems. They can develop novel applications and systematically improve their performance. They understand basic parallel algorithms and are able to independently understand and analyze current literature.

4 Prerequisite for participation

Programming skills in C/C++
Recommended: Systemnahe und Parallele Programmierung

5 Form of examination

Course related exam:

- [20-00-0419-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0419-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

Will be announced in lecture.

10 Comment

1.1.2.11 System Modelling and Engineering

Module name Applied Static Analysis					
Module nr. 20-00-0949	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. phil. Iryna Gurevych		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0949-iv	Applied Static Analysis	0	Integrated course	2

2 Teaching content

Foundations of (scalable) static analyses for large(r) software systems; in particular
- Basic Terminology:
- AST, SSA,
- Object-/ Field-/ Context-/ Flow-/ Path Sensitivity
- (I)CFG
- Inter-procedural analyses
- . . .
- stack based intermediate representations (JVM Bytecode)
- register based intermediate representations (LLVM IR)
- program transformations and native code analyses using LLVM

Concrete static analyses and algorithms:
- Call graph algorithms for libraries and applications
- Inter procedural data- and control-flow analyses
- IDE/IFDS
- Points-to analyses
- Escape analyses

Applications
- General software quality analyses
- Capability Analysis
- Security Vulnerabilities Detection
- Dead Paths/Computations
- Next generation software development tools

3 Learning objectives

Students can effectively use the basic static analyses related terminology.
Students are familiar with modern static analyses working on intermediate representations. They are able to apply and adapt available static analysis algorithms to new scenarios.

4 Prerequisite for participation

The lecture is targeted towards Master students with a very high degree of interest in reading, analyzing and also writing code. Basic knowledge in compiler construction is helpful. Deep knowledge of object-oriented programming concepts and in particular of object-oriented programming in Java is required. Interest in learning new programming languages (in particular Scala) is required.

5 Form of examination

Course related exam:
- [20-00-0949-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

	Pass exam (100%) Students joined the course 20-00-0732 or 20-00-0771 aren't allowed to visit this lecture.
7	**Grading** Course related exam: • [20-00-0949-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module**
9	**References**
10	**Comment**

Module name Advanced Multithreading in C++					
Module nr. 20-00-0977	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0977-iv	Advanced Multithreading in C++	0	Integrated course	4

2 Teaching content

C++ offers one of the most modern threading interfaces available today. Using this interface as an example, the course teaches advanced techniques to develop parallel software for shared memory with threads.

Based on the contents of the course Multithreading in C++, this course will cover the following topics:
• C++ memory model and atomic operations
• Designing lock-free concurrent data structures
• Advanced thread management (e.g., thread pools)

3 Learning objectives

After successfully completing the course, the students have advanced skills of developing parallel programs. They are able to
- Systematically develop correct and efficient multithreaded programs
- Design and implement parallel data structures

4 Prerequisite for participation

• Knowledge of C/C++
• Foundations of programming threads in C++ (lock-based synchronization and lock-based concurrent data structures)

5 Form of examination

Course related exam:
- [20-00-0977-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

Students who passed Modul "Fortgeschrittene parallele Programmierung 2" (FPPROG2), 20-00-0938 aren't allowed to pass this Modul.

7 Grading

Course related exam:
- [20-00-0977-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name Concepts of Programming Languages					
Module nr. 20-00-1117	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1117-iv	Concepts of Programming Languages	0	Integrated course	4

2 Teaching content

Brief introduction and history of Programming languages, Criteria to measure Programming languages, Basic concepts like Syntax, semantics, variables, names, bindings, scope, subprograms, expressions, arrays, pointers, abstract types, functional programs.

3 Learning objectives

Students will be able to understand the underlying mechanisms of the main concepts behind programming languages upon completion of the module. Students will have initial experience in building simple programming languages.

4 Prerequisite for participation

5 Form of examination

Course related exam:
- [20-00-1117-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.
Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1117-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Concepts of Programming Languages					
Module nr. 20-00-0072	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0072-iv	Concepts of Programming Languages	0	Integrated course	4

2 Teaching content

Fundamental concepts of programming languages. In particular, we identify various basic concepts of programming languages and discuss them in detail, for example:

- role of syntax
- functions
- meta-interpreters
- recursion
- lazy evaluation
- state and side effects
- continuations
- domain-specific languages and macros
- object-oriented programming

3 Learning objectives

After the successful completion of the lecture, students will be able to perform the following tasks:

- they will be able to identify the defining features of programming languages;
- they will be familiar with fundamental theoretical concepts of programming languages;
- they will be able to implement simple programming languages using different implementation techniques;
- students will understand the influence of different programming languages on the solution space of various software development problems;
- students will be able to overcome stereotypical categorizations of programming languages.

4 Prerequisite for participation

Recommended: Funktionale und Objektorientierte Programmierkonzepte

5 Form of examination

Course related exam:

- [20-00-0072-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0072-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8	**Usability of the module** B. Sc. Informatik M. Sc. Informatik M. Sc. Computer Science M. Sc. Autonome Systeme und Robotik M.Sc. IT Sicherheit M.Sc. IT Security May be used in other degree programs.
9	**References** • S. Krishnamurthi: Programming Languages - Application and Interpretation • M. Scott: Programming Language Pragmatics, Morgan Kaufmann • D. Friedman et al.: Programming Language Essentials, MIT Press
10	**Comment**

Module name Model Checking					
Module nr. 20-00-1115	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1115-iv	Model Checking	0	Lecture	4

2 Teaching content

- Temporal logics
  - Linear temporal logic (LTL), Computation tree logic (CTL) und CTL*: syntax, sematics, complexity
- Model checking LTL, CTL und CTL*
- Partial order reduction
- Timed automata

3 Learning objectives

In this module students acquire

- Knowledge of the theoretical foundations of LTL, CTL and CTL*
- Ability to choose a suitable logic for specification and model checking by taking into consideration the system to be modelled and the kind of properties to be checked
- Knowledge about different model checking techniques like model checking using Büchi automata, partial order reduction and more
- Knowledge about characteristics and limitations of model checking
- Knowledge in model checking of timed automata
- Ability to use model checker tools

4 Prerequisite for participation

Recommended is knowledge about

- propositional logic
- deduction systems
- automata theory

5 Form of examination

Course related exam:

- [20-00-1115-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1115-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Study-related Achievements

1.1.2.12 Seminars

Module name Advanced Seminar in Networked Embedded Systems					
Module nr. 20-00-1187	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1187-se	Advanced Seminar in Networked Embedded Systems	0	Seminar	3

2 Teaching content

This advanced seminar is about cutting-edge research in networked embedded systems, with a particular focus on wireless sensor networks, cyber-physical systems, and the Internet of Things. We will discuss research papers that present novel ideas and results on the design, development, deployment, application, and fundamental limits of these systems. The papers will cover a broad range of topics, from mobile sensing and embedded machine learning to wireless networking and energy harvesting. After choosing a research paper, each student writes a

term paper that summarizes the original paper. Afterward, each student reviews 2-3 term papers, and uses the feedback provided in the reviews to revise her/his term paper. Moreover, each student presents her/his research paper during one of the meetings. Students are requested to actively participate in the meetings, allowing for lively discussions in a pleasant atmosphere.

3 Learning objectives

By completing this module, students will have learned the fundamentals of doing research. In particular, the students will have learned how to

- read and critically analyze research papers
- present complex ideas and results to others
- write scientifically
- provide constructive feedback

In addition, the students will have learned about the latest breakthroughs and big open questions in networked embedded systems.

4 Prerequisite for participation

5 Form of examination

Course related exam:

- [20-00-1187-se] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible:
Colloquium (optional: including presentation), Term Paper.

6 Prerequisite for the award of credit points

Pass exam (100%).

7 Grading

Course related exam:

- [20-00-1187-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Actor-based Languages					
Module nr. 20-00-1074	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Dr.-Ing. Michael Eichberg		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1074-se	Actor-based Languages	0	Seminar	2

2 Teaching content

The focus of this seminar is on actor-based langauges like ABS, Encore, Scala/Akka and others.

Participants of this seminar are expected to present a representative of this class of languages, explain the concepts and discuss their advantages and disadvantages.

3 Learning objectives

* Ability to present a scientific topic
* Ability to read scientific papers and to research related work
* Acquisition of knowledge about actor-based languages and their application

4 Prerequisite for participation

Interests in programming languages and distributed systems

5 Form of examination

Course related exam:

- [20-00-1074-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1074-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B. Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Current Topics in Concurrency Theory					
Module nr. 20-00-1093	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Heiko Mantel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1093-se	Current Topics in Concurrency Theory	0	Seminar	2

2 Teaching content

Modern society is increasingly dependent on large-scale software systems that are distributed, collaborative, and communication-centred. Tackling the additional complexity that is caused by distributed actors is one of the major tasks in the research area concurrency theory. To understand the behaviour of such systems, concurrency theory studies the modelling, simulation, and verification of concurrent systems. The modelling languages range from graphical approaches such as Event Structures and Petri nets to approaches that are close to programming languages such as process calculi. To analyse such systems different techniques such as type systems, model checking, and interactive theorem proving are adapted to the needs of concurrent systems and new techniques are developed. In this seminar current articles on research in the area of concurrency theory are presented and discussed.

3 Learning objectives

Following successful participation of the module students get an idea about current research directions in the area of concurrency theory. They know how to present results in this area and to critically examine the advantages and merits of such approaches. Moreover, by learning how to present the given results, they improve the presentation of their own approaches.

4 Prerequisite for participation

Recommended: Foundations of theoretical computer sciences as expected from a student after the fourth term. In particular, we recommend some experience with formal languages.

5 Form of examination

Course related exam:

- [20-00-1093-se] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible:
Colloquium (optional: including presentation).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1093-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Current Topics in Concurrency and Parallelism					
Module nr. 20-00-0960	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Dr.-Ing. Michael Eichberg		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0960-se	Current Topics in Concurrency and Parallelism	0	Seminar	2

2 Teaching content

In this seminar we will discuss research articles on different aspects of concurrency and parallelism. Exemplary topics include:

- concurrency semantics (interleaving semantics, multicore semantics, weak memory models),
- parallel architectures (principles of parallel architectures, symmetric multiprocessing, massively parallel computing),
- parallel programming (parallel programming models, communication, synchronization),
- parallelization and compilation (fully-/semi-automatic parallelisation, data dependencies, load balancing),
- verification of concurrent programs (separation logic, rely/guarantee reasoning).

3 Learning objectives

After successfully participating in this course, students will be able to discuss developments in concurrency and parallelism. Furthermore, the students will have improved their skills in reading and understanding scientific articles and in presenting, discussing, and comparing scientific results.

4 Prerequisite for participation

Knowledge of Computer Science equivalent to the first four Semesters in the Computer Science Bachelor program.

5 Form of examination

Course related exam:

- [20-00-0960-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0960-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name Distributed Systems Programming: Seminar					
Module nr. 20-00-1066	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1066-se	Distributed Systems Programming: Seminar	0	Seminar	2

2 Teaching content

The course focuses on research topics in distributed systems (DS) and programming languages for DS. The offered topics depend on the current research of the DSP group including:
- Software-defined networking (SDN)
- Network function virtualization (NFV) and in-network processing (INP)
- Traffic engineering (TE)
- Network monitoring
- Resource management in datacenters (RMF)
- Big data analytics (Spark, YARN, OpenStack, ..)
- Event-based systems
- Security in SDN, INP, and big data
- Geo-distributed data processing
- Compiler infrastructures for DS
- Language abstractions for DS
- Session types / calculi for DS
- Network Protocols

In this project the students will realize their own seminar project defined together with their adviser.

3 Learning objectives

After participating in the course, the student is able to adress and present scientific problems in designing and developing future DS concepts and applications using state of the art scientific methods.

Acquired competences include (depending on the selected topic):
- Literature research in the project area
- Deep understanding of existing complex software systems
- Methodical analysis and evaluation of
- Models
- Experiments
- Software
- Writing of technical documents or project reports
- Research style presentation of the outcomes of the project

4 Prerequisite for participation

Interest to develop solutions for challenging problems of DS, self-motivation and high interest in recent research.

Lecture TK1 (optionally)

Due to the wide area of topics, we cannot offer a comprehensive list of requirements. All topics are research-oriented, hence topic-specific background knowledge is required. More details will be given in the first lecture, afterward the student can choose a presented topic.

5	**Form of examination** Course related exam: • [20-00-1066-se] (Study achievement, Oral/written examination, Default RS)
6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-1066-se] (Study achievement, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Extended Seminar - Systems and Machine Learning					
Module nr. 20-00-1057	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1057-se	Extended Seminar - Systems and Machine Learning	0	Seminar	3

2 Teaching content

This seminar serves the purpose of discussing new research papers in the intersection of hardware/software-systems and machine learning. The seminar aims to elicit new connections amongst these fields and discusses important topics regarding systems questions machine learning including topics such as hardware accelerators for ML, distributed scalable ML systems, novel programming paradigms for ML, Automated ML approaches, as well as using ML for systems.

Every participant will present one research paper, which will be subsequently discussed by all participants. In addition, summary papers will be written in groups and submitted to a peer review process. The papers will typically be recent publications in relevant research venues and journals.

The seminar will be offered as a block seminar. Further information can be found at: http://binnig.name

3 Learning objectives

After this seminar, the students should be able to
- understand a new research contribution in the areas of the seminar
- prepare a written report and present the results of such a paper in front of an audience
- participate in a discussion in the areas of the seminar
- to peer-review the results of other students

4 Prerequisite for participation

Basic knowledge in Machine Learning, Data Management, and Hardware-/Software-Systems.

5 Form of examination

Course related exam:
- [20-00-1057-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1057-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B. Sc Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name					
Advanced Seminar on Networking, Security, Mobility, and Wireless Communications					
Module nr. 20-00-0549	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Karsten Weihe		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0549-se	Advanced Seminar on Networking, Security, Mobility, and Wireless Communications	0	Seminar	3

2 Teaching content

The Advanced Seminar on Networking, Security, Mobility, and Wireless Communications covers current research that is considered highly relevant for the future development of the given topic areas. Goal of the seminar is to explore the aforementioned research area by studying, critically analyzing and discussing, summarizing, and presenting selected first-rate research articles. Deliverables are a short presentation, a final presentation, and a seminar paper.

The prospective topics for the advanced seminar will be derived from the current research topics of the SEEMOO group.

Course contents:
- Indepentent exploration of a topic in the area of networking, security, mobility, and wireless communications (typically in english)
- Own, enhanced literature study
- Interpretation and classification of the literature study
- Preparation of an introductory talk as well as a final talk including presentation slides
- Presentation of both talks for a heterogenous audience (experts/non-experts)
- Technical discussion after the talks
- Feedback to the speakers and the talks (including presentation skills) and technical content
- Understanding the process of scientific work as well as of scientific publications

3 Learning objectives

After successfully attending the course, students are able to independently explore new topics in a scientific manner. They have aquired detailed knowledge on selected mechanisms, methodologies as well as applications for the investigated topic area. Techniques such as thoroughly surveying literature, critical discussion and analysis of scientific articles, and the presentation of the obtained results are demonstrated by the students. Students can defend their work against a critical technical audience.

4 Prerequisite for participation

Successfull participation of an lecture of SEEMOO

5 Form of examination

Course related exam:
- [20-00-0549-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

	Course related exam: • [20-00-0549-se] (Study achievement, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Will be announced in seminar.
10	**Comment**

Module name Advanced Approaches in Software Verification					
Module nr. 20-00-1078	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Heiko Mantel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1078-se	Advanced Approaches in Software Verification	0	Seminar	2

2 Teaching content

The seminar deals with current research topics of the research group Semantics and Verification of Parallel Systems. You will learn about classical and recent research in the area of software verification (i.e., model checking, program analysis, testing, etc.). The topics of the current term are available on the webpage of the seminar (https://www.informatik.tu-darmstadt.de/svpsys/semantik_und_verifikation_paralleler_systeme_svpsys/lehre_svpsys/seminar_ftsv_svpsys/index.en.jsp)

Under the guidance of your supervisor you will
- use the given literature and search for additional literature to become acquainted with your topic,
- prepare and give a presentation about your topic and afterwards discuss the topic with the other participants,
- write a scientific report, which provides a summary of your topic.

3 Learning objectives

At the end of the seminar, students are able to autonomously familiarize themselves with a scientific topic and are able to present this topic to a heterogeneous audience orally and in written form.

More concrete, the students can search for scientific literature and assess the relevance of found literature. They are able to identify the main content of a scientific publication and critically evaluate them. Moreover, they can compare different scientific approaches. Students can explain and defend their topic and results to a heterogeneous audience in an oral presentation. Additionally, they are able to describe their topic and results in a scientific paper.

4 Prerequisite for participation

Recommended: Knowledge about computer science and mathematics taught int the first four terms of the bachelor degree in computer science
Helpful: Participation in a course of the research group Semantics and Verification of Parallel Systems

5 Form of examination

Course related exam:
- [20-00-1078-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1078-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9	**References**
10	**Comment**

Module name Protection in Infrastructures and Networks					
Module nr. 20-00-1022	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Stefan Katzenbeisser		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1022-se	Protection in Infrastructures and Networks	0	Seminar	2

2 Teaching content

The Seminar on Protection in Infrastructures and Networks is a cycle of seminars where students are given the chance to read, analyze and summarize current scientific publications. The topics are related to the areas of:
- Trust
- Privacy
- Resilience

in the domain of infrastructures and networks.

3 Learning objectives

Students participating in the seminar will have the opportunity to learn and conduct research in the direction of these topics.
Your task will be to understand state-of-the-art scientific publications in order to explain their contributions.
Furthermore, you are expected to write a survey in relation to the topic assigned to you.

4 Prerequisite for participation

Basic knowledge about it-security and distributed systems.

Lectures:
Computersystemsicherheit (CSS)
Computer-Netzwerke und verteilte Systeme (CNuvS)

5 Form of examination

Course related exam:
- [20-00-1022-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1022-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programss

9 References

10 Comment

<table>
<tr><td colspan="6">Module name
Seminar Software System Technology</td></tr>
<tr><td>Module nr.
18-su-2080</td><td>Credit points
4 CP</td><td>Workload
120 h</td><td>Self-study
90 h</td><td>Module duration
1 Term</td><td>Module cycle
Summer term</td></tr>
<tr><td colspan="3">Language
German</td><td colspan="3">Module owner
Prof. Dr. rer. nat. Andreas Schürr</td></tr>
</table>

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	18-su-2080-se	Seminar Software System Technology	0	Seminar	2
2	**Teaching content** In this course, the students produce scientific reports from changing subject areas. Each student has to explore a subject related to IT system development and produce a written report as well as a final talk with a presentation.				
3	**Learning objectives** Upon successful completion of the module, the students will be able to assess the reliability of information sources and explore an unknown topic under scientific aspects. The students learn to support the exploration by a literature research and to analyze the subject critically. They achieve the skills to present a definite subject in a written report as well as in an oral presentation.				
4	**Prerequisite for participation** Recommended: Basic knowledge in software engineering and programming languages				
5	**Form of examination** Module exam: • Module exam (Study achievement, Oral/written examination, Default RS) Report and/or Presentation and/or Colloquium. The type of examination will be announced in the beginning of the lecture.				
6	**Prerequisite for the award of credit points** Passing the final module examination				
7	**Grading** Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 100 %)				
8	**Usability of the module** BSc iST, BSc Informatik, MSc ETiT				
9	**References** https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/sst-s				
10	**Comment** A list of the subjects of the current semester is available at https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/sst-s.				

Module name Seminar on Networking, Security, Mobility, and Wireless Communications					
Module nr. 20-00-0582	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Matthias Hollick		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0582-se	Seminar on Networking, Security, Mobility, and Wireless Communications	0	Seminar	2

2 Teaching content

The Seminar on Networking, Security, Mobility, and Wireless Communications covers current research in the given topic areas. Under supervision of the tutors, the seminar imcludes studying, critically analyzing and discussing, summarizing, and presenting selected research articles. Deliverables are a short presentation, a final presentation, and a seminar paper.

Course contents:
- Indepentent exploration of a topic in the area of networking, security, mobility, and wireless communications (typically in english)
- Own, enhanced literature study, gudided by tutor
- Interpretation and classification of the literature study, gudided by tutor
- Preparation of an introductory talk as well as a final talk including presentation slides, gudided by tutor
- Presentation of both talks for a heterogenous audience (experts/non-experts)
- Technical discussion after the talks
- Feedback to the speakers and the talks (including presentation skills) and technical content

3 Learning objectives

After successfully attending the course, students are able to work in a scientific manner under guidance. They know the fundamental techniques for scientific literature work and can apply them to a well-defined topic area. They have aquired intermediate knowledge on selected mechanisms, methodologies as well as applications for the investigated topic area. Students can present this aquired knowledge to a heterogeneous audience and explain the technical details of the investigated topic.

4 Prerequisite for participation

Successfull participation in a lecture of SEEMOO.

5 Form of examination

Course related exam:
- [20-00-0582-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0582-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Depending on topic.
10	**Comment**

Module name Symbolic Execution					
Module nr. 20-00-0702	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Reiner Hähnle		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0702-se	Symbolic Execution	0	Seminar	2

2 Teaching content

Symbolic execution of programs is a fundamental analysis technique that forms the basis of test generation, compiler optimization, verification, visualization, etc. In recent years, major progress was made. In the seminar we review the most important classic as well as recent contributions to symbolic execution.

3 Learning objectives

Understanding the possibilities and the limitations of this fundamental program analysis technique.

4 Prerequisite for participation

5 Form of examination

Course related exam:

- [20-00-0702-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0702-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

1.1.2.13 Practical Lab in Teaching

Module name Practical Lab Computer Networks and Distributed Systems					
Module nr. 20-00-0962	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-0962-pl	Praktikum in der Lehre - Computernetzwerke und verteilte Systeme	0	Internship teaching	3
2	**Teaching content**				
3	**Learning objectives**				
4	**Prerequisite for participation**				
5	**Form of examination** Course related exam: • [20-00-0962-pl] (Study achievement, Oral/written examination, Default RS)				
6	**Prerequisite for the award of credit points** Passing the final module examination				
7	**Grading** Course related exam: • [20-00-0962-pl] (Study achievement, Oral/written examination, Weighting: 100 %)				
8	**Usability of the module**				
9	**References**				
10	**Comment**				

Module name Data Management - Teaching Lab					
Module nr. 20-00-1040	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1040-pl	Data Management - Teaching Lab	0	Internship teaching	3

2 Teaching content

Creation of lab exercises and teaching material

3 Learning objectives

Experience in the supervision of students on the topic of data management, especially with regard to using the newly created material.

4 Prerequisite for participation

Information Management (20-00-0015-iv)

5 Form of examination

Course related exam:

- [20-00-1040-pl] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1040-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik

9 References

10 Comment

Module name Practical Training in Teaching - Echtzeitsysteme					
Module nr. 20-00-1060	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1060-pl	Practical Training in Teaching - Echtzeitsysteme	0	Internship teaching	3

2 Teaching content

Concepting, conducting and supervising exercises and laboratories of the course “Echtzeitsysteme”.

3 Learning objectives

Students are able to:
- Present and explain the lecture contents in the exercises
- Supervise laboratories
- Measure learning success in a systematic way

4 Prerequisite for participation

Successful completion of the associated Echtzeitsysteme-course or corresponding knowledge.

5 Form of examination

Course related exam:
- [20-00-1060-pl] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1060-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Teaching Lab Introduction to Compiler Construction					
Module nr. 20-00-0988	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0988-pl	Teaching Lab Introduction to Compiler Construction	0	Internship teaching	3

2 Teaching content

- Creation of lab exercises and teaching material
- Supervision of students on the topic of introductory compiler construction, especially with regard to using the newly created material

3 Learning objectives

After successfully completing the course, students are able to create teaching materials on computer science topics. They are able to employ the material when tutoring other students and evaluate the didactical impact of the created materials. They are able to advise other students in exercises, either in person or using electronic forms of communication.

4 Prerequisite for participation

Contents of the courses Functional and Object-Oriented Programming Concepts, Algorithms and Datastructures, Introduction to Compiler Construction and Computer Organization (or similar classes)

5 Form of examination

Course related exam:

- [20-00-0988-pl] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0988-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name Teaching Lab: Formal Principles of Computer Science III					
Module nr. 20-00-0531	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Heiko Mantel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0531-pl	Praktikum in der Lehre - Formale Methoden im Softwareentwurf	0	Internship teaching	3

2 Teaching content

preparation and revision of exercises, mentoring of lab groups

3 Learning objectives

Creation and evaluation of teaching materials for courses in computer science and supervision of students.

4 Prerequisite for participation

Formal Principles of Computer Science III

5 Form of examination

Course related exam:

- [20-00-0531-pl] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0531-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name Teaching Lab - Internet Security and Security in Mobile Networks					
Module nr. 20-00-0957	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Stefan Katzenbeisser		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-0957-pl	Teaching Lab - Internet Security and Security in Mobile Networks	0	Internship teaching	3

2 Teaching content

The course is concerned with developing additional practical course materials for the topic area internet security and security in mobile networks.

This includes but is not limited to: implementing test systems for practical study of security weakness that have theoretically been discussed in the course; design of minitests for student self-assessment, design for specialized course material for particularly weak/strong students; design of bonus tasks.

3 Learning objectives

Students obtain the following competencies:
- Derive exercises and home assignments from lecture course contents
- Design and implement practical course material
- Design and carry out exercises with students of different knowledge level
- Design concepts for a practical exercise series that builds on previous contents
- Design and apply methods to evaluate the learning progress

4 Prerequisite for participation

Successful participation in the corresponding SEEMOO course which will be covered in this teaching lab.

5 Form of examination

Course related exam:
- [20-00-0957-pl] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0957-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name Compiler Tooling					
Module nr. 20-00-1013	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1013-pr	Compiler Tooling	0	Internship	4

2 Teaching content

Modern compilers are primarily designed to produce efficient code for a particular platform and in doing so they employ sophisticated analysis and transformation tools. Such an infrastructure is useful also for source code transformation, e.g. for tools to annotate, instrument, or canonicalize codes. The complexity of C++ makes the development of such tools a challenging task.
An open compiler infrastructure used in a variety of research and production compilers is the LLVM infrastructure (www.llvm.org). A well-established front-end for C, C++ and objective C is Clang, which provides powerful mechanisms for extracting information from an abstract syntax tree representation of the underlying code, and thus enables source code modifications as well as the generation of the LLVM intermediate representation.

The students will work with different components and techniques of the Clang/LLVM framework and implement practical exercises for source transformation. The Clang/LLVM techniques include, in particular, handling and matching of the Clang abstract syntax tree. Examples for source transformation will highlight various facets of code augmentation or refactoring, e.g. for instrumenting parallel codes, for passing information between the static analysis and runtime environment of (parallel) codes, or for code refactoring to conform to coding standards.

3 Learning objectives

After attending this course, the students know basic and advanced concepts of syntactic and semantic code analysis and source transformation for C++, based on the Clang/LLVM technology. In particular, they can design and implement custom static analysis and code transformation tools using the Clang/LLVM framework, reflect and decide on the appropriate level of abstraction of the code representation for the task at hand, and synthesize additional usage scenarios for compiler technology.

4 Prerequisite for participation

Lecture Introduction to Compiler Construction (EiCB), Lecture System- and Parallel Programming (SPP), Knowledge of C++

5 Form of examination

Course related exam:
- [20-00-1013-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1013-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Data Management - Lab					
Module nr. 20-00-1041	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-1041-pr	Data Management - Lab	0	Internship	4

2 Teaching content

Participants independently solve alone or in a small group an individually a given problem. The problems are usually programming projects inspired by the research performed at the Data Management Lab.

Possible areas are:
- Scalable Databases & Modern Hardware
- Cloud Databases & Blockchains
- Interactive Data and Text Exploration
- Natural Language Interfaces for Databases
- Scalable Systems for Machine Learning

In this lab the students will realise a project defined by their advisor. Compared to the "Data Management - Lab", the “Data Management - Extended Lab” requires more effort.

3 Learning objectives

After completion of this course the students are able to
- Understand state-of-the-art techniques in modern data management systems
- Apply and implemenation of techniques in individual projects
- Provide experimental evidence for design decisions with benchmarks and/or real workloads

4 Prerequisite for participation

Depending on selected topic.

5 Form of examination

Course related exam:
- [20-00-1041-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1041-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Data Management - Extended Lab					
Module nr. 20-00-1042	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1042-pp	Data Management - Extended Lab	0	Project	6

2 Teaching content

Participants independently solve alone or in a small group an individually a given problem. The problems are usually programming projects inspired by the research performed at the Data Management Lab.

Possible areas are:
- Scalable Databases & Modern Hardware
- Cloud Databases & Blockchains
- Interactive Data and Text Exploration
- Natural Language Interfaces for Databases
- Scalable Systems for Machine Learning

In this lab the students will realise a project defined by their advisor. Compared to the "Data Management - Lab", the “Data Management - Extended Lab” requires more effort.

3 Learning objectives

After completion of this course the students are able to
- Understand state-of-the-art techniques in modern data management systems
- Apply and implemenation of techniques in individual projects
- Provide experimental evidence for design decisions with benchmarks and/or real workloads

4 Prerequisite for participation

Depending on selected topic.

5 Form of examination

Course related exam:
- [20-00-1042-pp] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1042-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Distributed Systems Programming: Project					
Module nr. 20-00-0984	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Eberhard Mühlhäuser		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0984-pp	Distributed Systems Programming: Project	0	Internship	6

2 Teaching content

The course focuses on research topics in distributed systems (DS) and programming languages for DS. The offered topics depend on the current research of the DSP group including:

- Software-defined networking (SDN)
- Network function virtualization (NFV) and in-network processing (INP)
- Traffic engineering (TE)
- Network monitoring
- Resource management in datacenters (RMF)
- Big data analytics (Spark, YARN, OpenStack, ..)
- Event-based systems
- Security in SDN, INP, and big data
- Geo-distributed data processing
- Compiler infrastructures for DS
- Language abstractions for DS
- Session types / calculi for DS
- Network Protocols

In this project the students will realize their own/a group research project defined together with their adviser. Compared to the “DSP: Lab”, the “DSP: Project” requires more effort.

3 Learning objectives

After participating in the course, the student is able to solve and evaluate technical and scientific problems in designing and developing future DS concepts and applications using state of the art scientific methods.

Acquired competences include (depending on the selected topic):

- Literature research in the project area
- Design of complex DS
- Implementation and verification of components for DS
- Deep understanding of existing complex software systems
- Methodical analysis and evaluation of
  - Models
  - Experiments
  - Software
- Design of programming languages
- Writing of technical documents or project reports
- Research style presentation of the outcomes of the project

4 Prerequisite for participation

	Interest to develop solutions for challenging problems of DS, self-motivation and high interest in recent research. Due to the wide area of topics, we cannot offer a comprehensive list of requirements. All topics are research-oriented, hence topic-specific background knowledge is required. More details will be given in the first lecture.
5	**Form of examination** Course related exam: • [20-00-0984-pp] (Study achievement, Oral/written examination, Default RS)
6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-0984-pp] (Study achievement, Oral/written examination, Weighting: 100 %)
8	**Usability of the module**
9	**References**
10	**Comment**

Module name					
Embedded Systems Hands-On 1: Design and Implementation of Hardware-Software Systems					
Module nr. 20-00-0959	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0959-pr	Embedded Systems Hands-On 1: Design and Implementation of Hardware-Software Systems	0	Internship	4

2 Teaching content

These labs are intended for students interested in obtaining hands-on practical experience with the design and implementation of embedded systems.

The labs will begin by introducing fundamentals such as

- basic electrical engineering
- using lab test and measurement instruments
- design and fabrication of electronic circuits
- acquiring and processing data from sensors
- bus protocols in embedded systems
- programming and debugging heterogeneous embedded systems
- the use of the Linux kernel as an operating system in an embedded context

The lab core then has the participants implement a concrete embedded system. A number of possible projects will be offered, each with a different focus (e.g., hardware or software) to match student interest.

3 Learning objectives

After successful completion, students are familiar with the practical techniques and tools required for designing, implementing and bringing-up embedded hardware/software systems.

This includes basic knowledge of electrical engineering, the use of lab test and measurement instruments, the use of languages and EDA/CAD tools for hardware design. They are able to program and debug software in an embedded systems context as well as employ Linux as an operating system here.

4 Prerequisite for participation

Recommended: Successful completion of „Digital Design“, „Computer Organisation“, „Architecture and Design of Computer Systems“, „Operating Systems“ and „System-level and Parallel Programming“ or similar competencies obtained in other study programmes

5 Form of examination

Course related exam:

- [20-00-0959-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

	Course related exam: • [20-00-0959-pr] (Study achievement, Oral/written examination, Weighting: 100 %)
8	**Usability of the module**
9	**References**
10	**Comment**

Module name					
Embedded Systems Hands-On 2: Designing Hardware Accelerators for Systems-on-Chip					
Module nr. 20-00-0968	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0968-pr	Embedded Systems Hands-On 2: Designing Hardware Accelerators for Systems-on-Chip	0	Internship	4

2 Teaching content

These practical labs are intended for students interested in learning how to design hardware accelerators for systems-on-chips.

It covers a wide range of topics, including

- OS drivers for accelerators

- design and interfacing of accelerators in Bluespec SystemVerilog

- Design flows and tool chains for hardware/software co-development

The actual accelerators covered are inspired by typical applications, e.g., image processing or stereo-vision computations.

3 Learning objectives

Acquire skills in using the knowledge and techniques taught in prior classes to actually perform a complete hardware/software co-design of an application in an embedded systems context.

4 Prerequisite for participation

Basic knowledge using Linux on embedded Systems (e.g., acquired in ESHO1). Knowledge of the Bluespec SystemVerilog hardware description language (e.g., as taught in Architecture and Design of Computing Systems).

5 Form of examination

Course related exam:
- [20-00-0968-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0968-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name					
Advanced Topics in Embedded Systems and Applications					
Module nr. 20-00-1001	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1001-pp	Advanced Topics in Embedded Systems and Applications	0	Project	6

2 Teaching content

The course covers current topics in research and development of computing systems and programming tools, including focused ones in the areas of embedded and application-specific architectures. The subjects are determined by current research efforts in the ESA group and are intended to guide students towards acquiring technical as well as introductory scientific skills, for example, including one or more of the following domains:

- Computing systems architecture at the processor and systems-level
- Design of digital electronic circuits and hardware systems
- Use of Field-Programmable Gate Arrays
Hardware/Software design and programming tools
- Operating systems and low-level programming
Hardware/Software Co-Design
Application-specific architectures and techniques
- Design and/or programming of compute accelerators
- Debugging and analysis techniques for hardware/software-systems

3 Learning objectives

Participants are intended to acquire the skills necessary to quickly become familiar with a new domain and then solve a complex practical problem within that domain. These skills can include studies of scientific literature, surveying existing code-bases from the hardware/software domains, and the practical implementation of hardware and/or software systems. The final talk should show proficiency with basic presentation techniques.

4 Prerequisite for participation

An interest to develop high-quality solutions in the assigned problem domain. For different domains, different pre-requisites will be required. These can include digital design, compiler construction, system-level and parallel programming. Such skills can be acquired by successfully completing the appropriate lectures.

5 Form of examination

Course related exam:
- [20-00-1001-pp] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1001-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatjk
M.Sc Informatik
May be used in other degree programs.

9	**References**
10	**Comment**

Module name Implementation of Programming Languages					
Module nr. 20-00-0306	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0306-pr	Implementation of Programming Languages	0	Internship	4

2 Teaching content

3 Learning objectives

4 Prerequisite for participation

...

5 Form of examination

Course related exam:

- [20-00-0306-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0306-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name Parallel Programming Technology					
Module nr. 20-00-1008	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Dr.-Ing. Michael Eichberg		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1008-pr	Parallel Programming Technology	0	Internship	4

2 Teaching content

In this lab course, participants actively develop and/or apply parallel programming technologies in several areas:
- Parallelism discovery
- Performance analysis and modeling
- Correctness analysis
- Profiling
- Scalable algorithms
- Resource management and scheduling
- Applications (e.g., deep learning)

3 Learning objectives

- Become familiar with and develop and/or apply parallel programming technologies
- Practice software engineering methods
- Work in a team on software projects
- Present project results effectively in reports and presentations

4 Prerequisite for participation

- Knowledge of parallel programming and parallel systems

5 Form of examination

Course related exam:
- [20-00-1008-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1008-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name					
Practical Lab Algorithms					
Module nr. 20-00-0189	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Heiko Mantel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0189-pr	Practical Lab Algorithms	0	Internship	4

2 Teaching content

Solution of an algorithmic problem form practice and its implementation in software.

3 Learning objectives

In this course students acquire expertise in solving algorithmic problems from practice and skill to implement efficient algorithms

4 Prerequisite for participation

- Knowledge in program language (e.g. Java / C++)
- Knowledge about basic algorithms and data structure

5 Form of examination

Course related exam:

- [20-00-0189-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0189-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

9 References

Will be given in lecture.

10 Comment

Module name Compiler Construction Lab					
Module nr. 20-00-0911	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Ermira Mezini		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0911-pr	Compiler Construction Lab	0	Internship	4

2 Teaching content

Independently implement a compiler or extend an existing compile flow (e.g., realize new optimization passes or back-ends).

3 Learning objectives

After successfully completing the labs, students are able to independently implement core parts of a modern compiler, either from scratch or integrating them into an existing compiler framework. In this process, they can apply and improve their knowledge both of compiler technology (e.g, use of different intermediate representations), as well as of general implementation techniques (e.g., applying design patterns).

4 Prerequisite for participation

Recommended:
Participation of lecture „Rechnerorganisation“, „Einführung in den Compilerbau“ and „Fortgeschrittener Compilerbau“, respectively according knowledge.

5 Form of examination

Course related exam:
- [20-00-0911-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0911-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik
M.Sc. Informationssystemtechnik
May be used in other degree programs.

9 References

Will be given to actual topic.

10 Comment

Module name					
Lab Exercise on Secure Mobile Networking					
Module nr. 20-00-0552	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Karsten Weihe		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0552-pr	Secure Mobile Networking Lab	0	Internship	4

2 Teaching content

The Lab Exercise on Secure Mobile Networking covers the applied software development as well as hardware-software development. Topic areas covered are communication networks, IT security, mobile networks and wireless communications as well as the combination of these. Goal is the solving of a given problem by implementation in software or hardware/software in a team.

Course contents:
- Solving of a problem in the area of communication networks, IT security, mobile networks and wireless communications
- Survey on solution alternatives and discussion of pros and cons
- Conception of a software architecture or a combined hardware-software architecture
- Software/hardware design for the target platform
- Prototypical realization on the target platform
- Evaluation of the system with respect to performance aspects
- Documentation of the implemented solution

3 Learning objectives

After successfully attending the course, students have aquired the ability to solve problems in the area of secure mobile networking using software technology. The students have gained insight into the design/implementation of complex protocols or applications in one/multiple of the areas of communication networks, IT security, mobile netwokrs and wireless communications. They are able to implement the chosen protocols and application, and to test the functionality as well as to evaluate the performance. Students are able to document the developed software artefacts and to present the project progress and outcomes.

4 Prerequisite for participation

Successfull participation in an lecture of SEEMOO.

5 Form of examination

Course related exam:
- [20-00-0552-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0552-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Will be given in lab.
10	**Comment**

Module name					
Labs on Algorithms for Electronic Design Automation Tools					
Module nr. 20-00-0571	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German/English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0571-pr	Labs on Algorithms for Electronic Design Automation Tools	0	Internship	4

2 Teaching content

- Realizing Electronic Design Automation tools for layout synthesis, specifically for topics such as timing analysis, placement, and routing
- Evaluation of the quality-of-results and compute/memory requirements of developed tools in comparison to existing implementations

3 Learning objectives

After successfully attending the course, the students can independently implement Electronic Design Automation tools for the specified fabrication technology. They can evaluate their tools according to a number of quality metrics and perform a comparison with existing implementations.

4 Prerequisite for participation

Recommended:
Participation of lecture "Algorithmen für Hardware-Entwurfswerkzeuge".

5 Form of examination

Course related exam:
- [20-00-0571-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0571-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

9 References

Given scientific Papers to recommeded base-methods.

10 Comment

Module name					
Project on Secure Mobile Networking					
Module nr. 20-00-0553	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Karsten Weihe		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0553-pp	Secure Mobile Networking Project	0	Internship	6

2 Teaching content

The Project on Secure Mobile Networking covers the applied software development as well as hardware-software development. Topic areas covered are communication networks, IT security, mobile netwokrs and wireless communications as well as the combination of these. Goal is to independently carry out a development project in a team.

Course contents:
- Independent solving of a development project in the area of communication networks, IT security, mobile netwokrs and wireless communications
- Project planning and project management
- Survey on solution alternatives and discussion of pros and cons
- Conception of a software architecture or a combined hardware-software architecture
- Software/hardware design for the target platform
- Prototypical realization on the target platform
- Evaluation of the system with respect to performance aspects
- Documentation of the implemented solution as well as extensive documentation of the project management

3 Learning objectives

After successfully attending the course, students have aquired the ability to solve complex problems in the area of secure mobile networking using software technology. To this end, the students are able to independently define, manage and carrry out a project.
The students have gained insight into the design/implementation of complex protocols or applications in one/multiple of the areas of communication networks, IT security, mobile netwokrs and wireless communications. They are able to implement the chosen protocols and application, and to test the functionality as well as to evaluate the performance. The students are able to document the project planning and management, the developed software artefacts and to present the project progress and outcomes.

4 Prerequisite for participation

Successfull participation of an lecture of SEEMOO.

5 Form of examination

Course related exam:
- [20-00-0553-pp] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0553-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Will be given in project.
10	**Comment**

1.1.2.14 Specialization Visual Computing

Elective Areas

1.1.2.15 Computer Graphics

Module name Geometric Methods of CAE/CAD					
Module nr. 20-00-0140	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0140-iv	Geometrical Methods of CAE/CAD	0	Integrated course	3

2 Teaching content

- parametric curve models
- parametric surface models
- topology and volumetric CAD models
- CAD operations on surfaces
- tesselation
- approximation of curves and surfaces
- finite element method and computational fluid dynamics
- various applications from the area of CAD

3 Learning objectives

After successfully attending the course, students understand the foundations of computer-aided methods for geometric modelling and simulation. They understand multiple parametric representations for curves and surfaces and are able to analyze and compare them. They know classical data structures and algorithms from computer aided design (CAD). They can use the presented techniques to model and visualize 3D geometry.

4 Prerequisite for participation

Basic knowledge in Computer Science.

5 Form of examination

Course related exam:

- [20-00-0140-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0140-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
9	**References** Vorlesungsfolien Lee: Principles of CAD / CAM / CAE Systems, Addison-Wesley. Piegl, Tiller: The NURBS Book, Springer Verlag. Farin: Kurven und Flächen im Computer Aided Geometric Design, vieweg Shah, Mäntylä: Parametric and Feature-based CAD/CAM, Wiley & Sons
10	**Comment**

Module name Computer Graphics I					
Module nr. 20-00-0040	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0040-iv	Computer Graphics I	0	Integrated course	4

2 Teaching content

Introduction to basic principles of computer graphics, in particular input and output devices, rendering using OpenGL, ray tracing, illumination modelling, ongoing development in computer grapics.

3 Learning objectives

After successful completion of the modul, students are able to understand all components of the graphic pipeline and change variable parts (Vertex-Shader, Fragment-Shader, etc.). They are able to arrange, change and effectively store objects in the 3D-space, as well as appropriately choose the camera and the perspective, and utilize various shading-techniques and lighting-models to adapt all steps on the way to the displayed 2D-Image.

4 Prerequisite for participation

Recommended:
- Programming
- Basic algorithm and data structure
- Linear algebra
- Analysis
- Topics of lecture Visual Computing

5 Form of examination

Course related exam:
- [20-00-0040-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%).

7 Grading

Course related exam:
- [20-00-0040-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B. Sc. Informatik
M. Sc. Informatik
M. Sc. Computer Science
M. Sc. Autonome Systeme und Robotik
M.Sc. IT Sicherheit

May be used in other degree programs.

9	**References** - Real-Time Rendering: Tomas Akenine-Möller, Eric Haines, Naty Hoffman A.K. Peters Ltd., 3rd edition, ISBN 987-1-56881-424-7 - Fundamentals of Computer Graphics: Peter Shirley, Steve Marschner, third edition, ISBN 979-1-56881-469-8 - Additional literature will be given in the lecture.
10	**Comment**

Module name Computer Graphics II					
Module nr. 20-00-0041	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0041-iv	Computer Graphics II	0	Integrated course	4

2 Teaching content

Foundations of the various object- and surface-representations in computer graphics. Curves and surfaces (polynomials, splines, RBF) Interpolation and approximation, display techniques, algorithms: de Casteljau, de Boor, Oslo, etc. Volumes and implicit surfaces. visualization techniques, iso-surfaces, MLS, surface rendering, marching cubes. Meshes, mesh compression, mesh simplication, multiscale expansion, subdivision. Pointclouds: rendering techniques, surface reconstruction, voronoi-diagram and delaunay-triangulation.

3 Learning objectives

After successful completion of the module, students are able to handle various object- and surface-representations, i.e., to use, adapt, display (render), and effectively store these objects. This includes mathematical polynomial representations, iso-surfaces, volume representations, implicite surfaces, meshes, subdivision control meshes and pointclouds.

4 Prerequisite for participation

Recommended:
- Algorithmen und Datenstrukturen
- Grundlagen aus der Höheren Mathematik
- Graphische Datenverarbeitung I
- C / C++

5 Form of examination

Course related exam:
- [20-00-0041-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0041-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B. Sc. Informatik M. Sc. Informatik M. Sc. Computer Science M.Sc. IT Sicherheit May be used in other degree programs.
9	**References** - Real-Time Rendering: Tomas Akenine-Möller, Eric Haines, Naty Hoffman A.K. Peters Ltd., 3rd edition, ISBN 987-1-56881-424-7 - Additional literature will be given in the lecture.
10	**Comment**

Module name Higher-order Meshing					
Module nr. 20-00-1160	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Arjan Kuijper		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1160-vl	Higher-order Meshing	0	Lecture	2

2 Teaching content

This special course focuses on the recent research and advances in the field of higher-order meshing. We will learn about Bézier curves and triangles, NURBS, de Casteljau algorithm, injectivity/quality checking algorithms, 2D/3D meshing algorithms and their properties/guarantees and finally look into some open problems in this field.

3 Learning objectives

After completing the course, the students will know the basics of higher-order curves and surfaces, algorithms for higher-order mesh generation and quality testing. They will be at par with the current research in the field.

4 Prerequisite for participation

Recommended:
20-00-0040-iv Computer Graphics I

5 Form of examination

Course related exam:
- [20-00-1160-vl] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1160-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Physically based Simulation and Animation					
Module nr. 20-00-0682	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0682-iv	Physically based Simulation and Animation	0	Integrated course	4

2 Teaching content

- Basics of physically based simulation and animation
- Equations of motion and modeling of rigid bodies, mass-spring systems, deformable bodies and fluids
- Approximate numerical methods for the efficient solution of ordinary and partial differential equations
- Parallel computing for physically based simulations
- Collision detection and resolution

3 Learning objectives

After completing the module successfully, the students can
- Describe requirements for methods of physically based simulations for computer animation
- Apply concepts of physically based simulations
- Transfer learned concepts to other simulation applications
- Evaluate the suitability of algorithms and numerical methods for physically based simulation
- Describe open research questions in physics-based simulation and animation

4 Prerequisite for participation

- Basic knowledge of numerical computing, algorithms and data structures, computer graphics

5 Form of examination

Course related exam:
- [20-00-0682-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam of Modul (100%)

7 Grading

Course related exam:
- [20-00-0682-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
Can be used in other degree programs.

9 References

10 Comment

Module name					
Programming Massively Parallel Processors					
Module nr. 20-00-0419	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0419-iv	Programming Massively Parallel Processors	0	Integrated course	4

2 Teaching content
- foundations of massively parallel processors with a focus on modern accelerator hardware
- parallel algorithms
- efficient programming of massively parallel systems
- practical programming projects co-advised by domain scientists

3 Learning objectives
After successful completion of the course, students are able to analyze problems in the context of massively parallel systems. They can develop novel applications and systematically improve their performance. They understand basic parallel algorithms and are able to independently understand and analyze current literature.

4 Prerequisite for participation
Programming skills in C/C++
Recommended: Systemnahe und Parallele Programmierung

5 Form of examination
Course related exam:
- [20-00-0419-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points
Pass exam (100%)

7 Grading
Course related exam:
- [20-00-0419-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module
B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References
Will be announced in lecture.

10 Comment

Module name Distributed geometry processing					
Module nr. 20-00-1075	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Arjan Kuijper		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1075-iv	Distributed geometry processing	0	Integrated course	4

2 Teaching content

* Foundations and algorithms of geometry processing: smoothing, remeshing, Delaunay triangulation, parameterization, texturization, etc.
* Introduction into Big Data and Cloud Computing
* Indexing massive geometry datasets for faster access: quad trees, R-trees, space-filling curves, etc.
* Distributed and cloud-based data storage
* Architectures for distributed processing pipelines
* Programming models for distributed algorithms (e.g. MapReduce)
* Technologies and frameworks for distributed data processing (e.g. Spark, Vert.x) and geometry processing (Draco, etc.)
* Deployment of distributed applications in the Cloud
* There will be practical and theoretical exercises

3 Learning objectives

After successfully absolving the course, students will have knowledge in geometry processing and distributed, cloud-based processing of large datasets in general. They will be able to develop scalable applications and to deploy them to the cloud in order to increase performance of geometry processing through parallelization.

4 Prerequisite for participation

* Programming skills in Java or other JVM languages
* Basic algorithms and data structures

5 Form of examination

Course related exam:
- [20-00-1075-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1075-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Affective Computing					
Module nr. 20-00-1120	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Arjan Kuijper		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1120-iv	Affective Computing	0	Integrated course	4

2 Teaching content

- Introduction to affective computing with an overview of its application in entertainment, health and pedagogy
- Emotion theories: psychology, cognitive science and neuroscience
- Discussion on ways to make machines “have” emotions
- Experimental design, methodology, and analysis
- Emotion and the brain
- Bodily expression of emotions
- Synthesis of emotional behavior
- Emotion and social interaction
- Personality and cultures
- Emotion recognition in text, speech and face
- Hands-on programming experience for affective computing
- Bias and ethics of affective computing

3 Learning objectives

This module aims to teach the theories, methodologies and applications surrounding affective computing in an interdisciplinary perspective. After successfully completing the course, students understand affective interactions and its implications to human-computer interaction, learn to apply methods for collection, analysis and evaluations of affective behavior data. They demonstrate knowledge on computational analysis, synthesis and recognition of human affective behavior data, and designing emotionally sensitive interactive technologies such as interactions with virtual agents, robots and games. They gain hands-on experience with the frameworks for human affect and behavior understanding, and awareness of potential bias in data as well as possible dangers of dealing with sensitive personal data.

4 Prerequisite for participation

Recommended:
- Programming skills
- Statistical Machine Learning or Introduction to Artificial Intelligence

5 Form of examination

Course related exam:
- [20-00-1120-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.
Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-1120-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Image Processing					
Module nr. 20-00-0155	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0155-iv	Image Processing	0	Integrated course	2

2 Teaching content

Fundamentals of image processing:
- Image properties
- Image transformations
- Simple and complex filtering
- Image compression,
- Segmentation
- Classification

3 Learning objectives

After successfully completing the course, students have an overview over the mechanisms used in and the abilities of modern image processing techniques. They are able to solve basic to medium level problems in image processing.

4 Prerequisite for participation

5 Form of examination

Course related exam:
- [20-00-0155-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0155-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

9 References

	- Gonzalez, R.C., Woods, R.E., ""Digital Image Processing"", Addison- Wesley Publishing Company, 1992 - Haberaecker, P., ""Praxis der Digitalen Bildverarbeitung und Mustererkennung"", Carl Hanser Verlag, 1995 - Jaehne, B., ""Digitale Bildverarbeitung"", Springer Verlag, 1997
10	**Comment**

<table>
<tr><td colspan="6">Module name
Computer Vision I</td></tr>
<tr><td>Module nr.
20-00-0157</td><td>Credit points
6 CP</td><td>Workload
180 h</td><td>Self-study
120 h</td><td>Module duration
1 Term</td><td>Module cycle
Every 2. Semester</td></tr>
<tr><td colspan="3">Language
English</td><td colspan="3">Module owner
Prof. Dr. Bernt Schiele</td></tr>
</table>

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-0157-iv	Computer Vision	0	Integrated course	4

2 Teaching content

- Basics of image formation
- Linear and (simple) nonlinear image filtering
- Foundations of multi-view geometry
- Camera calibration and pose estimation
- Foundations of 3D reconstruction
- Foundations of motion estimation from video
- Template and subspace methods for object recognition
- Object classification with bag of words
- Object detection
- Basics of image segmentation

3 Learning objectives

After successfully attending the course, students are familiar with the basics of computer vision. They understand fundamental techniques for the analysis of images and videos, can name their assumptions and mathematical formulations, as well as describe the resulting algorithms. They are able to implement these techniques in order to solve basic image analysis tasks on realistic imagery.

4 Prerequisite for participation

Particiation of lecture Visual Computing is recommended.

5 Form of examination

Course related exam:

- [20-00-0157-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0157-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
9	**References** Literature recommendations will be updated regularly, an example might be: - R. Szeliski, ""Computer Vision: Algorithms and Applications"", Springer 2011 - D. Forsyth, J. Ponce, ""Computer Vision – A Modern Approach"", Prentice Hall, 2002
10	**Comment**

Module name Computer Vision II					
Module nr. 20-00-0401	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0401-iv	Computer Vision II	0	Integrated course	4

2 Teaching content

- Computer vision as (probabilistic) inference
- Robust estimation and modeling
- Foundations of Bayesian networks and Markov random fields
- Basic inference and learning methods in computer vision
- Image restoration
- Stereo
- Optical flow
- Bayesian tracking of (articulated) objects
- Semantic segmentation
- Current research topics

3 Learning objectives

After successfully attending the course, students have developed a more in-depth understanding of computer vision. They formulate image and video analysis tasks as inference problems, taking challenges of real applications into account, e.g. regarding robustness. They solve the inference problem using discrete or continuous inference algorithms, and apply these to realistic imagery. They quantitatively evaluate the application specific results.

4 Prerequisite for participation

Participation of lecture Visual Computing and Computer Vision I is recommended.

5 Form of examination

Course related exam:

- [20-00-0401-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0401-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Literature recommendations will be updated regularly, an example might be: - S. Prince, “Computer Vision: Models, Learning, and Inference”, Cambridge University Press, 2012 - R. Szeliski, ""Computer Vision: Algorithms and Applications"", Springer 2011
10	**Comment**

Module name Data Mining and Machine Learning					
Module nr. 20-00-0052	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0052-iv	Data Mining and Machine Learning	0	Integrated course	4

2 Teaching content

With the rapid development of information technology bigger and bigger amounts of data are available. These often contain implicit knowledge, which, if it were known, could have significant commercial or scientific value. Data Mining is a research area that is concerned with the search for potentially useful knowledge in large data sets, and machine learning is one of the key techniques in this area.

This course offers an introduction into the area of machine learning from the angle of data mining. Different techniques from various paradigms of machine learning will be introduced with exemplary applications. To operationalize this knowledge, a practical part of the course is concerned with the use of data mining tools in applications.

- Introduction (Foundation, Learning problems, Concepts, Examples, Representation)
- Rule Learning
  - Learning of indicvual rules (generalization vs. specialization, structured hypothesis spaces, version spaces)
  - Learning of rule sets (covering strategy, evaluation measures for rules, pruning, multi-class problems)
- Evaluation and cost-sensitive Learning (Accuracy, X-Val, ROC Curves, Cost-Sensitive Learning)
- Instance-Based Learning (kNN, IBL, NEAR, RISE)
- Decision Tree Learning (ID3, C4.5, etc.)
- Ensemble Methods (Bias/Variance, Bagging, Randomization, Boosting, Stacking, ECOCs)
- Pre-Processing (Feature Subset Selection, Discretization, Sampling, Data Cleaning)
- Clustering and Learning of Association Rules (Apriori)"

3 Learning objectives

After a successful completion of this module, students are in a position to
- understand and explain fundemental techniques of data mining and machine learning
- apply practical data mining systems and understand their strengths and limitations
- critically judge new developments in this area

4 Prerequisite for participation

5 Form of examination

Course related exam:
- [20-00-0052-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7	**Grading** Course related exam: • [20-00-0052-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B. Sc. Informatik M. Sc. Informatik M. Sc. Computer Science M. Sc. Autonome Systeme und Robotik M. Sc. Artificial Intelligence and Machine Learning M. Sc. IT Sicherheit May be used in other degree programs.
9	**References** - Mitchell: Machine Learning, McGraw-Hill, 1997 - Ian H. Witten and Eibe Frank: Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations, Morgan-Kaufmann, 1999
10	**Comment**

Module name Deep Learning for Medical Imaging					
Module nr. 20-00-1014	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1014-iv	Deep Learning for Medical Imaging	0	Integrated course	3

2 Teaching content

Formulating Medical Image Segmentation, Computer Aided Diagnosis and Surgical Planning as Machine Learning Problems, Deep Learning for Medical Image Segmentation, Deep Learning for Computer Aided Diagnosis, Surgical Planning from pre-surgical images using Deep Learning, Tool presence detection and localization from endoscopic videos using Deep learning, Adversarial Examples for Medical Imaging, Generative Adversarial Networks for Medical Imaging.

3 Learning objectives

After successful completion of the course, students should be able to understand all components of formulating a Medical Image Analysis problem as a Machine Learning problem. They should also be able to make informed decision of choosing a general purpose deep learning paradigm for given medical image analysis problem.

4 Prerequisite for participation

- Programming skills
- Understanding of Algorithmic design
- Linear Algebra
- Image Processing / Computer Vision I
- Statistical Machine Learning

5 Form of examination

Course related exam:
- [20-00-1014-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1014-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Deep Learning: Architectures & Methods					
Module nr. 20-00-1034	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1034-iv	Deep Learning: Architectures & Methods	0	Integrated course	4

2 Teaching content

- Review of machine learning background
- Deep Feedforward Networks
- Regularization for Deep Learning
- Optimization for Training Deep Models
- Convolutional Networks
- Sequence Modeling: Recurrent and Recursive Nets
- Linear Factor Models
- Autoencoders
- Representation Learning
- Structured Probabilistic Models for Deep Learning
- Monte Carlo Methods
- Approximate Inference
- Deep Generative Models
- Deep Reinforcement Learning
- Deep Learning in Vision
- Deep Learning in NLP

3 Learning objectives

This course provides students with the required advanced background on machine learning the knowledge to independently carry out research projects on the hot topic of deep learning, e.g. within the scope of a Bachelor's or Master's thesis. In particular, this class aims at providing the students with fundamental understanding of deep learning algorithms and the architecture of deep networks.

4 Prerequisite for participation

20-00-0358-iv Statistical Machine Learning
20-00-0052-iv Data Mining and Machine Learning

5 Form of examination

Course related exam:
- [20-00-1034-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1034-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name					
Medical Image Processing					
Module nr. 20-00-0379	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0379-vl	Medical Image Processing	0	Lecture	2

2 Teaching content

The lecture consists of two parts. The first half of the lecture describes how devices that yield medical image data (CT, NMR, PET, SPECT, Ultrasound) work. The second half of the lecture covers various image processing techniques that are typically applied to medical images.

3 Learning objectives

After successfully completing the course, students have an overview over the mechanisms used in and the abilities of modern medical image processing techniques. They are able to solve basic to medium level problems in medical image processing.

4 Prerequisite for participation

Basics within Mathematics are highly recommended.
Participation in lecture "Bildverarbeitung".

5 Form of examination

Course related exam:

- [20-00-0379-vl] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0379-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

	1) Heinz Handels: Medizinische Bildverarbeitung 2) 2) Gonzalez/Woods: Digital Image Processing (last edition) 3) 3) Bernd Jähne: Digitale Bildverarbeitung. 6. überarbeitete und erweiterte Auflage. Springer, Berlin u. a. 2005, ISBN 3-540-24999-0 4) Kristian Bredies, Dirk Lorenz: Mathematische Bildverarbeitung. Einführung in Grundlagen und moderne Theorie. Vieweg+Teubner, Wiesbaden 2011, ISBN 978-3-8348-1037-3
10	**Comment**

Module name Human and Identity centric Machine Learning					
Module nr. 20-00-1118	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Arjan Kuijper		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1118-iv	Human and Identity centric Machine Learning	0	Integrated course	4

2 Teaching content

Background and concepts of human-centric Machine Learning: the goal of identity and human-centric machine learning. The differences between identity learning and other
mainstream classification. Representation extraction for subject-related data: feature extraction methodology for identity related applications. Hand crafted and Deeply learned features background and
basics.

Deep learning strategies for identity representations: learning identities representations with deep learning. Learning strategies and learning losses. Network architectures and identityspecific components.

Knowledge transfer and distillation: transfer learning and identity-representation. Knowledge distillation concepts and applications.

Efficient machine learning: the relation between resource limitations, Green-AI, and deep learning. Methods to build efficient machine learning solutions.

Synthetic identity: the need of synthetic identity. Synthetic identity as adversarial. Generating synthetic identity-controlled data under different restrictions.

Machine learning biases: analyses of demographic fairness and the roots of the fairness issues. ML-based mitigation of demographic biases.

Learning privacy: analyzing unintentionally learned information. Learning strategies to the targeted suppression of information at different representation levels.

Data utility: understanding the effect of data utility in the training process. Understanding sample utility in operation. ML concepts and strategies of estimating sample utilities.

Sample-level attacks: overview on adversarial, sample manipulation, other attacks on human-centric ML. Deep learning concepts, network blocks, and loss strategies, to detect and mitigate sample-level attacks.

Explainability: overview on the need for explainability in different decision-making processes. Different strategies to provide explainability for decision made in different operations discussed in the previous lectures.

Ethics in identity-centric ML: overview on ethics in AI and AI regulation. AI ethics for human data processing and storage.

3 Learning objectives

	After successfully attending the module, students are familiar with machine learning concepts related to dealing with human and identity related information. They understand fundamental techniques for the subject-specific representation extraction, including related knowledge transfer and distillation concepts. Understanding of demographic-related machine learning biases and function-creep privacy concerns, including their main mitigation concepts. They understand the requirements and techniques to achieve embedded and efficient human-centric machine learning. They are familiar with the effect of data utility in the training process and the main concept to estimate the utility of subject-related data. They will have first hand understanding of explainability methodologies of ML decision based on identity-related data. The students will be introduced to AI ethics and AI regulation concepts related to human data processing and storage. They are able to implement these techniques in order to solve basic identity and human-centric machine learning tasks on realistic problems.
4	**Prerequisite for participation** It is recommended having previously taken Visual Computing. Basics in mathematics and probability theory are required.
5	**Form of examination** Course related exam: • [20-00-1118-iv] (Technical examination, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).
6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-1118-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Probabilistic Graphical Models					
Module nr. 20-00-0449	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Ph. D. Stefan Roth		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0449-iv	Probabilistic Graphical Models	0	Integrated course	4

2 Teaching content

- Refresher of probability & Bayesian decision theory
- Directed and undirected models and their properties
- Inference in tree graphs
- Approximate inference in general graphs: Message passing and mean field
- Learning of directed and undirected models
- Sampling methods for learning and inference
- Modeling in example applications, including topic models
- Deep networks
- Semi-supervised learning

3 Learning objectives

After successfully attending the course, students have developed an in-depth understanding of probabilistic graphical models. They describe and analyze properties of graphical models, and formulate suitable models for concrete estimation and learning tasks. They understand inference algorithms, judge their suitability and apply them to graphical models in relevant applications. Moreover, they determine which learning algorithms are suitable to estimate the model parameters from example data, and apply these.

4 Prerequisite for participation

Recommended: Participation in “Statistisches Maschinelles Lernen”.

5 Form of examination

Course related exam:

- [20-00-0449-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0449-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Literature recommendations will be updated regularly, an example might be: - D. Barber: “Bayesian Reasoning and Machine Learning”, Cambridge University Press 2012 - D. Koller, N. Friedman: “Probabilistic Graphical Models: Principles and Techniques”, MIT Press 2009
10	**Comment**

Module name					
Reinforcement Learning: From Foundations to Deep Approaches					
Module nr. 20-00-1047	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1047-iv	Reinforcement Learning: From Foundations to Deep Approaches	0	Integrated course	4

2 Teaching content

- Review of machine learning background
- Black box Reinforcement Learning
- Modeling as bandit, Markov Decision Processes and Partially Observable Markov Decision Processes
- Optimal control
- System identification
- Learning value functions
- Policy search
- Deep value functions methods
- Deep policy search methods
- Exploration vs exploitation
- Hierarchical reinforcement learning
- Intrinsic motivation

3 Learning objectives

This course provides students with the required basic background on machine learning the knowledge to independently carry out research projects on the hot topic of reinforcement learning, e.g. within the scope of a Bachelor's or Master's thesis. In particular, this class aims at providing the students with fundamental understanding of reinforcement learning algorithms and the application within deep learning.

4 Prerequisite for participation

Good programming in Python.
Lecture Statistical Machine Learning is helpful but not mandatory.

5 Form of examination

Course related exam:
- [20-00-1047-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1047-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name					
Statistical Relational Artificial Intelligence: Logic, Probability, and Computation					
Module nr. 20-00-1011	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1011-iv	Statistical Relational Artificial Intelligence: Logic, Probability, and Computation	0	Integrated course	4

2 Teaching content

+ Logic programming
+ Inductive logic programming, i.e., learning logical programs from data
+ Probabilistic graphical models: Inference and Learning
+ Statistical relational models such as ProbLog and Markov logic networks
+ Inference within statistical relational models
+ Learning statistical relational models from data
+ Relational linear and quadratic programs

3 Learning objectives

The lecture provides a systematic introduction to the foundations and methods of statistical relational learning and AI: the study and design of intelligent agents that act in worlds composed of individuals (objects, things), where there can be complex relations among the individuals, where the agents can be uncertain about what properties individuals have, what relations are true, what individuals exist, whether different terms denote the same individual, and the dynamics of the world. After the successful completion of the course, students understand the basic concepts and methods of statistical relational AI. They understand the basic challenges posed by relational domains and know the current state of the art to meet tem. They are able to apply the acquired toolbox to novel problems.

4 Prerequisite for participation

The successful completion of “Statistical Machine Learning” and of “Probabilistic Graphical Models” is recommended but not required.

5 Form of examination

Course related exam:

- [20-00-1011-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1011-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

	Pointers to literature will be updated regularly and include: Luc De Raedt, Kristian Kersting, Sriraam Natarajan, David Poole (2016): Statistical Relational Artificial Intelligence: Logic, Probability, and Computation. Synthesis Lectures on Artificial Intelligence and Machine Learning, Morgan & Claypool Publishers, ISBN: 9781627058414.
10	**Comment**

Module name Statistical Machine Learning					
Module nr. 20-00-0358	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Kristian Kersting		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0358-iv	Statistical Machine Learning	0	Integrated course	4

2 Teaching content

- Statistical Methods for Machine Learning
- Refreshers on Statistics, Optimization and Linear Algebra
- Bayes Decision Theory
- Probability Density Estimation
- Non-Parametric Models
- Mixture Models and EM-Algorithms
- Linear Models for Classification and Regression
- Statistical Learning Theory
- Kernel Methods for Classification and Regression

3 Learning objectives

The lecture gives a systematic introduction to statistical methods for machine learning. Upon successful completion of this lecture, students will understand the most important methods and approaches of statistical machine learning. They can apply machine learning to solve various new problems.

4 Prerequisite for participation

5 Form of examination

Course related exam:

- [20-00-0358-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0358-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9	**References** 1. C.M. Bishop, Pattern Recognition and Machine Learning (2006), Springer 2. K.P. Murphy, Machine Learning: a Probabilistic Perspective (expected 2012), MIT Press 3. D. Barber, Bayesian Reasoning and Machine Learning (2012), Cambridge University Press 4. T. Hastie, R. Tibshirani, and J. Friedman (2003), The Elements of Statistical Learning, Springer Verlag 5. D. MacKay, Information Theory, Inference, and Learning Algorithms (2003), Cambridge University Press 6. R.O. Duda, P.E. Hart, and D.G. Stork, Pattern Classification (2nd ed. 2001), Willey-Interscience 7. T.M. Mitchell, Machine Learning (1997), McGraw-Hill
10	**Comment**

1.1.2.17 Integrated Methods of Graphics and Vision

Module name 3D Scanning & Motion Capture					
Module nr. 20-00-1180	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Ph. D. Jan Peters		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1180-iv	3D Scanning & Motion Capture	0	Integrated course	4

2 Teaching content

The lecture and exercises will cover 3D reconstruction from various input modalities (Webcams, RGB-D cameras (Kinect, Realsense, ...). It will start with basic concepts of what is 3D, the different representations, how to capture 3D and how the devices and sensors function. Based on this introduction, rigid and non-rigid tracking and reconstruction will be discussed. Specialized face and body tracking methods will be covered and the applications of the 3D reconstruction and tracking will be shown. In addition to the 3D surface reconstruction, techniques for appearance modelling and material estimation will be shown.

- Basic concepts of geometry (Meshes, Point Clouds, Pixels & Voxels)
- RGB and Depth Cameras (Calibration, active/passive stereo, Time of Flight (ToF), Structured Light, Laser Scanner, Lidar)
- Surface Representations (Polygonal meshes, parametric surfaces, implicit surfaces (Radial basis functions, signed distance functions, indicator function), Marching cubes)
- Overview of reconstruction methods (Structure from Motion (SfM), Multi-view Stereo (MVS), SLAM, Bundle Adjustment)
- Rigid Surface Tracking & Reconstruction (Pose alignment, ICP, online surface reconstruction pipeline (KinectFusion), scalable surface representations (VoxelHashing, OctTrees), loop closures and global optimization)
- Non-rigid Surface Tracking & Reconstruction (Surface deformation for modeling, Regularizers: ARAP, ED, etc., Non-rigid surface fitting: e.g., non-rigid ICP. Non-rigid reconstruction: DynamicFusion/VolumeDeform/KillingFusion)
- Face Tracking & Reconstruction (Keypoint detection & tracking, Parametric / Statistical Models -> BlendShapes)
- Body Tracking & Reconstruction (Skeleton Tracking and Inverse Kinematics, Marker-based motion capture)
- Material capture (Lightstage, BRDF estimation)
- Outlook DeepLearning-based tracking

3 Learning objectives

After successful completion of the module students have a basic understanding of 3D capturing devices and underlying principles (active vs. passive stereo, ToF etc.), modelling of geometry and conversion between different representations, principles of static reconstruction (fusion, ICP) and non-rigid reconstruction using deformation priors. They will hab a basic understanding of specialized class-specific tracking (face, body, hands) and their applications.

4 Prerequisite for participation

	Recommended: - "Algorithms and Data Structures" - "Graphical Data Processing I" - Knowledge of fundamentals from higher mathematics - Knowledge about basics of Deep Learning - Programming knowledge in C / C++
5	**Form of examination** Course related exam: • [20-00-1180-iv] (Technical examination, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).
6	**Prerequisite for the award of credit points** Pass exam (100%).
7	**Grading** Course related exam: • [20-00-1180-iv] (Technical examination, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name					
Ambient Intelligence					
Module nr. 20-00-0390	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0390-iv	Ambient Intelligence	0	Integrated course	4

2 Teaching content

The course will provide an overview of a new vision for Human-Computer-Interaction (HCI) in which people are surrounded by intelligent and intuitive interfaces embedded in the everyday objects around them. In specific the course addresses the emergence of Ambient Mobility and the ubiquitous, pervasive information access, retrieval and display on mobile devices. It will focus on understanding enabling technologies and studying applications and experiments, and, to lesser extent, it will adress the sociocultural impact. Additional topics of the lecture include system architectures for distributed systems, context awareness and management, user models and their implications, sensing and interaction in smart environments. The lecture discusses recent topics and research projects in the domain of Ambient Intelligence.

3 Learning objectives

After successfully attending the lecture, the students will be able to describe technology trends and research results in the domain of Ambient Intelligence. The most important concepts to create smart environments - intelligent networks and objects, technologies for mobile, augmented reality, ubiquitous and pervasive information spaces, nomadic communications, real-time communication and related middle ware, embedded systems, sensor networks and wearable computing - can be discussed and classified. After completing the practical part, students will be able to plan and realize the different project phases required to develop an Ambient-Intelligence solution.

4 Prerequisite for participation

Master-Students
Participation in lecture “Visual Computing“ and „Multimodale Interaktion mit intelligenten Umgebungen“

5 Form of examination

Course related exam:
- [20-00-0390-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0390-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Will be given according to actual topics.
10	**Comment**

Module name Augmented Vision					
Module nr. 20-00-0160	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0160-iv	Virtual and Augmented Reality	0	Integrated course	4

2 Teaching content

This course starts to detail the principal concepts of Augmented and Virtual Reality in relation to Computer Graphics and Computer Vision. Starting from here basic principles, methods, algorithms as well as relevant standards are discussed. This includes
- VR/AR specific requirements and interfaces
- Interaction technologies (e.g. interaction with range camera technologies)
- Rendering technologies (in particular real-time rendering)
- Web-based VR and AR
- Computer-Vision-based Tracking
- Augmented Reality with range camera technologies
- Augmented Reality on smartphone platforms

The technologies will be illustrated and discussed with the results of actual research projects including in application fields „AR-maintenance support“ and „AR/VR based Cultural Heritage presentation“.

3 Learning objectives

After successfully attending the course, students are familiar with the challenges and the requirements of Virtual and Augmented reality applications. They know the standards used for the specification of VR/AR-applications. In particular, the students understand the potential of Computer Vision based tracking and they can decide which methods can be applied in with environment.

4 Prerequisite for participation

Grundlagen der Graphischen Datenverarbeitung (GDV)

5 Form of examination

Course related exam:
- [20-00-0160-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0160-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
9	**References** Dörner, R., Broll, W., Grimm, P., Jung, B. Virtual und Augmented Reality (VR / AR)
10	**Comment**

Module name Capturing Reality					
Module nr. 20-00-0489	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0489-iv	Capturing Reality	0	Integrated course	4

2 Teaching content

This course covers a broad range of techniques to capture and model our world with a focus on application in computer graphics and computer vision. This includes:
- basic tools and calibration techniques required in capturing applications
- capturing and modeling techniques for various object properties (such as geometry and reflectance)
- basic set of relevant mathematical modeling and optimization techniques
- implementation and practical application of several techniques

3 Learning objectives

After successful completion of the course, students are able to analyze digitization and modeling problems for objects and scenes in computer graphics and computer vision as well as the underlying techniques. They are able to develop new setups, perform experiments and evaluate the results.

4 Prerequisite for participation

Recommended:
Participation in lecture Graphische Datenverarbeitung I or Computer Vision I
Basic knowledge in C/C++

5 Form of examination

Course related exam:
- [20-00-0489-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0489-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

	Noriko Kurachi: The Magic of Computer Graphics. A K Peters/CRC Press Richard Szeliski: Algorithms and Applications, Springer Marcus Magnor, Oliver Grau, Olga Sorkine-Hornung, Christian Theobalt: Digital Representations of the Real World: How to Capture, Model, and Render Visual Reality Wolfgang Förstner, Bernhard P. Wrobel: Photogrammetric Computer Vision - Geometry, Orientation and Reconstruction
10	**Comment**

Module name Geometric Algebra Computing					
Module nr. 20-00-0490	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner**		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-0490-iv	Geometric Algebra Computing	0	Integrated course	4
2	**Teaching content** Geometric Computing based on a geometrically intuitive algebra.				
3	**Learning objectives** Use of a new math. System in engineering ares like visual computing and robotics.				
4	**Prerequisite for participation** HCS				
5	**Form of examination** Course related exam: • [20-00-0490-iv] (Technical examination, Oral/written examination, Default RS)				
6	**Prerequisite for the award of credit points** Passing the final module examination				
7	**Grading** Course related exam: • [20-00-0490-iv] (Technical examination, Oral/written examination, Weighting: 100 %)				
8	**Usability of the module**				
9	**References**				
10	**Comment**				

Module name					
Hands-On HCI					
Module nr. 20-00-1116	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Arjan Kuijper		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1116-iv	Hands-On HCI	0	Integrated course	4

2 Teaching content

You might have previously heard of or even tried out virtual/augmented reality, 3D printing, wearable or tangible user interfaces. The area of Human-Computer Interaction covers all these exciting topics and offers an opportunity to build new prototypes and try them out with people in the user studies. If you would like to better connect theory and practice in the area of Human-Computer Interaction (HCI), then the course of Hands-On Human-Computer Interaction (Hands-On HCI) is for you. The goal of the class is to walk you through the whole research cycle in HCI. It can play a great preparation role for your future bachelor/master thesis in HCI or lay a first brick in your academic path after finishing your studies.

3 Learning objectives

After completing the module, students can

- differentiate between and apply three approaches to HCI research.
- distinguish three types of empirical research.
- effectively read a scientific publication.
- differentiate between types of HCI contributions.
- Formulate and define research questions, hypotheses and experimental variables.
- create a suitable study design based on the previously developed research questions.
- conduct a study using quantitative and qualitative methods to collect data.
- Analyze, evaluate and interpret quantitative data on the basis of statistical methods.
- Analyze and interpret qualitative data on the basis of grounded theory.
- Understand the peer review process and write reviews for a scientific publication.
- Understand and apply evaluation techniques with and without users.
- Write the knowledge gained as a scientific publication and present it to a specialist audience.

4 Prerequisite for participation

Recommended: Human-Computer Interaction (TK2)

5 Form of examination

Course related exam:

- [20-00-1116-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.
Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1116-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name					
Information Visualization and Visual Analytics					
Module nr. 20-00-0294	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0294-iv	Information Visualization and Visual Analytics	0	Integrated course	4

2 Teaching content

This lecture will give a detailed introduction to the scientific topics of information visualization and Visual Analytics, and will cover current research areas as well as practical application scenarios of Visual Analytics.
• Overview of information visualization and Visual Analytics (definitions, models, history)
• Data representation and data transformation
• Mapping of data to visual structures
• Introduction to human cognition
• Visual representations and interaction for bivariate and multivariate Data, time series, networks and geographic data
• Basic data mining techniques
• Visual Analytics - Analytics reasoning - Data mining - Statistics Analytical techniques and scaling
• Evaluation of Visual Analytics Systems

3 Learning objectives

After successfully attending the course, students will be able to
• use information visualization methods for specific data types
• design interactive visualization systems for data from various application domains
• couple visualization and automated methods to solve large-scale data analysis problems
• apply knowledge about key characteristics of the human visual and cognitive system for information visualization and visual analytics
chose evaluation methods are used for specific situations and scenarios

4 Prerequisite for participation

Interesse an Methoden der Computergrafik und Visualisierung

Die Veranstaltung richtet sich an Informatiker, Wirtschaftsinformatiker, Mathematiker in Bachelor, Master und Diplomstudiengänge und weiteren interessierten Kreisen (z.B. Biologen, Psychologen).

5 Form of examination

Course related exam:
- [20-00-0294-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0294-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
9	**References** Will be announced in lecture, an example might be: C. Ware: Information Visualization: Perception for Design Ellis et al: Mastering the Information Age
10	**Comment**

Module name					
Interaction in Virtual and Augmented Reality					
Module nr. 20-00-1147	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. Arjan Kuijper		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1147-iv	Interaction in Virtual and Augmented Reality	0	Integrated course	4

2 Teaching content

This course offers an introduction to augmented and virtual realities from a human-centered perspective. The focus is less on computer graphics specific issues (e.g. rendering) but on understanding human-computer interaction specific problems. The course includes an introduction to the basic concepts of AR/VR and introduces methods and techniques to design and implement interactive applications. The material will be presented and reviewed using recent research results from conferences (CHI, UIST, IEEE VR, ISMAR, SIGGRAPH).

The format of the course consists of 2 semester hours of lecture and 2 semester hours of labs. The lecture will focus on the following topics:
- History of AR/VR
- Current technologies in AR/VR
- AR/VR and human perception
- Challenge of input
- Challenge of haptics
- Interaction design for AR/VR
- Application scenarios for AR/VR
- Current research questions and challenges

3 Learning objectives

After attending the course, students will be able to
- Be able to explain and apply the fundamentals of human perception used for AR and VR technology.
- understand which metrics are important in AR and VR applications (e.g., presence, immersion, embodiment, simulator sickness) and how to control them
- be able to evaluate and explain why certain concepts (interaction, haptics, presentation) work well or not so well in AR/VR
- understand which current technologies exist in AR/VR and what they can be used for
- understand current research questions in the field of HCI and AR/VR
- can independently implement and evaluate a VR application in Unity

4 Prerequisite for participation

Recommended: Fundamentals of Human-Computer Interaction (TK2: HCI)
Good programming skills in an object-oriented programming language (e.g. Java, C#)

5 Form of examination

Course related exam:
- [20-00-1147-iv] (Technical examination, Special form, Default RS)

Software development (optional: including documentation and submission of source code), colloquium, portfolio

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

	Course related exam: • [20-00-1147-iv] (Technical examination, Special form, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name Visualization in Medicine					
Module nr. 20-00-0467	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0467-iv	Medical Visualization	0	Integrated course	4

2 Teaching content

Medical Image Data; Image Processing; Medical Visualization with VTK; Indirect Volume Visualization; Direct Volume Visualization; Transfer Functions; Interactive Volume Visualization; Illustrative Rendering; Example: Visualization of Tensor Image Data; Example: Visualization of Tree Structures; Example: Virtual Endoscopy; Image-guided Surgery

3 Learning objectives

After successfully attending the course, students are familiar with volume visualization techniques. They understand the necessity of image enhancement for the visualization. They can use the "Visualization Toolkit" (VTK) to apply the techniques to implement computing systems for the visualization of medical image data for diagnosis, planning and therapy.

4 Prerequisite for participation

Useful but not mandatory: GDV I, (Medical) Image processing

5 Form of examination

Course related exam:
- [20-00-0467-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0467-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

Preim, Botha: Visual Computing for Medicine

10 Comment

Module name Serious Games					
Module nr. 18-de-2050	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Summer term
Language German/English			**Module owner** PD Dr.-Ing. Stefan Göbel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
18-de-2050-vl	Serious Games	0	Lecture	3
18-de-2050-ue	Serious Games	0	Practice	1

2 Teaching content

Introduction to the topic of ""Serious Games"": scientific and technical foundations, application areas and trends. Individual lectures include:

- Introduction to Serious Games
- Game Development, Game Design
- Game Technology, Tools and Engines
- Personalization and Adaptation
- Interactive Digital Storytelling
- Authoring and Content Generation
- Multiplayer Games
- Game Interfaces and Sensor Technology
- Effects, Affects and User Experience
- Mobile Games
- Serious Games Application Domains and Best Practice Examples

The exercise consists of theoretical and practical parts. Students are taught how to use a Game Engine.

3 Learning objectives

After successfully completing this course the students are able to explain the concept of "Serious Games" and can transfer it to different application domains (like education or health). They can describe the general approach for developing computer games and can apply basic principles of game design, personalisation / adaptation and interactive digital storytelling. Aside from that students are able to sketch out other current research questions regarding Serious Games as well as their solutions.

4 Prerequisite for participation

5 Form of examination

Module exam:

- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 8 students register, the examination will be an oral examination (duration: 30 min.). The type of examination will be announced in the beginning of the lecture.

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Module exam:

- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Will be given in lecture.
10	**Comment**

Module name User-Centered Design in Visual Computing					
Module nr. 20-00-0793	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0793-iv	User-Centered Design in Visual Computing	0	Integrated course	2

2 Teaching content

Developing user-centered software leads to a more efficient usage and increases the acceptance by the human user. The higher acceptance leads to a better dissemination and exploitation of the developed solutions. The lecture “User Centered Design in Visual Computing” aims at enabling students from the department of computer science to acquire knowledge about models, methods, and techniques for user-centered development of visualizations and interactive visual representations. This course will introduce methods that lead to designing more efficient solutions with higher acceptance. Furthermore, the lecture will explain evaluation methods that allow measuring acceptance and efficiency. User Centered Design introduces the mentioned topics with a special focus on visual computing and graphical user interfaces.

Content:

- Usability
- User experience
- Task analysis
- User interfaces
- Interaction design
- Prototyping
- Graphics design and information visualization
- Evaluation during and after software development
- Applications and examples

3 Learning objectives

After a successful participation, students will be able to:

- Identify and argue about adequate methods for developing user-centered software
- Apply techniques for user-centered visual interfaces
- Identify and choose adequate evaluation methods for the chosen techniques in the different stages of software development
- Recommend improvements for information acquisition and navigation based on studies and evaluations

4 Prerequisite for participation

- Basics of visual computing, as e.g. taught in the introductory course HCS and in the course GDV I

5 Form of examination

Course related exam:

- [20-00-0793-iv] (Technical examination, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0793-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT M.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References**
10	**Comment**

Study-related Achievements

1.1.2.18 Seminars

Module name 3D Animation & Visualization					
Module nr. 20-00-0216	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0216-se	3D Animation & Visualization	0	Seminar	2

2 Teaching content

This seminar focuses on current research topics and the latest results in the areas of physically-based simulation, animation, real-time rendering and visualization.
- participants independently familiarize themselves with the assigned seminar topic by working with the provided scientific papers (usually texts written in English)
- classification and interpretation of the gathered research results
- preparation of a textual summary and a slide-based presentation on the subject
- presentation in front of an audience with mixed prior knowledge on the topic and discussion

3 Learning objectives

Successful participation in the course enables students to get expertise by working with scientific papers. They can extract the essential aspects of the examined works and are able to concisely present them as textual form and presentation, targeting an audience with mixed prior experience on the subject. The students are able to actively participate in a scientific discussion on the presented topics.

4 Prerequisite for participation

GDV I, (GDV II)

5 Form of examination

Course related exam:
- [20-00-0216-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0216-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
9	**References** Selected articles from ACM SIGGRAPH, EUROGRPAHICS, IEEE and similar Conferences. All articles are written in English.
10	**Comment**

Module name					
Current Trends in Medical Computing					
Module nr. 20-00-0468	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0468-se	Aktuelle Trends im Medical Computing	0	Seminar	2

2 Teaching content

- Participants independently familiarize themselves with a chosen seminar topic by working with the provided initial scientific papers (usually English-language texts)
- Deeper and/or wider library research originating from the initially provided papers
- Critical discussion of the provided topic
- Preparation of a presentation (written text and slides) about the topic
- Giving a talk in front of a heterogenous (mixed prior knowledge) audience
- Interactive discussion after the presentation
- Medical application areas include oncology, orthopedics and navigated surgery.

Learning about methods related to medical image processing: segmentation, registration, visualization, simulation, navigation, tracking and others.

3 Learning objectives

Successful participation in the course enables students to become acquainted with an unfamilar topic by working with scientific papers. They recognize the essential aspects of the examined works and are able to concisely present them to an audience with mixed prior knowledge on the subject. They apply a number of presentation techniques in the process. The students are able to actively guide and participate in a scientific discussion on the presented topic.

4 Prerequisite for participation

Bachelor from 4. Semester or Master students.

5 Form of examination

Course related exam:

- [20-00-0468-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0468-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Will be announced in seminar.
10	**Comment**

<table>
<tr><td colspan="6">Module name
Reinforcement Learning Algorithms and Platforms</td></tr>
<tr><td>Module nr.
20-00-1050</td><td>Credit points
3 CP</td><td>Workload
90 h</td><td>Self-study
60 h</td><td>Module duration
1 Term</td><td>Module cycle
Every 2. Semester</td></tr>
<tr><td colspan="3">Language
English</td><td colspan="3">Module owner
Prof. Dr. techn. Johannes Fürnkranz</td></tr>
</table>

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-1050-se	Reinforcement Learning Algorithms and Platforms	0	Seminar	2

2 Teaching content

This seminar will cover learning methods and their application in intelligent technical systems. In the context of this seminar, students will train the ability to write a scientific article and present its content similar as at scientific conference.

3 Learning objectives

Upon completion of this class, students can follow ongoing work in reinforcement learning and can do a literature review for a research project in this research area.

4 Prerequisite for participation

Simultaneous Participation in "Reinforcement Learning: From Foundations to Deep Approaches" or previous participation in "Robot Learning."

5 Form of examination

Course related exam:
- [20-00-1050-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1050-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Applied Topics in Computer Graphics					
Module nr. 20-00-0724	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0724-se	Applied Topics in Computer Graphics	0	Seminar	2

2 Teaching content

Selected papers from the following fields of computer graphics:
- Visualization / Rendering
- Simulation
- Geometry processing and modeling
- Semantics and 3D

3 Learning objectives

After successfully completing the course, students know selected current topics in computer graphics. They are able to independently analyze the content of a scientific publications, to understand and to present the problem as well as the proposed solution. Furthermore, they can analyze and present directions for further improvements in the area.

4 Prerequisite for participation

Prior knowledge of GDV or geom. methods of CAD/CAE is advantageous

5 Form of examination

Course related exam:
- [20-00-0724-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0724-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

Will be given in seminar.

10 Comment

Module name					
Computer-aided planning and navigation in medicine					
Module nr. 20-00-0677	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Georgios Sakas		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0677-se	Computer-aided planning and navigation in medicine	0	Seminar	2

2 Teaching content

- Participants independently familiarize themselves with a chosen seminar topic by working with the provided initial scientific papers (usually English-language texts)
- Deeper and/or wider library research originating from the initially provided papers
- Critical discussion of the provided topic
- Preparation of a presentation (written text and slides) about the topic
- Giving a talk in front of a heterogenous (mixed prior knowledge) audience
- Interactive discussion after the presentation

Learning about methods related to planning and navigation are: segmentation, registration, visualization, simulation, navigation, tracking and others.

3 Learning objectives

Successful participation in the course enables students to become acquainted with an unfamilar topic by working with scientific papers. They recognize the essential aspects of the examined works and are able to concisely present them to an audience with mixed prior knowledge on the subject. They apply a number of presentation techniques in the process. The students are able to actively guide and participate in a scientific discussion on the presented topic.

4 Prerequisite for participation

Bachelors: >=4th semester
Masters: >=1st semester

5 Form of examination

Course related exam:

- [20-00-0677-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0677-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Will be given in seminar.
10	**Comment**

Module name Extended Seminar - Systems and Machine Learning					
Module nr. 20-00-1057	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 75 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1057-se	Extended Seminar - Systems and Machine Learning	0	Seminar	3

2 Teaching content

This seminar serves the purpose of discussing new research papers in the intersection of hardware/software-systems and machine learning. The seminar aims to elicit new connections amongst these fields and discusses important topics regarding systems questions machine learning including topics such as hardware accelerators for ML, distributed scalable ML systems, novel programming paradigms for ML, Automated ML approaches, as well as using ML for systems.

Every participant will present one research paper, which will be subsequently discussed by all participants. In addition, summary papers will be written in groups and submitted to a peer review process. The papers will typically be recent publications in relevant research venues and journals.

The seminar will be offered as a block seminar. Further information can be found at: http://binnig.name

3 Learning objectives

After this seminar, the students should be able to
- understand a new research contribution in the areas of the seminar
- prepare a written report and present the results of such a paper in front of an audience
- participate in a discussion in the areas of the seminar
- to peer-review the results of other students

4 Prerequisite for participation

Basic knowledge in Machine Learning, Data Management, and Hardware-/Software-Systems.

5 Form of examination

Course related exam:
- [20-00-1057-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1057-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B. Sc Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Advanced Topics in Computer Vision and Machine Learning					
Module nr. 20-00-0645	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0645-se	Advanced Topics in Computer Vision and Machine Learning	0	Seminar	2

2 Teaching content

- Basics of scientific presentations and reviewing
- Independent familiarization with current publications in computer vision or machine learning (in English)
- Further research on background literature, with help from a mentor
- Preparation of a two-part slide presentation (problem statement and proposed solution) of one publication, with feedback from mentor
- Writing a scientific “mock” review of another publication, with aid from mentor
- Giving the presentation in front of a mixed audience
- Guiding the interactive discussion after both presentation parts
- Active participation in discussions, including feedback to presenters

3 Learning objectives

After successfully completing the seminar, students are able to use recent scientific publications to become acquainted with current topics in computer vision and/or machine learning in an independent fashion. They can recognize the key contributions of the publications and are able to present them to a heterogeneous audience, taking into account good practices of scientific presentation. They can direct a scientific discussion following the presentation. Moreover, they are able to author a scientific review following common standards of the scientific review process.

4 Prerequisite for participation

Teilnehmer sollten Grundkenntnisse in Computer Vision, sowie idealerweise maschinellem Lernen besitzen (z.B. durch Besuch von Computer Vision I, Maschinelles Lernen: Statistische Verfahren I).

5 Form of examination

Course related exam:

- [20-00-0645-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0645-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Actual publications, mostly last year.
10	**Comment**

Module name Advanced Topics in Computer Graphics					
Module nr. 20-00-0604	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0604-se	Advanced Topics in Computer Graphics	0	Seminar	2

2 Teaching content

- Basics of scientific presentations and reviewing
- Independent familiarization with current publications in computer graphics (in English)
- Further research on background literature, with help from a mentor
- Preparation of a two-part slide presentation (problem statement and proposed solution) of one publication, with feedback from mentor
- Writing a scientific "mock" review of another publication, with aid from mentor
- Giving the presentation in front of a mixed audience
- Guiding the interactive discussion after both presentation parts
- Active participation in discussions, including feedback to presenters

3 Learning objectives

After successfully completing the seminar, students are able to use recent scientific publications to become acquainted with current topics in computer graphics in an independent fashion. They can recognize the key contributions of the publications and are able to present them to a heterogeneous audience, taking into account good practices of scientific presentation. They can direct a scientific discussion following the presentation. Moreover, they are able to author a scientific review following common standards of the scientific review process.

4 Prerequisite for participation

Basics in Computer Graphics (e.g. as given in lecture Graphische Datenverarbeitung I).

5 Form of examination

Course related exam:

- [20-00-0604-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0604-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Publications, most from last year.
10	**Comment**

Module name					
Intelligent Robotic Manipulation: Part II					
Module nr. 20-00-1168	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1168-se	Intelligent Robotic Manipulation: Part II	0	Seminar	2

2 Teaching content

This advanced seminar introduces fundamental algorithms for creating robot systems that can autonomously perceive and manipulate objects in unstructured environments like homes, restaurants, supermarkets, etc. It addresses the complex and timely challenge of understanding and developing intelligent robotic manipulation. The seminar will discuss fundamental methods in perception (including approaches based on deep learning and approaches based on 3D geometry), planning (robot kinematics and trajectory generation, collision-free motion planning, task-and-motion planning, and planning under uncertainty), and dynamics and control (mainly force control and its variants).

The seminar will contain a combination of introductory lectures and a reading group to discuss and learn about advanced algorithmic approaches in robotics. After an introductory lecture, small groups of students (or individuals) will be assigned a research paper that is fundamental for each topic (depending on the class size, there might be an alternating style). The students shall present the basic concept of the paper in class and engage in discussion regarding the presented topics.

Possibly, a specific theme will be selected every semester, that will be announced by the lecturer in Moodle.

List of topics (non-exhaustive):

- Refresher on kinematics and dynamics
- Pick-and-place pipeline
- Object pose estimation
- Grasp generation
- Robot force control (stiffness, impedance, admittance)
- Sampling-based motion planning
- Trajectory Optimization
- Task and Motion Planning
- Mobile Manipulation
- Human-Robot Interaction

3 Learning objectives

Students have the chance to gain knowledge in advanced topics in Robotics, AI and Learning. By presenting high-end robotics research papers, the students learn how to communicate effectively scientific topics, and they also will learn how to collaborate with their colleagues for preparing their presentation.

4 Prerequisite for participation

Recommended:
The students should have fundamental knowledge in robotics, and linear algebra. Furthermore, Fundamentals of Robotics (20-00-0735-iv Grundlagen der Robotik) is recommended.

5 Form of examination

	Course related exam: • [20-00-1168-se] (Study achievement, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible: Colloquium (optional: including presentation), Term Paper.
6	**Prerequisite for the award of credit points** Pass exam (100%).
7	**Grading** Course related exam: • [20-00-1168-se] (Study achievement, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
9	**References**
10	**Comment**

Module name					
Seminar Data Mining and Machine Learning					
Module nr. 20-00-0102	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0102-se	Seminar Data Mining and Machine Learning	0	Seminar	2

2 Teaching content

This seminar serves the purpose of discussing new research papers in the areas of data mining and machine learning. Every participant will present one paper, which will be subsequently discussed by all participants. Grades are based on the preparation and presentation of the paper, as well as the participation in the discussion, in some cases also a written report.

The papers will typically recent publications in relevant journals such as "Data Mining and Knowledge Discovery", ""Machine Learning"", as well as ""Journal of Machine Learning Research"". Students may also propose their own topics if they fit the theme of the seminar.

Please note current announcements to this course at http://www.ke.informatik.tu-darmstadt.de/lehre.

3 Learning objectives

After this seminar, students should be able to
- understand an unknown text in the area of machine learning
- work out a presentation for an audience proficient in this field
- make useful contributions in a scientific discussion in the area of machine learning

4 Prerequisite for participation

Basic knowledge in Machine Learning and Data Mining

5 Form of examination

Course related exam:
- [20-00-0102-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0102-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

9	**References**
10	**Comment**

Module name Serious Games Seminar					
Module nr. 20-00-0328	**Credit points** 4 CP	**Workload** 120 h	**Self-study** 90 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0328-se	Serious Games Seminar	0	Seminar	2

2 Teaching content

In this seminar the students will analyze and discuss the current state of the art for serious games (e.g. in education, health and sports).

The topics relate to current research questions in the field, partly in cooperation with partners from the games industry and/or Serious Games users.

3 Learning objectives

After successfully completing this course the students are able to become acquainted with an unfamiliar subject in the field of "Serious Games". They are familiar with library research techniques for scientific papers and industry sources. The techniques and results mentioned in these references can be summarized, assessed and compared to each other. Besides, the students are able to present their findings in front of an audience applying a number of different presentation techniques and to actively participate in a scientific discussion on their topic.

4 Prerequisite for participation

5 Form of examination

Course related exam:
- [20-00-0328-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0328-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

10 Comment

Module name					
Scale Space and PDE methods in image analysis and processing					
Module nr. 20-00-0469	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0469-se	Scale space and PDE methods in image analysis and processing	0	Seminar	2

2 Teaching content

Image analysis & processing deals with the investigation of images and the application of specific tasks on them, like enhancement, denoising, deblurring, and segmentation. In this course, mathematical methods that are commonly used are presented and discussed. The focus will be on the axiomatic choice for the models, their mathematical properties, and their practical use.
Some key words:
- Filtering (Edge detection, enhancement, Wiener, Fourier, ...)
- Images & Observations: Scale space, regularisation, distributions
- Objects: Differential structure, invariants, feature detection
- Deep structure: Catastrophes & multi-scale hierarchy
- Variational Methods & Partial Differential Methods: Perona Malik, anisotropic diffusion, total variation, Mumford-Shah, Chan-Vese, geometric PDEs, level sets
- Curve Evolution: Normal motion, mean curvature motion, Euclidean shortening flow.

3 Learning objectives

After successful participation in the course students are able to describe the foundational mathematical concepts as well as the basic models and methods of image analysis and processing. They explain important approaches for scale space and PDE methods and can evaluate, transfer, and explain representative technical papers.

4 Prerequisite for participation

Da Bildanalyse und -verarbeitung eine Mischung aus verschiedenen Disziplinen, wie Physik, Mathematik, Vision, Informatik und Engineering, ist, ist dieser Kurs gezielt auf ein breites Publikum zugeschnitten. Daher werden nur Grundkenntnisse in Analysis angenommen. Weitere notwendige mathematische Werkzeuge werden in den Sitzungen skizziert.

5 Form of examination

Course related exam:
- [20-00-0469-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0469-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Main: - B. M. ter Haar Romeny, Front-End Vision and Multi-scale Image Analysis, Dordrecht, Kluwer Academic Publishers, 2003. Recommended: - T. Lindeberg: Scale-Space Theory in Computer Vision, Dordrecht, Kluwer Academic Publishers, 1994. - J. Weickert: Anisotropic Diffusion in Image Processing, Teubner-Verlag, Stuttgart, Germany, 1998. G. Aubert & P. Kornprobst: Mathematical problems in image processing: Partial Differential Equations and the Calculus of Variations (second edition), Springer, Applied Mathematical Sciences, Vol 147, 2006.
10	**Comment**

Module name Visual Analytics: Interactive Visualization of Very Large Data					
Module nr. 20-00-0268	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0268-se	Visual Analytics: Interactive Visualization of very large amounts of data	0	Seminar	2

2 Teaching content

This seminar is targeted at computer science students with an interest in information visualization, in particular the visualization of extremely large data. Students will analyze and present a topic from visual analytics. They will also write a paper about this topic.

3 Learning objectives

After successfully completing the course, students are able to analyze and understand a scientific problem based on the literature. Students are able to present and discuss the topic.

4 Prerequisite for participation

Interesse sich mit einer graphisch-analytischen Fragestellung bzw. Anwendung aus der aktuellen Fachliteratur zu befassen. Vorkenntnisse in Graphischer Datenverarbeitung, Informationssysteme oder Informationsvisualisierung

5 Form of examination

Course related exam:
- [20-00-0268-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0268-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

9 References

10 Comment

Module name Visual trend analysis					
Module nr. 20-00-0542	**Credit points** 3 CP	**Workload** 90 h	**Self-study** 60 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0542-se	Visual trend analysis	0	Seminar	2

2 Teaching content

Participants independently familiarize themselves with a scientific topic in the area of Visual Analytics, Trend Analytics and Visual Trend Analysis

This includes:

* self-dependent literature research and review, assisted by the advisor
* classification and interpretation of the gathered research results
* writing independently a document in a scientific paper format about the chosen topic (German or English), assisted by the advisor
* preparing independently a presentation of their results, assisted by the advisor
* giving the presentation in front of experts in their field
* discussing the results after the presentation

Participants will get immediately feedback to their presentation, talk and discussion (rhetoric, presentation techniques)

3 Learning objectives

Successful participation in the course enables students to become acquainted with an unfamiliar subject by working with scientific papers and writing down the outcomes in a scientific way. They learn various techniques for literature research and different sources for searching literature. This enables them to apply the sources and techniques to further scientific works. Furthermore, the students become acquainted with recent and interesting topics from applied research projects.
In general, the students learn to research a topic from the area of Semantics Visualization, write their research results in a scientific way and present their topic in front of experts. The students are able to actively participate in a scientific discussion on the presented topics.

4 Prerequisite for participation

Recommended:
Lecture Visual Computing

5 Form of examination

Course related exam:

- [20-00-0542-se] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0542-se] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

	B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References** Will be given to actual topics.
10	**Comment**

1.1.2.19 Practical Lab in Teaching

Module name Teaching Lab on Algorithm Visualisation					
Module nr. 20-00-1036	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1036-pl	Teaching Lab on Algorithm Visualisation	0	Internship teaching	3

2 Teaching content

Within the Teaching Lab on Algorithm Visualisation, an existing algorithm visualisation system will be extended, the tasks for the associated lab will be adapted accordingly and the student submissions in the lab will be graded.

3 Learning objectives

Participants in the Teaching Lab Algorithm Visualisation improve their knowledge in the areas of visualisation, algorithms and data structures. At the same time, they also gain insights in to teaching by supervising students, grading submissions and redrafting and adapting exercises.

4 Prerequisite for participation

The lab "Visualisation and Animation of Algorithms and Data Structures" (lecture ID 20-00-0344-pr) or an equivalent offer has to be finished successfully before taking this lab, to show that the applicant possesses sufficient skills and knowledge for the Teaching Lab.

5 Form of examination

Course related exam:

- [20-00-1036-pl] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1036-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name Computer Graphics I - Teaching L ab					
Module nr. 20-00-1101	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner**		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-1101-pl	Computer Graphics I - Teaching Lab	0	Internship teaching	3
2	**Teaching content** Preparing teaching material, rating and supervision of exercises.				
3	**Learning objectives** Upon successful completion of the module, students will have learned the skills, to create suitable learning materials for training courses in IT topics, to critically monitor their use and also to supervise and guide the learners.				
4	**Prerequisite for participation** Recommended: • „Computer Graphics I“ with a very good final grade • Programming knowledge in C ++ and OpenGL				
5	**Form of examination** Course related exam: • [20-00-1101-pl] (Study achievement, Oral/written examination, Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Colloquium (optional: including presentation), portfolio, report (optional: including submission of course material).				
6	**Prerequisite for the award of credit points** Pass exam (100%)				
7	**Grading** Course related exam: • [20-00-1101-pl] (Study achievement, Oral/written examination, Weighting: 100 %)				
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.				
9	**References**				
10	**Comment**				

Module name Practical Lab in Teaching - Computer Graphics II					
Module nr. 20-00-0954	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0954-pl	Internship Teaching - Computer Graphics II	0	Internship teaching	3

2 Teaching content

The creation of teaching material, the rating and supervision of exercises.

3 Learning objectives

Processing and communication of the lecture content.

4 Prerequisite for participation

The content of the course „Computer Graphics II“.

5 Form of examination

Course related exam:

- [20-00-0954-pl] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0954-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs

9 References

10 Comment

Module name Practical Lab in Teaching - Information Visualization and Visual Analytics					
Module nr. 20-00-0767	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0767-pl	Internship Teaching - Information Visualization and Visual Analytics	0	Internship teaching	3

2 Teaching content

This course allows students to create the exercises for the course "Information Visualization and Visual Analytics" under the guidance of the instructors. Students furthermore teach the exercises and evaluate the knowledge gained by the participants of the lecture.

3 Learning objectives

After successfully completing the course, students are able
- to create exercises for the lecture
- to teach exercises to groups of students
- to develop a concept for practical exercises
- to apply various methods to evaluate the knowledge gained by the participants of the lecture

4 Prerequisite for participation

Information visualization and Visual Analytics

5 Form of examination

Course related exam:
- [20-00-0767-pl] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0767-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

10 Comment

Module name Practical Lab in Teaching - Visual Computing					
Module nr. 20-00-0519	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0519-pl	Praktikum in der Lehre - Visual Computing	0	Internship teaching	3

2 Teaching content

Assistance in organizing tutorials for Introduction to Human Computer Systems

3 Learning objectives

Creation and evaluation of teaching materials for courses in computer science and supervision of students.

4 Prerequisite for participation

Visul Computing

5 Form of examination

Course related exam:

- [20-00-0519-pl] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass Exam (100%)

7 Grading

Course related exam:

- [20-00-0519-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name					
Practical Lab in Teaching - Visual Inference					
Module nr. 20-00-1131	**Credit points** 5 CP	**Workload** 150 h	**Self-study** 105 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** Prof. Dr. Arjan Kuijper		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-1131-pl	Practical Lab in Teaching - Visual Inference	0	Internship teaching	3
2	**Teaching content** Creation of lab exercises and teaching material for courses of the FG Visual Inference				
3	**Learning objectives** After students have taken the module, they will be able to classify problems in exercises, evaluate them, and grade them correctly.				
4	**Prerequisite for participation** Recommended: successful participation of the lecture Computer Vision I (20-00-0157-iv) and/or Computer Vision II (20-00-0401-iv), depending on the semester.				
5	**Form of examination** Course related exam: • [20-00-1131-pl] (Study achievement, Oral examination, Duration: 15 Min., Default RS) The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Colloquium (optional: including presentation), portfolio, report (optional: including submission of course material).				
6	**Prerequisite for the award of credit points** Pass exam 100%.				
7	**Grading** Course related exam: • [20-00-1131-pl] (Study achievement, Oral examination, Weighting: 100 %)				
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.				
9	**References**				
10	**Comment**				

1.1.2.20 Labs, Project Labs, Related Courses

Module name Advanced User Interfaces					
Module nr. 20-00-0570	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0570-pr	Advanced User Interfaces	0	Internship	4

2 Teaching content

- Requirements analysis of a given problem
- Design and presentation of a user interface concept
- Implementation of a prototype

3 Learning objectives

Students have been provided insights into the principles and methods to realize multimedial, collaborative and adaptive user interfaces for a given problem.

4 Prerequisite for participation

- Interesse an neuen, innovativen Benutzungsschnittstellen
- Wünschenswert sind Grundkenntnisse der Human Computer Interaction
- gute Programmierkenntnisse (C#/WPF und/oder Java)

5 Form of examination

Course related exam:

- [20-00-0570-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0570-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

Depending on topic.

10 Comment

Module name Application of Reinforcement Learning Methods					
Module nr. 20-00-1048	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1048-pp	Application of Reinforcement Learning Methods	0	Project	6

2 Teaching content

In this project, students get hands-on experience in reinforcement learning research conducted by a team of students. Small groups of students pursue their own Reinforcement Learning experiment, involving standard platforms (Cartpole, Furuta-Pendel, etc). Starting from a project idea, students are guided by the lecturer through the whole process of developing the experiment, collecting and analyzing data and writing a research report/paper which is ready to publish.

3 Learning objectives

Hands-on introduction into Research, Designing and conducting an Experiment, potentially resulting in a first publication.

4 Prerequisite for participation

Gleichzeitige Belegung der Vorlesung "Reinforcement Learning: Von Grunlagen zu den Tiefen Ansätzen" oder vorhergehende Belegung von "Lernende Roboter."

5 Form of examination

Course related exam:
- [20-00-1048-pp] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-1048-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name					
Advanced Visual Computing Lab					
Module nr. 20-00-0537	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0537-pr	Advanced Visual Computing Lab	0	Internship	4

2 Teaching content

Students work in this lab on selected advanced topics in the area of visual computing. Project results will be presented in a talk at the end of the course. The specific topics addressed in the lab change every semester and should be discussed directly with one of the instructors.

3 Learning objectives

After successful completion of this course, the students will be able to independently analyze and solve an advanced problem in the area of visual computing and to evaluate the results.

4 Prerequisite for participation

Programming skills, e.g. Java, C++
Basic knowledge in Visula Computing
Participation in at least one basic lectures and one lab in the are of Visual Computing.

5 Form of examination

Course related exam:
- [20-00-0537-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0537-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

Will be announced in lecture.

10 Comment

Module name Creating an IT-Start-Up					
Module nr. 20-00-1016	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1016-pr	Creating an IT-Start-Up	0	Internship	4

2 Teaching content

Introduction to methods for the development and implementation of innovative business models. Learning of tools for different process steps. Pratical examples are presented and discussed.

Get familiar with the tools while working on a self selected business model. Presentation of the results after each step during the preparation of the business model.

3 Learning objectives

After successful completion of the course, students are able to understand the principle components and the creation of a business plan. They are able to identify and work on the relevant issues for the creation of business plans for innovative business models.

4 Prerequisite for participation

- Software Engineering
- Bachelor Praktikum

5 Form of examination

Course related exam:

- [20-00-1016-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-1016-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik

9 References

Will be given in Lab.

10 Comment

Module name Robot Learning: Integrated Project - Part 1					
Module nr. 20-00-0753	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Courses of this module**

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0753-pj	Robot Learning: Integrated Project - Part 1	0	Project	4

2	**Teaching content** In "Robot Learning: Integrated Project, Part 1", students will pose a current research problem in the domain of robot learning with assistance of their advisor. The students will select a robot learning topic to fit their research interests, on which they will pursue in-depth literature studies. Using these results, they will develop a plan for their project, try out the algorithms of interest and implement a prototype in simulation.
3	**Learning objectives** Upon successful completion of this course, students will be able to independently develop small research projects in the domain of robot learning and test first research ideas in simulation.
4	**Prerequisite for participation** Previous or concurrent participation in the lecture "Robot Learning".
5	**Form of examination** Course related exam: • [20-00-0753-pj] (Study achievement, Oral/written examination, Default RS)
6	**Prerequisite for the award of credit points** Pass exam (100%)
7	**Grading** Course related exam: • [20-00-0753-pj] (Study achievement, Oral/written examination, Weighting: 100 %)
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
9	**References**
10	**Comment**

Module name Robot Learning: Integrated Project - Part 2					
Module nr. 20-00-0754	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-0754-pj	Robot Learning: Integrated Project - Part 2	0	Project	4
2	**Teaching content** In "Robot Learning: Integrated Project, Part 2", students will complete their approach to the research problem from Part 1 and apply it to a real robot. A scientific article on the research problem, methods and results will be written and potentially submitted to a national or international scientific venue.				
3	**Learning objectives** Upon successful completion of this course, students will be able to independently develop small research projects in the domain of robot learning and test first research ideas in simulation.				
4	**Prerequisite for participation** Previous or concurrent participation in the lecture "Robot Learning".				
5	**Form of examination** Course related exam: • [20-00-0754-pj] (Study achievement, Oral/written examination, Default RS)				
6	**Prerequisite for the award of credit points** Pass exam (100%)				
7	**Grading** Course related exam: • [20-00-0754-pj] (Study achievement, Oral/written examination, Weighting: 100 %)				
8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.				
9	**References**				
10	**Comment**				

Module name Augmented & Virtual Reality Lab					
Module nr. 20-00-1166	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. Arjan Kuijper		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-1166-pr	Augmented & Virtual Reality Lab	0	Internship	4

2 Teaching content

Students are given a selection of relevant topics in the domain of augmented and virtual reality and choose one to work on. Topics vary from semester to semester and should be discussed with the teaching staff.

3 Learning objectives

After successful completion of the module, students are able to understand, analyze and work on current topics in augmented and virtual reality and evaluate their results.

4 Prerequisite for participation

Recommended:
Participation of lecture “Virtual & Augmented Reality”, as well as “Computer Vision 1”.
Programming experience in languages such as Python, Java, C++, ...

5 Form of examination

Course related exam:
- [20-00-1166-pr] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Report (optional: including submission of source code), colloquium (optional: including presentation).

6 Prerequisite for the award of credit points

Pass exam (100%).

7 Grading

Course related exam:
- [20-00-1166-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

9 References

10 Comment

Module name					
Practical Course in Artificial Intelligence					
Module nr. 20-00-0412	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0412-pr	Practical Course in Artificial Intelligence	0	Internship	4

2 Teaching content

Students have to work on a concrete practical problem in the area of artificial intelligence and solve it with the help of tools and techniques that they developed on their own or that are already publicly available.

Note the announcements on the homepage of the KE group regarding this course (http://www.ke.informatik.tu-darmstadt.de/lehre/)!
In semesters, where this course is not announced on the above pages, there is often the possibility of individual projects (please ask).

3 Learning objectives

After completion of this practical course, students should be able to
- recognize potential uses of artificial intelligence tools
- select appropriate tools for a given task and apply them to this task
- evaluate and measure the success of the use of such tools

4 Prerequisite for participation

Basic knowledge in artificial intelligence

5 Form of examination

Course related exam:
- [20-00-0412-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0412-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

10 Comment

Module name					
Visual Computing Lab					
Module nr. 20-00-0418	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr. Bernt Schiele		

1	**Courses of this module**				
	Course nr.	**Course name**	**Workload (CP)**	**Teaching form**	**HPW**
	20-00-0418-pr	Lab Visual Computing	0	Internship	4

2 Teaching content

Students work in this lab on selected topics in the area of visual computing. Project results will be presented in a talk at the end of the course. The specific topics addressed in the lab change every semester and should be discussed directly with one of the instructors.

3 Learning objectives

After successful completion of this course, the students will be able to independently analyze and solve a problem in the area of visual computing and to evaluate the results.

4 Prerequisite for participation

Practical programming skills, e.g. Java, C++
Basic knowledge or interest within Visual Computing
Participation in one basic lecture within Visiual Computing

5 Form of examination

Course related exam:

- [20-00-0418-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0418-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
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B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

Will be announced in course.

10 Comment

<table>
<tr><td colspan="6">Module name
Practical Project Knowledge Engineering and Machine Learning</td></tr>
<tr><td>Module nr.
20-00-0919</td><td>Credit points
9 CP</td><td>Workload
270 h</td><td>Self-study
180 h</td><td>Module duration
1 Term</td><td>Module cycle
Every 2. Semester</td></tr>
<tr><td colspan="3">Language
German/English</td><td colspan="3">Module owner
Prof. Dr. techn. Johannes Fürnkranz</td></tr>
</table>

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0919-pp	Practical Project Knowledge Engineering and Machine Learning	0	Project	6

2 Teaching content

In the course of this practical project, students implement a larger, predefined task in the areas of knowledge engineering, artificial intelligence, machine learning or data mining. The topics will be defined in collaboration with their tutor.

Possible areas:
- Machine Learning and Data Mining
- Inductive Rule Learning
- Learning from Preferences
- Multilabel Classification
- Information Extraction
- Web Mining
- Semantic Web
- Game Playing

Concrete tasks will be assigned on an individual basis. The project can be started at any time.

Students that are interested in such a project, please contact a staff member of the Knowledge Engineering group (http://www.ke.tu-darmstadt.de).

3 Learning objectives

After completion of this project, students should be able to
- autonomously program larger research projects in the areas knowledge engineering, artificial intelligence, maschine learning and data mining
- conduct scientific experiments and evaluations using the implemented instruments

4 Prerequisite for participation

Basic knowledge in Knowledge Engineering, Artificial Intelligence, Data Mining and Machine Learning.
Basic knowledge in programming (e.g. Java).
Autonomous work and Interest on actual research.

5 Form of examination

Course related exam:
- [20-00-0919-pp] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0919-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

8	**Usability of the module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.	
9	**References**	
10	**Comment**	

Module name					
Project Lab Capturing Reality					
Module nr. 20-00-0764	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0764-pp	Project Lab Capturing Reality	0	Internship	6

2 Teaching content

Groups of students work in this project lab on selected large topics in capturing reality, i.e., on the boundary between computer vision and computer graphics. Project results will be presented in a talk at the end of the course. The specific topics addressed in the project lab change every semester.

3 Learning objectives

Students learn in this project lab to solve a large problem in a topic located at the boundary between graphics and vision. They are able to analyze, modify and apply current state-of-the-art techniques.

4 Prerequisite for participation

Participation in Lecture Capturing Reality is recommended
Basic skills in C/C++

5 Form of examination

Course related exam:
- [20-00-0764-pp] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0764-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

Will be given in lab.

10 Comment

Module name					
Project Lab Deep Learning in Computer Vision					
Module nr. 20-00-0980	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0980-pp	Project Lab Deep Learning in Computer Vision	0	Internship	6

2 Teaching content

In this project lab groups of students will work on selected topics in deep learning (deep neural networks) for problems in computer vision. This includes the practical implementation with modern deep learning frameworks. Results will be presented in a talk at the end of the lab. Concrete topics follow the current state of the art and change from term to term.

3 Learning objectives

Through their successful participation, students acquire in-depth knowledge on deep neural networks and their applications in computer vision. They are able to analyze, modify, and apply state-of-the-art techniques in this area. Moreover, they practice their abilities for presenting their results and for collaboration in teams.

4 Prerequisite for participation

* Solid programming skills in C/C++ or Python or Lua
* Prior or concurrent registration for "Computer Vision I"

5 Form of examination

Course related exam:

- [20-00-0980-pp] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0980-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

Module name Project Lab Programming Massively Parallel Systems					
Module nr. 20-00-0763	**Credit points** 9 CP	**Workload** 270 h	**Self-study** 180 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German/English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0763-pp	Project Lab Programming Massively Parallel Systems	0	Internship	6

2 Teaching content

Groups of students work in this project lab on selected large topics in the area of massively parallel systems (e.g., GPUs). Project results will be presented in a talk at the end of the course. The specific topics addressed in the project lab change every semester.

3 Learning objectives

After successful completion of this course the students will be able to handle large massively parallel projects which are significantly larger and more complex than the most projects encountered during their studies. They are able to analyze, modify and apply current state-of-the-art techniques.

4 Prerequisite for participation

Good knowledge of programming in C/C++
foundations of programming massively parallel systems, e.g., as taught in lecture PMPP

5 Form of examination

Course related exam:
- [20-00-0763-pp] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:
- [20-00-0763-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
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M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

Will be given in lab.

10 Comment

Module name Autonomous Driving Lab I					
Module nr. 18-su-2070	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 135 h	**Module duration** 1 Term	**Module cycle** Winter term
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
18-su-2070-pj	Autonomous Driving Lab I	0	Project seminar	3

2 Teaching content

During this module students gain practical experience in software development for embedded systems in the field of autonomous driving using a model car. In teamwork, they learn to cope with an extensive task. In order to solve this task they practice to use the theoretical knowledge available in the group (from other courses such as real-time systems, software engineering - introduction, C++ lab, digital control systems).

- Hands-on programming experience with C++ in the development of embedded software systems for autonomous driving based on a model car
- Application of control methods from the area of autonomous driving
- Application of software engineering techniques (design, documentation, test, ...) of a non-trivial embedded software system with hard real-time requirements and limited resources (memory, ...)
- Use of a given software framework and further libraries including a modular (real-time) operating system
- Hands-on experience using source code management systems, time management and other project management tools
- Presentations of the project results

3 Learning objectives

Students that have successfully participated in this module are able to organize and set-up a non-trivial software project in an interdisciplinary team according to a given problem independently. The participants acquire the following skills in detail:

- Independent familiarization with a given software framework and ready-made libraries
- Transfer of theoretic knowledge into a software system
- Extensive use of tools for version, configuration, and change management
- Realistic time and resource management (project management)
- Development of hardware/software systems with C++ considering important limitations of embedded systems
- Planning and implementation of extensive quality assurance measures
- Collaboration and communication in and between teams

4 Prerequisite for participation

Recommended:

- ETiT/DT, iST, Informatik, WI-ET/DT: Basic software technology knowledge and advanced knowledge of object-oriented programming languages (especially C++)

Additionally desired:

- Basic knowledge of the development of real-time systems or image processing
- ETiT/AUT, MEC: Basic knowledge in control engineering including state space control design, some additional basic knowledge in digital control design may be helpful

5 Form of examination

	Module exam: • Module exam (Study achievement, Oral examination, Duration: 30 Min., Default RS)
6	**Prerequisite for the award of credit points** Passing the final module examination
7	**Grading** Module exam: • Module exam (Study achievement, Oral examination, Weighting: 100 %)
8	**Usability of the module** MSc ETiT, BSc iST
9	**References** https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/ps-af-i and Moodle
10	**Comment**

Module name Serious Games Lab					
Module nr. 18-de-2060	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every Semester
Language German/English			**Module owner** PD Dr.-Ing. Stefan Göbel		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
18-de-2060-pr	Serious Games Lab	0	Internship	4

2 Teaching content

In this lab the students will design concepts and implement prototypes in the field of serious games (e.g. in education, health and sports).

The topics relate to current research questions in the field, partly in cooperation with partners from the games industry and/or Serious Games users.

3 Learning objectives

After successfully attending the course, the students can conceptualize and prototypically implement practical tasks in the context of “Serious Games”. Besides, the students are able to present their findings in front of an audience applying a number of different presentation techniques and to actively participate in a scientific discussion on their topic.

4 Prerequisite for participation

Recommended: Programming skills (depending on topic).

5 Form of examination

Module exam:

- Module exam (Study achievement, Oral/written examination, Default RS)

Report (including submission of programming code) and/or Presentation and/or Oral examination and/or Colloquium (testate), but never more than two out of it. The type of examination will be announced in the beginning of the lecture.

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Module exam:

- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

9 References

10	Comment

Module name
Serious Games Project Seminar

Module nr.	Credit points	Workload	Self-study	Module duration	Module cycle
18-de-2070	9 CP	270 h	195 h	1 Term	Every Semester

Language	Module owner
German/English	PD Dr.-Ing. Stefan Göbel

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
18-de-2070-pj	Serious Games Project Seminar	0	Project seminar	5

2 Teaching content

In this project the students will design concepts and implement prototypes in the field of serious games (e.g. in education, health and sports).

The topics relate to current research questions in the field, partly in cooperation with partners from the games industry and/or Serious Games users.

3 Learning objectives

After successfully attending the course, the students can conceptualize and prototypically implement practical tasks in the context of “Serious Games”. Additionally they acquire practical knowledge in the area of project management, which they can apply to their own topic as well as transfer it to future projects. Besides, the students are able to present their findings in front of an audience applying a number of different presentation techniques and to actively participate in a scientific discussion on their topic.

4 Prerequisite for participation

Recommended: Programming skills (the language will depended on the topic and may be chosen at will for certain topics).

5 Form of examination

Module exam:
- Module exam (Study achievement, Oral/written examination, Default RS)

Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Module exam:
- Module exam (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

B.Sc. Informatik
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M.Sc. Computational Engineering
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M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

9 References

10	Comment

Module name					
Visualization and Animation of Algorithms and Data Structures					
Module nr. 20-00-0344	**Credit points** 6 CP	**Workload** 180 h	**Self-study** 120 h	**Module duration** 1 Term	**Module cycle** Every 2. Semester
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Courses of this module

Course nr.	Course name	Workload (CP)	Teaching form	HPW
20-00-0344-pr	Visualization and Animation of Algorithms and Data Structures	0	Internship	4

2 Teaching content

The students will be enabled to create animations of algorithms and data structures to enhance the learning process. The contents will be usable for studying the topics covered and can be used in the ICS / GdI 2 lecture. The competencies gained especially include:

* Becoming familiar with a complex software system for animating algorithms and data structures
* Familiarization with a scripting language, a Java-based API and a framework for generators for creating animations.
* Design and implementation of at least two generators for algorithm or data structure animations
* Learning criteria for determining if animations support learning processes
* Creation and provision of contents ready for use in teaching and self-study
* Competent use of the CS learning platform for submitting feedback and finished tasks

3 Learning objectives

After taking part in this lab, students will be able to...

- use the provided API for animating algorithms.
- analyze a given algorithm with regard to its central elements.
- construct one visualization each for the central elements of two chosen algorithms.
- generalize the generated visualizations by an appropriate support of adjustable parameters.
- critically reflect whether the created visualization will support the learning process of the viewer.

4 Prerequisite for participation

Participants need good Java programming skills and should be familiar with the algorithms and data structures taught in ICS 2.

5 Form of examination

Course related exam:

- [20-00-0344-pr] (Study achievement, Oral/written examination, Default RS)

6 Prerequisite for the award of credit points

Pass exam (100%)

7 Grading

Course related exam:

- [20-00-0344-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

8 Usability of the module

9 References

10 Comment

1.2 Studium Generale