Module description
Master in Computer Science, PO Version of 2019 (WT)

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<td>MIN-322-01</td>
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Module MIN-301 Software Architecture

Subheading (MIN-SWA)
Level of Module Basic module
Type of Module Compulsory module
Submodules MIN-301-01 Software Architecture, Compulsory
Person in Charge Dunkel, Jürgen, Prof. Dr.
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Semester 1
Duration of Module 1 semester
Prerequisites none
Recommended Prerequisites none
Examination Examination (written or oral) and experimental work

Learning Outcomes
Technological skills: in-depth knowledge of software architecture principles and design methodologies.
Methodological competence: modeling complex software architectures with formal methods.
Analysis design and implementation competence: capability of defining the requirements and critical success factors of software architectures; applying formal methods for describing software architectures; using software architectures as basis for implementing complex software systems
Submodule MIN-301-01 Software Architecture

Subheading (MIN-SWA)
Person in Charge Dunkel, Jürgen, Prof. Dr.
Language of Instruction by agreement
Curriculum Allocation MIN
Course Type, Contact Hours per Week Lecture with exercise, 4 SWS
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Semester 1
Suggestions for Independent Study see bibliography
Recommended Prerequisites none
Examination Examination (written or oral examination) and experimental work
Group Size 30

Learning Outcomes
Technological skills: in-depth knowledge of software architecture principles and design methodologies.
Methodological competence: modeling complex software architectures with formal methods.
Analysis design and implementation competence: capability of defining the requirements and critical success factors of software architectures; applying formal methods for describing software architectures; using software architectures as basis for implementing complex software systems

Content
Basic concepts and characteristics of modern software architectures, design principles and advanced technologies used in complex software architectures. For instance: components and connectors, architectural patterns and styles, design by contract with OCL, Domain Driven Design, model-driven software development, business process modeling.

Requirements for Contact Hours
Active participation, solving exercises, project work

Requirements for Independent Study Hours
Pre- and post-preparation of the content

Bibliography
E. Evans: Domain-Driven Design, Addison Wesley, 2004
Module MIN-302 Project and Quality Management

<table>
<thead>
<tr>
<th>Subheading</th>
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<td>Type of Module</td>
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<td>Submodules</td>
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<td>Prerequisites</td>
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<tr>
<td>Recommended Prerequisites</td>
<td>Successful completion of a Bachelor's degree program with the focus on computer science that is at least comparable to programming and software engineering courses.</td>
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<td>Examination</td>
<td>Examination (written or oral examination) and experimental work.</td>
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</table>

Learning Outcomes
Analysis, design, and methodological skills: Students acquire the ability to work independently in their field of profession. They learn about methods and concepts relating to project and quality management in order to be able to work as a team leader in a team, which can consist of members from a number of different disciplines and with different levels of competence.
Submodule  MIN-302-01 Project and Quality Management

Introduction to basic forms of organization and processes (MIN-PMQM)

Salzwedel, Jussi, M.Sc.

by agreement

MIN

Lecture with exercise, 4 SWS

6

68 h / 112 h

1

see bibliography

none

Examination (written or oral) and experimental work

30

Analysis, design, and methodological skills: Students acquire the ability to work independently in their field of profession. They learn methods and concepts relating to project and quality management in order to be able to work as a team leader in a team, that can consist of members from a number of different disciplines and with different levels of competence.

Introduction to basic organizational structures and processes with the goal of executing projects. These include
- project acquisition,
- project organization and planning,
- measures for project controlling and risk management,
- configuration management,
- and quality control measures. In addition, process quality ensuring procedural models, such as ISO 9000 or CMM, are discussed.

Examination (written or oral) and experimental work

DeMarco, T.: Der Termin, Hanser.
Cockburn, A.: Agile Software-Entwicklung, Mitp (or English original).
Other sources on Advanced topics.
Module MIN-303 Visualization and HCI

Subheading (MIN-VISH)
Level of Module Basic module
Type of Module Compulsory module
Submodules MIN-303-01 Visualization and HCI, Compulsory
Person in Charge Ahlers, Volker, Prof. Dr.
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Semester 2
Duration of Module 1 semester
Prerequisites none
Recommended Prerequisites none
Examination Written or oral examination, experimental work

Learning Outcomes
Algorithmic and mathematical skills: Knowledge of the basic principles of human-computer interaction (HCI), understanding of visualization algorithms, knowledge of different types of data representation.
Analysis, design, and realization skills: Analysis of data sets and visualization requirements, design and realization of visualization solutions, implementation of algorithms.
Technological skills: Knowledge of the use of visualization techniques in different areas of application.
Methodological skills: Knowledge of the opportunities, the benefits, and the limits of the use of visualization techniques, detection of errors in visualization solutions.
Submodule MIN-303-01 Visualization and HCI

Subheading (MIN-VISH)
Person in Charge Ahlers, Volker, Prof. Dr.
Language of Instruction by agreement
Curriculum Allocation MIN
Course Type, Contact Hours per Week Lecture with exercise, 4 SWS
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Semester 2
Suggestions for Independent Study see bibliography
Recommended Prerequisites none
Examination Written or oral examination, experimental work
Group Size 30

Learning Outcomes
Algorithmic and mathematical skills: Knowledge of the basic principles of human-computer interaction (HCI), understanding of visualization algorithms, knowledge of different types of data representation.
Analysis, design, and realization skills: Analysis of data sets and visualization requirements, design and realization of visualization solutions, implementation of algorithms.
Technological skills: Knowledge of the use of visualization techniques in different areas of application.
Methodological skills: Knowledge of the opportunities, the benefits, and the limits of the use of visualization techniques, detection of errors in visualization solutions.

Content
- Fundamentals: human-computer interaction (HCI), perception and cognition, gestalt laws, color models, data representation
-Scalar data: charts (e.g., line charts, bar charts, scatter plots, histograms), color coding, contour lines, multi-variate data
- Volume data: isosurfaces, volume rendering, ray casting
- Vector fields: glyphs, flow lines, flow paths Relations: visualization of hierarchies (trees) and networks (graphs), e.g., tree map, force-directed layout
- Software: Current visualization libraries and graphical development environments, application to real data

Requirements for Contact Hours
Active participation, solving exercise problems, project work

Requirements for Independent Study Hours
Preparation and review of the lectures, reading literature

Bibliography
Lecture notes
Telea, A.C.: Data Visualization, CRC Press
Munzner, T.: Visualization Analysis & Design, CRC Press
Ward, M., Grinstein, G.G., Keim, D.: Interactive Data Visualization. CRC Press
Ware, C.: Information Visualization. Morgan Kaufmann
## Module MIN-304 Theory of Algorithms and Complexity

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<td>Type of Module</td>
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<td>Semester</td>
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<td>Duration of Module</td>
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<td>Prerequisites</td>
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<tr>
<td>Recommended Prerequisites</td>
<td>Theoretical Computer Science (BIN-104), Algorithms and Datastructures (BIN-109 or MDI-202)</td>
</tr>
<tr>
<td>Examination</td>
<td>Written or oral exam, experimental work</td>
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### Learning Outcomes
Theoretical and mathematical competences: Characterizing the difficulty of given problems as well as their classification with respect to efficient algorithms and solvability.
Analysis, design and realization competences: Knowledge of different algorithmic strategies for solving practically relevant problems of high complexity (time, memory).
Technological competences: Implementation of these algorithms.
Submodule MIN-304-01 Theory of Algorithms and Complexity

Subheading \(\text{(MIN-AK)}\)

Person in Charge Ginkel, Ingo, Prof. Dr.

Language of Instruction by agreement

Curriculum Allocation MIN

Course Type, Contact Hours per Week Lecture with exercise, 4 SWS

ECTS Credits 6

Contact Hours / Independent Study Hours 68 h / 112 h

Semester 1

Suggestions for Independent Study See bibliography

Recommended Prerequisites Theoretical Computer Science (BIN-104), Algorithms and Datastructures (BIN-109 or MDI-202)

Examination Written or oral exam, experimental work

Group Size 30

Learning Outcomes
Theoretical and mathematical competences: Characterizing the difficulty of given problems as well as their classification with respect to efficient algorithms and solvability.
Analysis, design and realization competences: Knowledge of different algorithmic strategies for solving practically relevant problems of high complexity (time, memory).
Technological competences: Implementation of these algorithms

Content
Theory: Computability, classes P and NP, NP-completeness, Polynomial reduction, theorem of Cook-Levin, graph algorithms.
Solution strategies: Divide and conquer (master theorem), backtracking, branch-and-bound, local improvement (greedy), linear programming, genetic algorithms, simulated annealing, randomization, bin-packing
Problems: Max-Cut problem, traveling salesman problem, knapsack, Euler circles, minimum spanning tree, etc.

Requirements for Contact Hours
Active participation, solving exercise problems

Requirements for Independent Study Hours
Preparation and postprocessing of the lectures, group work, theoretical and practical exercises.

Bibliography
lecture slides
Module MIN-305 Seminar

Subheading (MIN-MSEM)  
Level of Module Specific module  
Type of Module Compulsory module  
Submodules MIN-305-01 Seminar, Compulsory  
Person in Charge Wohlfeil, Stefan, Prof. Dr.  
ECTS Credits 6  
Contact Hours / Independent Study Hours 34 h / 146 h  
Semester 2  
Duration of Module 1 semester  
Prerequisites none  
Recommended Prerequisites All modules of semester 1  
Examination Term paper, presentation, compulsory attendance  

Learning Outcomes  
Specialist skills: In the seminar, students delve deeper into the contents of the previous courses using different examples and expand their analytical skills by dealing with new topics that are currently under research/development. Because these topics can also come from related fields, students will also expand their interdisciplinary skills.  
Methodological skills: Students expand their knowledge in working independently with challenging scientific literature. Social and personal skills: Students learn to present scientific contexts convincingly both verbally and in writing. Discussions provide an opportunity to practice critical reflection. Project management skills and the willingness to learn as well as to perform are trained since the students are obliged to adhere to deadlines using only limited resources.
Submodule MIN-305-01 Seminar

Subheading (MIN-MSEM)
Person in Charge Wohlfeil, Stefan, Prof. Dr.
Language of Instruction by agreement
Curriculum Allocation MIN
Course Type, Contact Hours per Week Seminar, 2 SWS
ECTS Credits 6
Contact Hours / Independent Study Hours 34 h / 146 h
Suggestions for Independent Study Depends on the individual topic of the student
Recommended Prerequisites All modules of semester 1
Examination Term paper, presentation, compulsory attendance
Group Size 12

Learning Outcomes
Specialist skills: In the seminar, students delve deeper into the contents of the previous courses using different examples and expand their analytical skills by dealing with new topics that are currently under research/development. Because these topics can also come from related fields, students will also expand their interdisciplinary skills.

Methodological skills: Students expand their knowledge in working independently with challenging scientific literature.

Social and personal skills: Students learn to present scientific contexts convincingly both verbally and in writing. Discussions provide an opportunity to practice critical reflection. Project management skills and the willingness to learn as well as to perform are trained since the students are obliged to adhere to deadlines using only limited resources.

Content
Participants deal independently with a demanding scientific topic, prepare a written report and present their findings, using scientific methods and techniques.

Requirements for Contact Hours
Give presentation about assigned topic. Listen to all other presentations. Ask questions and participate in discussions. (compulsory attendance)

Requirements for Independent Study Hours
Search literature about assigned topic using the library and the Digital Libraries of ACM and/or IEEE. Prepare a presentation about the topic and write a paper (report) about it.

Bibliography
To be announced by the lecturer at the beginning of the course
Module MIN-306 Master Project

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<td>All courses in the student's chosen area of specialization (major), in particular MIN-302.</td>
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Learning Outcomes
- Analytical skills: Ability to analyze the given problem using scientific methods and findings
- Design/realization skills: Ability to develop solution strategies and implementing them
- Technological skills: Ability to combine knowledge from different areas and use it for a specific purpose
- Methodological skills: Ability to use different innovative methods to solve practical problems
- Project management skills: Ability to plan projects, set up an organizational structure and to steer projects to reach the desired goal.
- Social skills: Use of conflict-solving strategies
Submodule MIN-306-01 Master Project

Subheading (MIN-MSPR)

Person in Charge Dunkel, Jürgen, Prof. Dr.

Language of Instruction by agreement

Curriculum Allocation MIN

Course Type, Contact Hours per Week Project, 6 SWS

ECTS Credits 12

Contact Hours / Independent Study Hours 68 h / 112 h

Semester 3

Suggestions for Independent Study see bibliography

Recommended Prerequisites none

Examination experimental work

Group Size 10

Learning Outcomes
Analytical skills: Ability to independently analyze the given problem using scientific methods and findings
Analytical skills: Ability to analyze the given problem using scientific methods and findings
Design/realization skills: Ability to develop solution strategies and implement them using the skills acquired
Technological skills: Ability to combine knowledge from different areas and use it for a specific purpose
Methodological skills: Ability to use different innovative methods to solve practical problems
Project management skills: Ability to plan projects, set up an organizational structure and to steer projects to reach the desired goal. Risk management
Social skills: Use of conflict-solving strategies

Content
The Master project focuses on dealing with a complex, current problem from the field of computer science; it may originate from one of the areas of specialization (majors). The task is characterized by independent teamwork on the project with project-specific organization, planning and execution. The concrete contents, processes and methods are derived from the problem at hand.

Requirements for Contact Hours
active involvement in the project, also taking organizational roles

Requirements for Independent Study Hours
implementation of specific project tasks: e. g. design, programming, testing, documentation

Bibliography
project specific
Module MIN-307 Master Thesis

Subheading (MIN-MA)
Level of Module Specific module
Type of Module Compulsory module
Submodules MIN-307-01 Master Thesis, Compulsory
Person in Charge Wohlfeil, Stefan, Prof. Dr.
ECTS Credits 30
Contact Hours / Independent Study 90 h / 810 h
Semester 4
Duration of Module 1 semester
Prerequisites At least 54 CP in MIN course
Recommended Prerequisites All modules of semesters 1 to 3
Examination Written thesis, own presentation and discussion, defense of thesis.

Learning Outcomes
Ability to work through a complex, practical topic from the field of computer science independently using scientific methods, i.e. analyzing the problem, finding solution approaches, classifying these in the state-of-the-art science/technology and perhaps implementing and finally evaluating them.
Ability to write a sophisticated scientific treatise on the chosen topic. In the colloquium, students show that they are able to present complex information in a short time to an audience of other specialists in this field in an understandable way.
Submodule MIN-307-01 Master Thesis

Subheading (MIN-MA)
Person in Charge Wohlfell, Stefan, Prof. Dr.
Language of Instruction by agreement
Curriculum Allocation MIN
Course Type, Contact Hours per Week Final Thesis
ECTS Credits 30
Contact Hours / Independent Study Hours 90 h / 810 h
Suggestions for Independent Study Depends on the chosen topic
Recommended Prerequisites All modules of semesters 1 to 3
Examination Written thesis, own presentation and discussion, defense of thesis.
Group Size 1

Learning Outcomes
Ability to work through a complex, practical topic from the field of computer science independently using scientific methods, i.e. analyzing the problem, finding solution approaches, classifying these in the state-of-the-art science/technology and perhaps implementing and finally evaluating them.
Ability to write a sophisticated scientific treatise on the chosen topic. In the colloquium, students show that they are able to present complex information in a short time to an audience of other specialists in this field in an understandable way.

Content
In contrast to the Bachelor thesis, the Master thesis focuses on a more challenging, perhaps more extensive topic on a higher academic/scientific level over a longer period of time.

Requirements for Contact Hours
Discussions with thesis advisor; Give presentation and be able to defend it during discussion about the topic.

Requirements for Independent Study Hours

Bibliography
Dependent on the topic of the thesis; is recommended by the thesis advisor and then independently updated, expanded and supplemented by the student.
## Module MIN-311 Geometric Modeling

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<td>Sprengel, Frauke, Prof. Dr.</td>
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<td>68 h / 112 h</td>
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<td>Duration of Module</td>
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<td>BIN-200 or MDI-200</td>
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<tr>
<td>Examination</td>
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### Learning Outcomes

Theoretical and methodological skills: Fundamental knowledge in geometric modeling; understanding of applicable methods and their limits
Analysis, design and realization skills: Ability to formulate, formalize, and solve modeling problems (i.e., implement appropriate algorithms)
Submodule MIN-311-01 Geometric Modeling

Subheading (MIN-GM)

Person in Charge Sprengel, Frauke, Prof. Dr.

Language of Instruction by agreement

Curriculum Allocation MIN

Course Type, Contact Hours per Week Lecture with exercise, 4 SWS

ECTS Credits 6

Contact Hours / Independent Study Hours 68 h / 112 h

Suggestions for Independent Study see bibliography

Recommended Prerequisites BIN-200 or MDI-200

Examination Examination (written or oral examination) and experimental work

Group Size 30

Learning Outcomes

Theoretical and methodological skills: Fundamental knowledge in geometric modeling; understanding of applicable methods and their limits

Analysis, design and realization skills: Ability to formulate, formalize, and solve modeling problems (i.e., implement appropriate algorithms)

Content Free-form curves and surfaces (Bézier, B-splines, NURBS), subdivision surfaces, solid modeling (constructive solid geometry), geometric continuity, interpolation, approximation

Requirements for Contact Hours Active participation, individual task-solving in small groups, discussion

Requirements for Independent Study Hours Preparation and postprocessing of the lectures, reading literature, individual or group task-solving, individual discussion

Bibliography

Lecture notes

G. Farin: Curves and Surfaces in CAGD, latest edition


H. Prautzsch: Bézier and B-Spline Techniques, Springer 2002
Module MIN-312 Computer Graphics and Interaction

Subheading (MIN-CGI)
Level of Module Specific module
Type of Module Optional module
Submodules MIN-312-01 Computer Graphics and Interaction, Compulsory
Person in Charge Ahlers, Volker, Prof. Dr.
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Duration of Module 1 semester
Prerequisites none
Recommended Prerequisites Bachelor level computer graphics lecture, e.g., BIN-200 or MDI-200
Examination Written or oral examination, experimental work

Learning Outcomes
Algorithmic skills: Understanding of mathematical and algorithmic fundamentals of computer graphics, in particular real-time rendering as well as virtual and augmented reality.
Analysis, design and realization skills: Design and realization of interactive graphics applications with current graphics libraries, design and realization of natural user interfaces.
Technological skills: Understanding of the function of modern graphics processors, knowledge of the use of computer graphics in different areas of application.
Methodological skills: Knowledge of the possibilities, the benefits, and the limits of using techniques of computer graphics as well as virtual and augmented reality.
Submodule MIN-312-01 Computer Graphics and Interaction

Subheading (MIN-CGI)

Person in Charge Ahlers, Volker, Prof. Dr.

Language of Instruction by agreement

Curriculum Allocation MIN

Course Type, Contact Hours per Week Lecture with exercise, 4 SWS

ECTS Credits 6

Contact Hours / Independent Study Hours 68 h / 112 h

Suggestions for Independent Study see bibliography

Recommended Prerequisites Bachelor level computer graphics lecture, e.g., BIN-200 or MDI-200

Examination Written or oral examination, experimental work

Group Size 30

Learning Outcomes

Algorithmic skills: Understanding of mathematical and algorithmic fundamentals of computer graphics, in particular real-time rendering as well as virtual and augmented reality.

Analysis, design and realization skills: Design and realization of interactive graphics applications with current graphics libraries, design and realization of natural user interfaces.

Technological skills: Understanding of the function of modern graphics processors, knowledge of the use of computer graphics in different areas of application.

Methodological skills: Knowledge of the possibilities, the benefits, and the limits of using techniques of computer graphics as well as virtual and augmented reality.

Content

- Fundamentals: real-time rendering, architecture of modern graphics processors, rendering pipeline, programmable shaders, concepts of virtual and augmented reality
- Advanced rendering techniques: mirroring, shadows, image-based rendering, particle systems, collision detection
- Modeling: scene graphs, spatial data structures
- Interaction: natural user interfaces, stereo rendering, motion tracking, peripheral device interfaces
- Software: current graphics, scene graph, and VR libraries. applications of computer graphics

Requirements for Contact Hours

Active participation, solving exercise problems, project work

Requirements for Independent Study Hours

Preparation and review of the lectures, reading literature

Bibliography

Lecture Notes
Nischwitz, A., Fischer, M., Haberäcker, P., Socher, G.: Computergrafik und Bildverarbeitung, Band 1, Vieweg +Teubner
### Module MIN-313 Visual Computing

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<td>Recommended Prerequisites</td>
<td>Basic knowledge of digital image processing and computer graphics</td>
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<td>Examination</td>
<td>Examination (written or oral examination) and experimental work</td>
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**Learning Outcomes**
- **Technological skills:** Profound knowledge in a selected field of visual computing; understanding of applicable methods and their limits
- **Methodological skills:** Application of innovative methods in the selected field of work
- **Analysis, design and realization skills:** Ability to formulate, formalize, and solve problems in a new and developing field of computer graphics, computer vision, and visualization
Submodule  MIN-313-01 Visual Computing

Subheading  (MIN-VC)
Person in Charge  Sprengel, Frauke, Prof. Dr.
Language of Instruction  by agreement
Curriculum Allocation  MIN
Course Type, Contact Hours per Week  Lecture with exercise, 4 SWS
ECTS Credits  6
Contact Hours / Independent Study Hours  68 h / 112 h
Suggestions for Independent Study  see bibliography
Recommended Prerequisites  Basic knowledge of digital image processing and computer graphics
Examination  Examination (written or oral examination) and experimental work
Group Size  30

Learning Outcomes
Technological skills: Profound knowledge in a selected field of visual computing; understanding of applicable methods and their limits
Methodological skills: Application of innovative methods in the selected field of work
Analysis, design and realization skills: Ability to formulate, formalize, and solve problems in a new and developing field of computer graphics, computer vision, and visualization

Content
A selected topic of visual computing is introduced, e.g., medical visualization, digital image creation, pattern recognition and machine learning, artificial intelligence, robotics, GPU computing, image databases, finding events in image sequences, modeling and simulation.
First and foremost current topics and developments shall be considered. Research-oriented problems may lay the foundation of the master thesis.

Requirements for Contact Hours
Active participation, individual task-solving in small groups, discussion

Requirements for Independent Study Hours
Preparation and postprocessing of the lectures, reading literature, individual or group task-solving, individual discussion

Bibliography
Lecture notes
Current literature according to contents
Module MIN-314 Computational Geometry

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**Learning Outcomes**

Theoretical and mathematical competences: Characterizing the difficulty of given geometric problems as well as their classification with respect to efficient algorithms and solvability. Analysis, design and realization competences: Knowledge of different algorithmic strategies for solving practically relevant geometric problems. Technological competences: Implementation of these algorithms.
Submodule MIN-314-01 Computational Geometry

Subheading (MIN-COG)
Person in Charge Ginkel, Ingo, Prof. Dr.
Language of Instruction by agreement
Curriculum Allocation MIN
Course Type, Contact Hours per Week Lecture with exercise, 4 SWS
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Suggestions for Independent Study See bibliography
Recommended Prerequisites MIN-312
Examination Written or oral exam, experimental work
Group Size 30

Learning Outcomes
Theoretical and mathematical competences: Characterizing the difficulty of given geometric problems as well as their classification with respect to efficient algorithms and solvability. Analysis, design and realization competences: Knowledge of different algorithmic strategies for solving practically relevant geometric problems. Technological competences: Implementation of these algorithms

Content
Selected topics in the field of computational geometry, e.g. art gallery problem, polygon triangulation, Voronoi diagrams, Delaunay triangulation, windowing, point location, efficient collision detection and avoidance, spacial data structures like like Octrees or kd-Trees, robot motion planning, graph theory and algorithms, point-based graphics, geometric filtering, etc.

Requirements for Contact Hours
Active participation, solving exercise problems

Requirements for Independent Study Hours
Preparation and postprocessing of the lectures, reading literature, implementing algorithms

Bibliography
De Berg: Computational Geometry, Springer 2008, further literature based on varying topics
Module MIN-315 Computer Vision

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Learning Outcomes
Algorithmic and mathematical skills: profound knowledge and understanding of the mathematical and algorithmic principles of digital image processing.
Analysis and design skills: being able to solve unusually or incompletely defined image analysis problems in different application scenarios.
Technological skills: combined knowledge from image processing, mathematics and computer science; being able to recognize the limitations of image analysis techniques.
Submodule MIN-315-01 Computer Vision

Subheading (MIN-CV)
Person in Charge Pigors, Adrian, Prof. Dr.
Language of Instruction by agreement
Curriculum Allocation MIN
Course Type, Contact Hours per Week Lecture with exercise, 4 SWS
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Suggestions for Independent Study See bibliography
Recommended Prerequisites Basic principles of digital image processing as in BIN-207 or MDI-210
Examination Written or oral examination, experimental work
Group Size 30

Learning Outcomes
Algorithmic and mathematical skills: profound knowledge and understanding of the mathematical and algorithmic principles of digital image processing.
Analysis and design skills: being able to solve unusually or incompletely defined image analysis problems in different application scenarios.
Technological skills: combined knowledge from image processing, mathematics and computer science; being able to recognize the limitations of image analysis techniques.

Content
In-depth knowledge of methods for recognizing and extracting logically connected image contents in images or image sequences as well as their description at a higher level of abstraction, in order to recognize, for example, depicted objects:
- segmentation methods,
- representation and description of segments,
- object recognition and
- characterization and comparison of similar images.

Requirements for Contact Hours
Participating actively, solving exercise problems

Requirements for Independent Study Hours
Preparing and following up lectures, solving exercise problems, discussing material

Bibliography
Lecture notes
Jähne, B.: Digitale Bildverarbeitung, Springer
Baggio, Escriva, Mahmood et al.: Mastering OpenCV with Practical Computer Vision Projects, Packt
Module MIN-316 HCI and Virtual Reality

Subheading (MIN-HCI)
Level of Module Specific module
Type of Module Optional module
Submodules MIN-316-01 HCI und Virtual Reality, Compulsory
Person in Charge Schild, Jonas, Prof. Dr.
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Duration of Module 1 semester
Prerequisites None
Recommended Prerequisites Basic understanding of design and development of 3D computer graphics, interactive systems and environments is recommended, but not required
Examination Written or oral examination, experimental work

Learning Outcomes
Students acquire a solid understanding of advanced interactive and immersive systems, e.g., virtual and augmented reality, 3D input devices, motion controls, complex interaction, graphical user interfaces, multimodal interaction, 3D audio. Students learn to design, implement and evaluate such systems in accordance with relevant software and hardware design goals, i.e., usability, performance, ergonomics. Students can analyse and relate own work to current state of academic research and to the technological state of the art.
Submodule MIN-316-01 HCI und Virtual Reality

Subheading (MIN-HCI)

Person in Charge Schild, Jonas, Prof. Dr.

Language of Instruction by agreement

Curriculum Allocation MIN

Course Type, Contact Hours per Week Lecture with exercise, 4 SWS

ECTS Credits 6

Contact Hours / Independent Study Hours 68 h / 112 h

Suggestions for Independent Study see bibliography

Recommended Prerequisites Basic understanding of design and development of 3D computer graphics, interactive systems and environments is recommended, but not required

Examination Written or oral examination, experimental work

Group Size 30

Learning Outcomes
Students acquire a solid understanding of advanced interactive and immersive systems, e.g., virtual and augmented reality, 3D input devices, motion controls, complex interaction, graphical user interfaces, multimodal interaction, 3D audio. Students learn to design, implement and evaluate such systems in accordance with relevant software and hardware design goals, i.e., usability, performance, ergonomics. Students can analyse and relate own work to current state of academic research and to the technological state of the art.

Content
Foundations of augmented and virtual reality: 3D perception, stereoscopic 3D vision, immersive display systems, applications in virtual and augmented reality
Foundations of user interfaces (basic and advanced HCI models, perception of interactivity, cognition and ergonomics, input devices, user-centered design)
alysing and experimenting with selected advanced topics on interaction with virtual and augmented realities (e.g., 3D navigation, gestural interaction, physical input, speech-based systems, interactive surfaces and displays, 3D user interfaces, 3D audio, collaborative systems, social VR)

Requirements for Contact Hours
Active participation, independent working on exercises, possibly project work in groups

Requirements for Independent Study Hours
Preparation and follow-up, independent processing of research papers and project tasks, possibly in groups

Bibliography
Current literature and conference proceedings.
Module MIN-317 Game Development

Subheading (MIN-GD)
Level of Module Specific module
Type of Module Optional module
Submodules MIN-317-01 Game Development, Compulsory
Person in Charge Schild, Jonas, Prof. Dr.
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Duration of Module 1 semester
Prerequisites None
Recommended Prerequisites Basic knowledge of technical principles of 3D computer graphics, human-machine interaction; practical experience with project work in teams; extensive own experience with digital games.
Examination Written or oral examination, experimental work

Learning Outcomes
Students know the systematic structure of digital games and can understand and apply technical design principles (e.g. concept, gameplay, game mechanics, balancing, narrative, game interfaces).
Students understand working methods and can apply the agile development process and methods of project management in small teams.
Students understand the relevance of game experience and can optimize digital games based on user metrics and evaluation data.
Submodule MIN-317-01 Game Development

Subheading (MIN-GD)

Person in Charge Schild, Jonas, Prof. Dr.

Language of Instruction by agreement

Curriculum Allocation MIN

Course Type, Contact Hours per Week Lecture with exercise, 4 SWS

ECTS Credits 6

Contact Hours / Independent Study Hours 68 h / 112 h

Suggestions for Independent Study see bibliography

Recommended Prerequisites Basic knowledge of technical principles of 3D computer graphics, human-machine interaction; practical experience with project work in teams; extensive own experience with digital games.

Examination Written or oral examination, experimental work

Group Size 30

Learning Outcomes

Students know the systematic structure of digital games and can understand and apply technical design principles (e.g. concept, gameplay, game mechanics, balancing, narrative, game interfaces).

Students understand working methods and can apply the agile development process and methods of project management in small teams.

Students understand the relevance of game experience and can optimize digital games based on user metrics and evaluation data.

Content

Basics of game design and game technologies (e.g. structure of digital games, formal elements of gameplay and game narratives, game interaction, game engines).

Advanced basics of game experience (e.g. game balancing, player modeling, game experience evaluation, information management, decision crafting).

Principles and methods of game development (game production, agile project management, scrum, crunches)

Requirements for Contact Hours

Active participation, independent working on exercises, possibly project work in groups

Requirements for Independent Study Hours

Preparation and follow-up, independent processing of research papers and project tasks, possibly in groups

Bibliography

Sylvester, Designing Games: A Guide to Engineering Experiences, O'Reilly, 2013


Current literature and conference proceedings
**Module MIN-321 IT Security I**

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**Learning Outcomes**

Technological skills: Students have acquired sound, in-depth knowledge of security measures and mechanisms. They are able to combine knowledge from the fields of mathematics, computer networks and IT security and handle the level of complexity involved. They know the principles of the most important security technologies and are able to expand and delve deeper into these subjects independently. Design and realization skills: Students are able to solve unusual, incompletely defined problems from the field of IT security and also implement the solutions technically. Social skills: In the exercises, students acquire the skills to act independently (familiarization, analysis, concept and implementation) as well as in cooperation with teams.
Submodule MIN-321-01 IT Security I

Subheading (MIN-ITS1)

Person in Charge Wohlfeil, Stefan, Prof. Dr.

Language of Instruction by agreement

Curriculum Allocation MIN

Course Type, Contact Hours per Week Lecture with exercise, 4 SWS

ECTS Credits 6

Contact Hours / Independent Study Hours 68 h / 112 h

Suggestions for Independent Study See bibliography

Recommended Prerequisites BIN-112 and BIN-202

Examination Written or oral exam, experimental work

Group Size 30

Learning Outcomes
Technological skills: Students have acquired sound, in-depth knowledge of security measures and mechanisms. They are able to combine knowledge from the fields of mathematics, computer networks and IT security and handle the level of complexity involved. They know the principles of the most important security technologies and are able to expand and delve deeper into these subjects independently.

Design and realization skills: Students are able to solve unusual, incompletely defined problems from the field of IT security and also implement the solutions technically.

Social skills: In the exercises, students acquire the skills to act independently (familiarization, analysis, concept and implementation) as well as in cooperation with teams.

Content
Terminology: Threats, risks, weaknesses, protection goal. Security Technologies: Authentication, Authorization, Identiy Management, Cryptography; Hash functions; message authentication codes; digital signatures; X.509 certificates; use of security technologies for e-mail (PGP and S/MIME), surfing (SSL), remote log-in (SSH); Kerberos; security standards and processes; forensics; web security

Requirements for Contact Hours
Active participation, solving exercise problems

Requirements for Independent Study Hours
Preparation and postprocessing of the lectures, reading literature

Bibliography
Lecture notes
C. Eckert: IT Sicherheit. Konzepte, Verfahren, Protokolle; Oldenbourg
W. Stallings: Cryptography and Network Security; Prentice Hall
S. Wohlfeil: Kurs 01866 - Sicherheit im Internet, FernUniversität Hagen
Module MIN-322 IT Security II

Subheading (MIN-ITS2)
Level of Module Specific module
Type of Module Optional module
Submodules MIN-322-01 IT Security II, Compulsory
Person in Charge Wohlfeil, Stefan, Prof. Dr.
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Duration of Module 1 semester
Prerequisites none
Recommended Prerequisites MIN-321
Examination Examination (written or oral examination) and experimental work

Learning Outcomes
Technological skills: Students have acquired sound, in-depth knowledge of security measures and mechanisms. They are able to combine knowledge from the fields of mathematics, computer networks and IT security and handle the level of complexity involved. They know the principles of the most important security technologies and are able to expand and delve deeper into these subjects independently.
Design and realization skills: Students are able to solve unusual, incompletely defined problems from the field of IT security and also implement the solutions technically.
Social skills: In the exercises, students acquire the skills to act independently (familiarization, analysis, concept and implementation) as well as in cooperation with teams.
Submodule MIN-322-01 IT Security II

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<tr>
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Learning Outcomes
Technological skills: Students have acquired sound, in-depth knowledge of security measures and mechanisms. They are able to combine knowledge from the fields of mathematics, computer networks and IT security and handle the level of complexity involved. They know the principles of the most important security technologies and are able to expand and delve deeper into these subjects independently.

Design and realization skills: Students are able to solve unusual, incompletely defined problems from the field of IT security and also implement the solutions technically.

Social skills: In the exercises, students acquire the skills to act independently (familiarization, analysis, concept and implementation) as well as in cooperation with teams.

Content
Security in e-commerce, secure methods of payment; biometry; anonymity and privacy (mixes); intrusion detection (principles and network-based as well as host-based systems); Virtual Private Networks (how they work, characteristics, technologies, such as layer 2 vs. layer 3, systems like IPSEC, OpenVPN), security architectures, development of secure systems; Firewalls (Architectures, packet filters ALG, DMZ, etc.);
Virtualization

Requirements for Contact Hours
Active participation, solving exercise problems

Requirements for Independent Study Hours
Preparation and postprocessing of the lectures, reading literature

Bibliography
Lecture notes
S. Northcutt, J. Novak: Network Intrusion Detection; New Riders
J. Snader: VPNs Illustrated; Addison-Wesley
S. Wohlfeil: Kurs 01867 - Sicherheit im Internet 2; FernUniversität Hagen
Module  MIN-323 Advanced Topics in IT Security

Subheading (MIN-SSI)
Level of Module Specific module
Type of Module Optional module
Submodules MIN-323-01 Advanced Topics in IT Security, Compulsory
Person in Charge Hovestadt, Matthias, Prof. Dr.
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Duration of Module 1 semester
Prerequisites none
Recommended Prerequisites MIN-321 and MIN-322
Examination Written or oral examination, experimental work

Learning Outcomes
Technological skills: Students have advanced knowledge on a special topic of IT security. Students have knowledge on applicable technologies and their limitations.
Design, implementation and methodic skills: Students are able to apply innovative methods of the focused domain.
Comprehensive: Students are able to transfer theoretical knowledge and comprehend complex contexts.
Submodule MIN-323-01 Advanced Topics in IT Security

Subheading (MIN-SSI)

Person in Charge Hovestadt, Matthias, Prof. Dr.

Language of Instruction by agreement

Curriculum Allocation MIN

Course Type, Contact Hours per Week Lecture with exercise, 4 SWS

ECTS Credits 6

Contact Hours / Independent Study Hours 68 h / 112 h

Suggestions for Independent Study The listed literature is intended as an entry point only. It is highly recommended to look into literature beyond the listed books, e.g. using the university library. Since highly topical issues are addressed, the notion of literature does not only imply books but particularly also journals and research papers.

Recommended Prerequisites MIN-321 and MIN-322

Examination Written or oral examination, experimental work

Group Size 30

Learning Outcomes
Technological skills: Students have advanced knowledge on a special topic of IT security. Students have knowledge on applicable technologies and their limitations.

Design, implementation and methodic skills: Students are able to apply innovative methods of the focused domain.

Comprehensive: Students are able to transfer theoretical knowledge and comprehend complex contexts.

Content
Selected topical issues from IT security, e.g. trusted computing, cryptography, development of secure software, security assessment, security evaluation and security management, threats and risks, penetration testing

Requirements for Contact Hours
Active participation, solving exercise problems

Requirements for Independent Study Hours
Preparation and postprocessing of the lectures, reading literature, practical evaluation of theoretical concepts

Bibliography
Depending on the specific topic
Module MIN-324 Secure Software Engineering

Subheading (MIN-SSE)
Level of Module Specific module
Type of Module Optional module
Submodules MIN-324-01 Secure Software Engineering, Compulsory
Person in Charge Peine, Holger, Prof. Dr.
ECTS Credits 6
Contact Hours / Independent Study 68 h / 112 h
Hours
Duration of Module 1 semester
Prerequisites none
Recommended Prerequisites MIN-321
Examination Examination (written or oral) and experimental work

Learning Outcomes
Analytical and technological skills: Students can recognize the most important types of security vulnerabilities in real software and assess their damage potential.
Design, implementation and methodic skills: Students master techniques and methods for various activities to avoid or detect vulnerabilities in the software development process.
Submodule MIN-324-01 Secure Software Engineering

Subheading (MIN-SSE)

Person in Charge Peine, Holger, Prof. Dr.

Language of Instruction by agreement

Curriculum Allocation MIN

Course Type, Contact Hours per Week Lecture, 4 SWS

ECTS Credits 6

Contact Hours / Independent Study Hours 68 h / 112 h

Suggestions for Independent Study See bibliography

Recommended Prerequisites MIN-321

Examination Examination (written or oral) and experimental work

Group Size 30

Learning Outcomes
Analytical and technological skills: Students can recognize the most important types of security vulnerabilities in real software and assess their damage potential.
Design, implementation and methodic skills: Students master techniques and methods for various activities to avoid or detect vulnerabilities in the software development process.

Content
- Types of security vulnerabilities in software and their causes
- Eliciting and stating security requirements
- Finding, ranking and preventing security threats
- Security in software architecture
- Secure coding
- Testing and inspections for security vulnerabilities
- Secure user interfaces and process models for secure software

Requirements for Contact Hours
Active participation, solving exercise problems

Requirements for Independent Study Hours
Preparation and postprocessing of the lectures, reading literature

Bibliography
Adam Shostack: Threat Modeling, 2014
Module MIN-331 Database Paradigms

Subheading (MIN-DBP)
Level of Module Specific module
Type of Module Optional module
Submodules MIN-331-01 Database Paradigms, Compulsory
Person in Charge Heine, Felix, Prof. Dr.
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Duration of Module 1 semester
Prerequisites None
Recommended Prerequisites None
Examination Written or oral examination, experimental work

Learning Outcomes
Analysis and design skills: Recognize usage scenarios for alternative DB paradigms; ability to select the correct model / system for a given problem. Design of applications based on alternative DB paradigms
Algorithmic skills: Knowledge of modern DB algorithms, especially memory organization and query processing. Knowledge of the pros and cons of the algorithms for a given problem.
Technological skills: Knowledge of query languages and access APIs.
**Submodule MIN-331-01 Database Paradigms**

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<tr>
<td>Contact Hours / Independent Study Hours</td>
<td>68 h / 112 h</td>
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<td>Suggestions for Independent Study</td>
<td>See bibliography</td>
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<tr>
<td>Recommended Prerequisites</td>
<td>None</td>
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<tr>
<td>Examination</td>
<td>Written or oral examination, experimental work</td>
</tr>
<tr>
<td>Group Size</td>
<td>30</td>
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</tbody>
</table>

**Learning Outcomes**

Analysis and design skills: Recognize usage scenarios for alternative DB paradigms; ability to select the correct model / system for a given problem. Design of applications based on alternative DB paradigms

Algorithmic skills: Knowledge of modern DB algorithms, especially memory organization and query processing. Knowledge of the pros and cons of the algorithms for a given problem.

Technological skills: Knowledge of query languages and access APIs.

**Content**

This module focuses on alternatives to relational databases and advanced extensions for relational databases. The module contains topics ranging from data modeling, query languages up to implementation details like query processing. It optionally includes application programming using alternative DB paradigms. Specific topics might include:

- Object-relational and object-oriented databases
- XML databases and query languages
- Graph databases
- Key/value databases
- Document databases
- Column-oriented storage of data
- In-memory databases
- Embedded databases

**Requirements for Contact Hours**

Active participation, solving exercise problems

**Requirements for Independent Study Hours**

Preparation and postprocessing

**Bibliography**


Sadalage, Fowler: NoSQL Distilled, Pearson, 2012

Additional material according to latest lecture contents.
Module  MIN-332 Distributed Information Systems

<table>
<thead>
<tr>
<th>Subheading</th>
<th>(MIN-VIS)</th>
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</thead>
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<td>Level of Module</td>
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<td>Type of Module</td>
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<tr>
<td>Submodules</td>
<td>MIN-332-01  Distributed Information Systems, Compulsory</td>
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<tr>
<td>Person in Charge</td>
<td>Koschel, Arne, Prof. Dr.</td>
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<td>ECTS Credits</td>
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<td>Contact Hours / Independent Study Hours</td>
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<td>Duration of Module</td>
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<td>Prerequisites</td>
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<tr>
<td>Recommended Prerequisites</td>
<td>Completed Bachelor studies with computer science contents at least comparable to modules in Programming, Database Systems and Operating Systems and Networks</td>
</tr>
<tr>
<td>Examination</td>
<td>Written or oral exam, experimental work</td>
</tr>
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</table>

**Learning Outcomes**
Analysis and design skills: Evaluate, design and implement information systems with respect to given criteria; select and apply patterns.
Algorithmic skills: Understand and apply distributed algorithms.
Technological skills: Knowledge of concepts and technologies for the implementation, operation and usage of distributed information systems; review required aspects of distributed information systems in the context of different architecture models.
Submodule MIN-332-01 Distributed Information Systems

Subheading (MIN-VIS)
Person in Charge Koschel, Arne, Prof. Dr.
Language of Instruction by agreement
Curriculum Allocation MIN
Course Type, Contact Hours per Week Lecture, 4 SWS
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Suggestions for Independent Study See bibliography
Recommended Prerequisites Completed Bachelor studies with computer science contents at least comparable to BIN modules in Programming, Database Systems and Operating Systems and Networks
Examination Written or oral exam, experimental work
Group Size 30

Learning Outcomes
Analysis and design skills: Evaluate, design and implement information systems with respect to given criteria; select and apply patterns.
Algorithmic skills: Understand and apply distributed algorithms.
Technological skills: Knowledge of concepts and technologies for the implementation, operation and usage of distributed information systems; review selected aspects of distributed information systems in the context of different architecture models.

Content
In this module advanced skills for the implementation and operation of distributed information systems are taught. For this end core requirements of distributed information systems will be presented and methods to fulfill these requirements will be introduced. Theoretical concepts are learned and applied in the context of existing software systems. The teaching content includes:
- Distributed relational DBMS
- Parallelization aspects (scalability, load balancing, partitioning, replication, consistency, advanced transaction concepts, ...)
- Distributed file systems
- Patterns for distributed information systems, for example, map reduce, ...
- Distributed data analytics algorithms, for example, k-means, cluster, pagerank, ...
- Potentially selected additional topics and current research.

Requirements for Contact Hours
Active participation, solving exercise problems

Requirements for Independent Study Hours
Preparation and postprocessing of the lectures, reading literature

Bibliography
Further literature according to concrete contents.
Module  MIN-333 Data Analytics

<table>
<thead>
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<th>Subheading</th>
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<td>Level of Module</td>
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<td>Submodules</td>
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<td>Person in Charge</td>
<td>Heine, Felix, Prof. Dr.</td>
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<tr>
<td>Examination</td>
<td>Written or oral examination, experimental work</td>
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</table>

Learning Outcomes
Analysis and design skills: Knowledge of methods to locate and analyze data. Ability to choose the right method or the right combination of methods for a given problem. Understand the architecture of a Data Warehouse.
Algorithmic skills: Understand algorithms for data analytics. Knowledge of prerequisites, application areas and pros and cons.
Technological skills: Knowledge of example systems (e.g. Rapid-Miner).
Submodule MIN-333-01 Data Analytics

Subheading (MIN-DA)
Person in Charge Heine, Felix, Prof. Dr.
Language of Instruction by agreement
Curriculum Allocation MIN
Course Type, Contact Hours per Week Lecture with exercise, 4 SWS
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Suggestions for Independent Study See bibliography
Recommended Prerequisites None
Examination Written or oral examination, experimental work
Group Size 30

Learning Outcomes
Analysis and design skills: Knowledge of methods to locate and analyze data. Ability to choose the right method or the right combination of methods for a given problem. Understand the architecture of a Data Warehouse.
Algorithmic skills: Understand algorithms for data analytics. Knowledge of prerequisites, application areas and pros and cons.
Technological skills: Knowledge of example systems (e.g. RapidMiner).

Content
The lecture focuses on various approaches to the organization and analytics of large data sets. The following topics might be covered:
- Data Warehousing
- Data Mining
- Machine Learning and Neural Networks
- Data Quality
Based on exemplary systems such as Pentaho, RapidMiner or TensorFlow, and programming (e.g. Python or Java) the methods are used in practice in the exercises.

Requirements for Contact Hours
Active participation, solving exercise problems

Requirements for Independent Study Hours
Preparation and postprocessing

Bibliography
Bauer, Günzel: Data Warehouse Systeme, dpunkt.verlag, 2013
Tan, Steinbach, Kumar: Introduction to Data Mining, Pearson India, 2016
Additional material according to latest lecture contents.
Module MIN-334 Geographic and Multimedia Information Systems

Subheading (MIN-GMI)

Level of Module Specific module

Type of Module Optional module

Submodules MIN-334-01 Geographic and Multimedia Information Systems, Compulsory

Person in Charge Kleiner, Carsten, Prof. Dr.

ECTS Credits 6

Contact Hours / Independent Study Hours 68 h / 112 h

Duration of Module 1 semester

Prerequisites None

Recommended Prerequisites BIN-106, BIN-109, BIN-214 and MIN-331 resp. MDI-107, MDI-202, MDI-222 and MIN-331

Examination Written or oral examination, experimental work

Learning Outcomes

Analysis, design and implementation skills: Knowledge about and assessment of strengths and weaknesses of different options for persistent storage of two- and three-dimensional data; knowledge about and assessment and comparison of modeling and querying of geographic and multimedia data; selection and implementation of optimal persistent storage option in particular application scenario

Algorithmical skills: Understand, assess and implement different algorithms for efficient indexing of spatial data, assessment and implementation of different algorithms for text information retrieval and similarity comparison of multimedia data, assessment of their efficiency and applicability

Technological skills: Master and implement/use storage and querying of spatial data in different data models and systems (Oracle Spatial, PostGIS, NoSQL systems); master and implement storage and querying of multimedia data in different database systems (Oracle, PostgreSQL)
Submodule MIN-334-01 Geographic and Multimedia Information Systems

Subheading (MIN-GMI)
Person in Charge Kleiner, Carsten, Prof. Dr.
Language of Instruction by agreement
Curriculum Allocation MIN
Course Type, Contact Hours per Week Lecture with exercise, 4 SWS
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Suggestions for Independent Study Work on slides and literature, reflection and self-contained application of content
Recommended Prerequisites BIN-106, BIN-109, BIN-214 and MIN-331 resp. MDI-107, MDI-202, MDI-222 and MIN-331
Examination Written or oral examination, experimental work
Group Size 30

Learning Outcomes
Analysis, design and implementation skills: Knowledge about and assessment of strengths and weaknesses of different options for persistent storage of two- and three-dimensional data; knowledge about and assessment and comparison of modeling and querying of geographic and multimedia data; selection and implementation of optimal persistent storage option in particular application scenario
Algorithmical skills: Understand, assess and implement different algorithms for efficient indexing of spatial data, assessment and implementation of different algorithms for text information retrieval and similarity comparison of multimedia data, assessment of their efficiency and applicability
Technological skills: Master and implement/use storage and querying of spatial data in different data models and systems (Oracle Spatial, PostGIS, NoSQL systems); master and implement storage and querying of multimedia data in different database systems (Oracle, PostgreSQL)

Content
Foundation of geo information systems, datatypes and storage of spatial data in database and information systems (of different paradigms), algorithms for text analysis, algorithms for text information retrieval, applications of information retrieval, foundations of multimedia information systems, similarity search on multimedia documents and corresponding algorithms, typical query types for multimedia data

Requirements for Contact Hours
Lecture: Following presentations and examples, discussion, following executions and visualizations in learning software, reflection of content, self-contained application of subjects
Exercise: Self-contained work on problems on paper and by using learning software, theoretical problems, presentation of problem solutions and project results

Requirements for Independent Study Hours
Preparation and post-processing of lectures and exercises, self-contained work on problems, turning in homework in small groups, self-contained work on a project task in small groups, exam preparation, reading literature

Bibliography
de Berg, van Kreveld, Overmars: Computational Geometry, Springer
Rigaux, Scholl, Voissard: Spatial Databases with application to GIS, Morgan Kaufmann
T. Brinkhoff: Geodatenbanksysteme in Theorie und Praxis, Wichmann
Ingo Schmitt: Ähnlichkeitssuche in Multimedia-Datenbanken, Oldenburg-Verlag
### Module MIN-324 Secure Software Engineering

<table>
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<tr>
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<td>Peine, Holger, Prof. Dr.</td>
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<tr>
<td>Examination</td>
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</table>

**Learning Outcomes**

Analytical and technological skills: Students can recognize the most important types of security vulnerabilities in is real software and assess their damage potential.

Design, implementation and methodic skills: Students master techniques and methods for various activities to avoid or detect vulnerabilities in the software development process.
Submodule MIN-324-01 Secure Software Engineering

Subheading (MIN-SSE)
Person in Charge Peine, Holger, Prof. Dr.
Language of Instruction by agreement
Curriculum Allocation MIN
Course Type, Contact Hours per Week Lecture, 4 SWS
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Suggestions for Independent Study See bibliography
Recommended Prerequisites MIN-321
Examination Examination (written or oral) and experimental work
Group Size 30

Learning Outcomes
Analytical and technological skills: Students can recognize the most important types of security vulnerabilities in real software and assess their damage potential.
Design, implementation and methodic skills: Students master techniques and methods for various activities to avoid or detect vulnerabilities in the software development process.

Content
- Types of security vulnerabilities in software and their causes
- Eliciting and stating security requirements
- Finding, ranking and preventing security threats
- Security in software architecture
- Secure coding
- Testing and inspections for security vulnerabilities
- Secure user interfaces and process models for secure software

Requirements for Contact Hours
Active participation, solving exercise problems

Requirements for Independent Study Hours
Preparation and postprocessing of the lectures, reading literature

Bibliography
Adam Shostack: Threat Modeling, 2014
Module MIN-341 Programming Paradigms

<table>
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<td>Examination</td>
<td>Written or oral exam, experimental work</td>
</tr>
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</table>

**Learning Outcomes**

Analytical and technological skills: Classify and assess the expressive means of programming languages
Design, implementation and methodic skills: Extended problem solving capabilities by mastering alternative approaches to thinking, deepen the understanding of object-oriented programming
Technological skills: Learning a functional programming language (e.g. Scala) and (to a limited extent) a logical programming language (e.g. Prolog)
Submodule MIN-341-01 Programming Paradigms

Subheading (MIN-PPD)
Person in Charge Peine, Holger, Prof. Dr.
Language of Instruction by agreement
Curriculum Allocation MIN
Course Type, Contact Hours per Week Lecture, 4 SWS
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Suggestions for Independent Study See bibliography
Recommended Prerequisites BIN-102 and BIN-108
resp. MDI-102 and MDI-109
Examination Written or oral exam, experimental work
Group Size 30

Learning Outcomes
Analytical and technological skills: Classify and assess the expressive means of programming languages
Design, implementation and methodic skills: Extended problem solving capabilities by mastering alternative approaches to thinking, deepen the understanding of object-oriented programming
Technological skills: Learning a functional programming language (e.g. Scala) and (to a limited extent) a logical programming language (e.g. Prolog)

Content
Programming languages and paradigms (short)
Imperative paradigm (short)
Object-oriented paradigm (medium)
Encapsulation, inheritance: Polymorphism, substitution principle, variance
Functional paradigm (long): Immutability and side effect avoidance, function objects, higher-order functions, closures, lazy evaluation, continuations, functional state.
Logical paradigm (medium): Propositional, predicate and Horn calculus, resolution, unification, negation as failure, procedural semantics

Requirements for Contact Hours
Active participation, solving exercise problems

Requirements for Independent Study Hours
Preparation and postprocessing of the lectures, reading literature

Bibliography
Michael L. Scott: Programming Language Pragmatics
Bertrand Meyer: Object oriented software construction
P. Chiusano, R. Bjarnason: Functional Programming in Scala
Ivan Bratko: PROLOG Programming for Artificial Intelligence.
Module MIN-342 Intelligent Systems

Subheading (MIN-INS)
Level of Module Specific module
Type of Module Optional module
Submodules MIN-342-01 Intelligent Systems, Compulsory
Person in Charge Bruns, Ralf, Prof. Dr.
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Duration of Module 1 semester
Prerequisites none
Recommended Prerequisites MIN-301
Examination Examination (written or oral examination) and experimental work

Learning Outcomes
Technological skills: Acquisition of solid knowledge in the area of Intelligent Systems (Artificial Intelligence), understanding for applicable techniques and methods; assessment of usefulness and limitations of intelligent technologies
Methods skills: Application and critical assessment of innovative methods in the area Intelligent Systems
Analysis, design and realization skills: Capability to formulate, structure and solve problems of new application domains by means of intelligent software technologies
Submodule MIN-342-01 Intelligent Systems

Subheading (MIN-INS)
Person in Charge Bruns, Ralf, Prof. Dr.
Language of Instruction by agreement
Curriculum Allocation MIN
Course Type, Contact Hours per Week Lecture with exercise, 4 SWS
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Suggestions for Independent Study see bibliography
Recommended Prerequisites MIN-301
Examination Examination (written or oral examination) and experimental work
Group Size 30

Learning Outcomes
Technological skills: Acquisition of solid knowledge in the area of Intelligent Systems (Artificial Intelligence), understanding for applicable techniques and methods; assessment of usefulness and limitations of intelligent technologies
Methods skills: Application and critical assessment of innovative methods in the area Intelligent Systems
Analysis, design and realization skills: Capability to formulate, structure and solve problems of new application domains by means of intelligent software technologies

Content
Theoretical foundations and concepts for design and development of intelligent (application) systems, e.g. introduction to Artificial Intelligence, Multi-Agent Systems, inference algorithms, Semantic Web, Complex Event Processing
In particular, recent research topics will be discussed, with focus on intelligent web and mobile systems. If appropriate, research problems can be further investigated in Master Theses.

Requirements for Contact Hours
Active participation, solving exercises

Requirements for Independent Study Hours
Pre- and post-preparation of the content

Bibliography
According to concrete contents.
Module MIN-343 Advanced Aspects of Distributed Systems

Subheading (MIN-FAVS)
Level of Module Specific module
Type of Module Optional module
Submodules MIN-343-01 Advanced Aspects of Distributed Systems, Compulsory
Person in Charge Koschel, Arne, Prof. Dr.
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Duration of Module 1 semester
Prerequisites none
Recommended Prerequisites Completed Bachelor studies with computer science contents at least comparable to BIN modules in Programming, Information Systems and operating Systems and Networks
Examination Written or oral exam, experimental work

Learning Outcomes
Analysis and design skills: Assess challenges of different forms of distributed systems and meet these challenges by means of suitable methods and technologies; select and apply patterns.
Algorithmic skills: Understand and apply distributed algorithms.
Technological skills: Profound knowledge of challenges, methods and current research results for different approaches to distributed systems.
Submodule  MIN-343-01 Advanced Aspects of Distributed Systems

Subheading  (MIN-FAVS)
Person in Charge  Koschel, Arne, Prof. Dr.
Language of Instruction  by agreement
Curriculum Allocation  MIN
Course Type, Contact Hours per Week  Lecture, 4 SWS
ECTS Credits  6
Contact Hours / Independent Study Hours  68 h / 112 h
Suggestions for Independent Study  See bibliography
Recommended Prerequisites  Completed Bachelor studies with computer science contents at least comparable to BIN modules in Programming, Information Systems and operating Systems and Networks
Examination  Written or oral exam, experimental work
Group Size  30

Learning Outcomes
Analysis and design skills: Assess challenges of different forms of distributed systems and meet these challenges by means of suitable methods and technologies; select and apply patterns.
Algorithmic skills: Understand and apply distributed algorithms.
Technological skills: Profound knowledge of challenges, methods and current research results for different approaches to distributed systems.

Content
In this module advanced skills for the architecture and functionality of different forms of distributed systems are taught. For this end fundamental models of distributed systems are introduced - such as cloud computing, P2P, SOA, Microservices - and characteristic properties of architecture, administration and runtime behavior as well as parallelization and error tolerance are treated. Selected theoretical concepts are realized by means of different software systems. In addition current research results and open problems are studied.

Requirements for Contact Hours
Active participation, solving exercise problems

Requirements for Independent Study Hours
Preparation and postprocessing of the lectures, reading literature

Bibliography
Further literature according to concrete contents.
Module MIN-344 Software Tests and Requirements

| Subheading                                      | (MIN-STR) |
| Level of Module                                | Specific module |
| Type of Module                                 | Optional module |
| Submodules                                     | MIN-344-01 Software Tests and Requirements, Compulsory |
| Person in Charge                               | Garmann, Robert, Prof. Dr. |
| ECTS Credits                                   | 6 |
| Contact Hours / Independent Study Hours         | 68 h / 112 h |
| Duration of Module                             | 1 semester |
| Prerequisites                                  | none |
| Recommended Prerequisites                      | Practical experience in all software development phases, esp. in specification and in programming tests. Knowledge of test techniques (e. g. black box / white box) at various test levels (from component tests to acceptance tests) |
| Examination                                    | Examination (written or oral examination) and experimental work |

**Learning Outcomes**

Analytical and design skills: knowledge of basic principles and techniques to analyze requirements, ability to utilize that knowledge in a certain requirements domain. Deep insight into all relevant test techniques. Ability to design test cases targeted at a complex system and proving an expected quality. Ability to evaluate a system’s quality including domain specific and technical aspects.

Realization skills: The students understand how to realize technical test activities and how to implement necessary tools and techniques to achieve defined test goals.
Submodule MIN-344-01 Software Tests and Requirements

Subheading (MIN-STR)
Person in Charge Garmann, Robert, Prof. Dr.
Language of Instruction by agreement
Curriculum Allocation MIN
Course Type, Contact Hours per Week Lecture with exercise, 4 SWS
ECTS Credits 6
Contact Hours / Independent Study Hours 68 h / 112 h
Suggestions for Independent Study see bibliography
Recommended Prerequisites Practical experience in all software development phases, esp. in specification and in programming tests. Knowledge of test techniques (e.g. black box / white box) at various test levels (from component tests to acceptance tests)
Examination Examination (written or oral examination) and experimental work
Group Size 30

Learning Outcomes
Analytical and design skills: knowledge of basic principles and techniques to analyze requirements, ability to utilize that knowledge in a certain requirements domain. Deep insight into all relevant test techniques. Ability to design test cases targeted at a complex system and proving an expected quality. Ability to evaluate a system's quality including domain specific and technical aspects.
Realization skills: The students understand how to realize technical test activities and how to implement necessary tools and techniques to achieve defined test goals.

Content
Requirements: system und system context, requirements elicitation, requirements documentation (using natural language), requirements consolidation, requirements validation and negotiation.
Software test: test process, test techniques (specification-based, structure-based, defect-based, experience-based), testing of software characteristics in domain and technical testing, test tools and test automation.

Requirements for Contact Hours
presentation, discussion, talk about papers

Requirements for Independent Study Hours
independent problem solving, project work

Bibliography