

# Module Handbook

for the

Master Programme “Computer Science”

at

Rheinischen Friedrich-Wilhelms-Universität Bonn

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The curriculum of the master programme is divided into four sub-curricula, each corresponding to one of the four main areas of competence in research of the Bonn Institute of Computer Science:

1. Algorithmics
2. Graphics, Vision, Audio
3. Information and Communication Management
4. Intelligent Systems

Module numbers **MA-INF ASXY** have been assigned according to the following key: vergeben:

- **A** = number of the area of competence
- **S** = semester within the master curriculum
- **XY** = sequential number within the semester and the respective area of competence (two digits)

According to the curriculum, all modules ought to be taken between the first and the third semester. The fourth semester is reserved for preparing the master thesis.

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# 1 Algorithmics

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<b>Module</b> MA-INF 1102	<b>Combinatorial Optimization</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every year		
<b>Module coordinator</b>	Prof. Dr. Jens Vygen				
<b>Lecturer(s)</b>	Prof. Dr. Jens Vygen, Prof. Dr. Norbert Blum, Prof. Dr. Stefan Hougardy, Prof. Dr. Marek Karpinski, Prof. Dr. Bernhard Korte, Prof. Dr. Stephan Held				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1. or 2.		
<b>Technical skills</b>	Advanced knowledge of combinatorial optimization. Modelling and development of solution strategies for combinatorial optimization problems				
<b>Soft skills</b>	Mathematical modelling of practical problems, abstract thinking, presentation of solutions to exercises				
<b>Contents</b>	Matchings, b-matchings and T-joins, optimization over matroids, submodular function minimization, travelling salesman problem, polyhedral combinatorics, NP-hard problems				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• B. Korte, J. Vygen: Combinatorial Optimization: Theory and Algorithms. Springer, 5th edition, 2012</li> <li>• A. Schrijver: Combinatorial Optimization: Polyhedra and Efficiency. Springer 2003</li> <li>• W. Cook, W. Cunningham, W. Pulleyblank, A. Schrijver: Combinatorial Optimization. Wiley 1997</li> </ul>				

<b>Module</b> MA-INF 1103	<b>Cryptography</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Joachim von zur Gathen				
<b>Lecturer(s)</b>	Prof. Dr. Joachim von zur Gathen, Dr. Michael Nüsken				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1. or 2.		
<b>Technical skills</b>	Understanding of security concerns and measures, and of the interplay between computing power and security requirements. Mastery of the basic techniques for cryptosystems and cryptanalysis				
<b>Soft skills</b>	Oral presentation (in tutorial groups), written presentation (of exercise solutions), team collaboration in solving homework problems, critical assessment				
<b>Contents</b>	Basic private-key and public-key cryptosystems: AES, RSA, group-based. Security reductions. Key exchange, cryptographic hash functions, signatures, identification; factoring integers and discrete logarithms; lower bounds in structured models.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Stinson, Cryptography: Theory and Practice, 2nd edition</li> <li>• Course notes</li> </ul>				

<b>Module</b> MA-INF 1104	<b>Advanced Algorithms</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Stefan Kratsch				
<b>Lecturer(s)</b>	Prof. Dr. Stefan Kratsch, Prof. Dr. Heiko Röglin				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1.		
<b>Technical skills</b>	Deeper insights into selected methods and techniques of modern algorithmics.				
<b>Soft skills</b>	Presentation of solutions and methods, critical discussion of applied methods and techniques.				
<b>Contents</b>	Advanced algorithmic techniques from e.g. approximation, randomized and exact exponential time algorithms. We will also revisit some essential topics such as linear programs and network flows.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 1201	<b>Approximation Algorithms for NP-Hard Problems</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every year		
<b>Module coordinator</b>	Prof. Dr. Marek Karpinski				
<b>Lecturer(s)</b>	Prof. Dr. Marek Karpinski, Prof. Dr. Norbert Blum, Prof. Dr. Rolf Klein, Prof. Dr. Bernhard Korte, Prof. Dr. Jens Vygen, Prof. Dr. Stefan Hougardy, Prof. Dr. Stephan Held				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Introduction to design and analysis of most important approximation algorithms for NP-hard combinatorial optimization problems, and various techniques for proving lower and upper bounds, probabilistic methods and applications				
<b>Soft skills</b>	Presentation of solutions and methods, critical discussion of applied methods and techniques				
<b>Contents</b>	Approximation Algorithms and Approximation Schemes. Design and Analysis of Approximation algorithms for selected NP-hard problems, like Set-Cover, and Vertex-Cover problems, MAXSAT, TSP, Knapsack, Bin Packing, Network Design, Facility Location. Introduction to various approximation techniques (like Greedy, LP-Rounding, Primal-Dual, Local Search, randomized techniques and Sampling, and MCMC-Methods), and their applications. Analysis of approximation hardness and PCP-Systems.				
<b>Prerequisites</b>	<b>Recommended:</b> Introductory knowledge of foundations of algorithms and complexity theory is essential.				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• S. Arora, C. Lund: Hardness of Approximations. In: Approximation Algorithms for NP-Hard Problems (D. S. Hochbaum, ed.), PWS, 1996</li> <li>• M. Karpinski: Randomisierte und approximative Algorithmen für harte Berechnungsprobleme, Lecture Notes (5th edition), Universität Bonn, 2007</li> <li>• B. Korte, J. Vygen: Combinatorial Optimization: Theory and Algorithms (5th edition), Springer, 2012</li> <li>• V. V. Vazirani: Approximation Algorithms, Springer, 2001</li> <li>• D. P. Williamson, D. B. Shmoys: The Design of Approximation Algorithms, Cambridge University Press, 2011</li> </ul>				

<b>Module</b> MA-INF 1202	<b>Chip Design</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Jens Vygen				
<b>Lecturer(s)</b>	All lecturers of Discrete Mathematics				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1. or 2.		
<b>Technical skills</b>	Knowledge of the central problems and algorithms in chip design. Competence to develop and apply algorithms for solving real-world problems, also with respect to technical constraints. Techniques to develop and implement efficient algorithms for very large instances.				
<b>Soft skills</b>	Mathematical modelling of problems occurring in chip design, development of efficient algorithms, abstract thinking, presentation of solutions to exercises				
<b>Contents</b>	Problem formulation and design flow for chip design, logic synthesis, placement, routing, timing analysis and optimization, clocktree design				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• C.J. Alpert, D.P. Mehta, S.S. Sapatnekar: The Handbook of Algorithms for VLSI Physical Design Automation. CRC Press, New York, 2008.</li> <li>• S. Held, B. Korte, D. Rautenbach, J. Vygen: Combinatorial optimization in VLSI design. In: "Combinatorial Optimization: Methods and Applications" (V. Chvátal, ed.), IOS Press, Amsterdam 2011, pp. 33-96</li> <li>• J. Vygen: Chip Design. Lecture Notes (distributed during the course)</li> </ul>				

<b>Module</b> MA-INF 1203	<b>Discrete and Computational Geometry</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Rolf Klein				
<b>Lecturer(s)</b>	Prof. Dr. Rolf Klein, Prof. Dr. Norbert Blum, Prof. Dr. Marek Karpinski, PD Dr. Elmar Langetepe				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1., 2., 3. or 4.		
<b>Technical skills</b>	To acquire fundamental knowledge on topics and methods in Discrete and Computational Geometry; to gain experience in, and practice, applying this knowledge autonomously in solving new problems, aiming at reliable experience.				
<b>Soft skills</b>	<p>Sozialkompetenz (Kommunikationsfähigkeit, Präsentation eigener Lösungsansätze und zielorientierte Diskussion im Gruppenrahmen, Teamfähigkeit), Methodenkompetenz (Analysefähigkeit, Abstraktes Denken, Führen von Beweisen), Individualkompetenz (Leistungs- und Lernbereitschaft, Kreativität, Ausdauer).</p> <p>Social competence( communication, presenting one's own solutions, goal-oriented discussions in teams), methodical competence (analysis, abstraction, proofs), individual competence (commitment and willingness to learn,creativity, endurance).</p>				
<b>Contents</b>	<p>Geometric distance problems in dimension two and higher, Voronoi diagrams, well-separated pair decomposition, spanner, metric space embedding, dimension reduction, dilation, geometric inequalities, VC-dimension, epsilon-nets, visibility, point location;</p> <p>randomized incremental construction, Chan's technique.</p>				
<b>Prerequisites</b>	<b>Recommended:</b> BA-INF 114 – Grundlagen der algorithmischen Geometrie				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Matousek, Lectures on Discrete Geometry</li> <li>• Narasimhan/Smid, Geometric Spanner Networks</li> <li>• Klein, Concrete and Abstract Voronoi Diagrams</li> </ul>				



<b>Module</b> MA-INF 1204	<b>Seminar Selected Topics in Information and Learning Theory</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every 2 years		
<b>Module coordinator</b>	Prof. Dr. Norbert Blum				
<b>Lecturer(s)</b>	Prof. Dr. Norbert Blum				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Ability to perform individual literature search, critical reading, understanding, and clear didactic presentation				
<b>Soft skills</b>	Presentation of own and others' solutions and methods, critical discussion of applied methods, techniques and solutions.				
<b>Contents</b>	Advanced topics in information and learning theory based on modern research literature				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The relevant literature will be announced towards the end of the previous semester.				

<b>Module</b> MA-INF 1205	<b>Graduate Seminar Discrete Optimization</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Jens Vygen				
<b>Lecturer(s)</b>	All lecturers of Discrete Mathematics				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science		<b>Mode</b> Optional	<b>Semester</b> 2.	
<b>Technical skills</b>	Competence to understand new research results based on original literature, to put such results in a broader context and present such results and relations.				
<b>Soft skills</b>	Ability to read and understand research papers, abstract thinking, presentation of mathematical results in a talk				
<b>Contents</b>	A current research topic in discrete optimization will be chosen each semester and discussed based on original literature.				
<b>Prerequisites</b>	<b>Required:</b> MA-INF 1102 – Combinatorial Optimization				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	4	60 T / 120 S	6
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The topics and the relevant literature will be announced towards the end of the previous semester.				

<b>Module</b> MA-INF 1206	<b>Seminar Design and Analysis of Randomized Approximation Algorithms</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Marek Karpinski				
<b>Lecturer(s)</b>	Prof. Dr. Marek Karpinski, Prof. Dr. Heiko Röglin				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Ability to perform individual literature search, critical reading, understanding, and clear didactic presentation.				
<b>Soft skills</b>	Presentation of solutions and methods, critical discussion of applied methods and techniques				
<b>Contents</b>	Current topics in design and analysis of randomized and approximation algorithms based on latest research literature				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The relevant literature will be announced in time.				

<b>Module</b> MA-INF 1207	<b>Lab Combinatorial Algorithms</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Jens Vygen				
<b>Lecturer(s)</b>	All lecturers of Discrete Mathematics				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Competence to implement advanced combinatorial algorithms, handling nontrivial data structures, testing, documentation. Advanced software techniques.				
<b>Soft skills</b>	Efficient implementation of complex algorithms, abstract thinking, documentation of source code				
<b>Contents</b>	Certain combinatorial algorithms will be chosen each semester. The precise task will be explained in a meeting in the previous semester.				
<b>Prerequisites</b>	<b>Required:</b> MA-INF 1102 – Combinatorial Optimization				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	none				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	The topics and the relevant literature will be announced towards the end of the previous semester				

<b>Module</b> MA-INF 1209	<b>Seminar Advanced Topics in Cryptography</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Joachim von zur Gathen				
<b>Lecturer(s)</b>	Prof. Dr. Joachim von zur Gathen, Dr. Michael Nüsken				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Understanding research publications, often written tersely. Distilling this into a presentation. Determination of relevant vs. irrelevant material. Developing a presentation that fascinates fellow students.				
<b>Soft skills</b>	Understanding and presenting material both orally and in visual media. Motivating other students to participate. Critical assessment of research results.				
<b>Contents</b>	A special topic within cryptography, changing from year to year, is studied in depth, based on current research literature				
<b>Prerequisites</b>	<b>Required:</b> MA-INF 1103 – Cryptography and one further course in cryptography like The Art of Cryptography or eSecurity.				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	Current conference publications, to be announced in time				

<b>Module</b> MA-INF 1210	<b>Probabilistic Analysis of Algorithms</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Heiko Röglin				
<b>Lecturer(s)</b>	Prof. Dr. Heiko Röglin				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 4.		
<b>Technical skills</b>	understanding of models and techniques for the probabilistic analysis of algorithms				
<b>Soft skills</b>	oral and written presentation of solutions and methods, abstract thinking				
<b>Contents</b>	smoothed and average-case analysis <ul style="list-style-type: none"> <li>• simplex algorithm</li> <li>• local search algorithms</li> <li>• clustering algorithms</li> <li>• combinatorial optimization problems</li> <li>• multi-objective optimization</li> </ul>				
<b>Prerequisites</b>	<b>Required:</b> None of the following modules have been passed: MA-INF 1213 – Randomized Algorithms and Probabilistic Analysis				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	lecture notes, research articles				

<b>Module</b> MA-INF 1211	<b>Parameterized Complexity</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every 2 years		
<b>Module coordinator</b>	Prof. Dr. Stefan Kratsch				
<b>Lecturer(s)</b>	Prof. Dr. Stefan Kratsch				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1., 2. or 3.		
<b>Technical skills</b>	A fundamental understanding of the more fine-grained complexity analysis of NP-hard problems that is provided by parameterized complexity. Learning to employ a rich toolbox of techniques for upper and lower bounds on the complexity of parameterized problems.				
<b>Soft skills</b>	<ul style="list-style-type: none"> <li>• Social competence: solving exercise tasks in teams, presenting solutions</li> <li>• methodical competence: analysis, abstraction, proofs</li> <li>• individual competence: learning, reading scientific papers/book chapters, abstraction</li> </ul>				
<b>Contents</b>	<ul style="list-style-type: none"> <li>• Parameterized problems</li> <li>• Algorithmic techniques: bounded search trees, kernelization, treewidth, iterative compression, color coding, algebraic algorithms, etc.</li> <li>• Methods for establishing intractability: parameterized reductions, hardness under ETH/SETH, lower bounds for kernelization</li> </ul>				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Downey/Fellows: Fundamentals of Parameterized Complexity</li> <li>• Flum/Grohe: Parameterized Complexity Theory</li> <li>• Niedermeier: Invitation to Fixed Parameter Algorithms</li> <li>• Cygan et al.: Parameterized Algorithms (to appear)</li> </ul>				

<b>Module</b> MA-INF 1212	<b>Seminar Parameterized Complexity</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Stefan Kratsch				
<b>Lecturer(s)</b>	Prof. Dr. Stefan Kratsch				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers from parameterized complexity.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					



<b>Module</b> MA-INF 1213	<b>Randomized Algorithms and Probabilistic Analysis</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Heiko Röglin				
<b>Lecturer(s)</b>	Prof. Dr. Heiko Röglin				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 4.		
<b>Technical skills</b>	understanding of models and techniques for the probabilistic analysis of algorithms as well as for the design and analysis of randomized algorithms				
<b>Soft skills</b>	oral and written presentation of solutions and methods, abstract thinking				
<b>Contents</b>	<p>design and analysis of randomized algorithms</p> <ul style="list-style-type: none"> <li>• complexity classes</li> <li>• Markov chains and random walks</li> <li>• tail inequalities</li> <li>• probabilistic method</li> </ul> <p>smoothed and average-case analysis</p> <ul style="list-style-type: none"> <li>• simplex algorithm</li> <li>• local search algorithms</li> <li>• clustering algorithms</li> <li>• combinatorial optimization problems</li> <li>• multi-objective optimization</li> </ul>				
<b>Prerequisites</b>	<b>Required:</b> None of the following modules have been passed: MA-INF 1210 – Probabilistic Analysis of Algorithms				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• lecture notes</li> <li>• research articles</li> <li>• Motwani, Raghavan: Randomized Algorithms</li> <li>• Mitzenmacher, Upfal: Probability and Computing</li> </ul>				

<b>Module</b> MA-INF 1301	<b>Algorithmic Game Theory and the Internet</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every 2 years		
<b>Module coordinator</b>	Prof. Dr. Marek Karpinski				
<b>Lecturer(s)</b>	Prof. Dr. Marek Karpinski, Prof. Dr. Norbert Blum				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science		<b>Mode</b> Optional	<b>Semester</b> 2. or 3.	
<b>Technical skills</b>	The goal is to provide basic techniques and methods related to the Game Theory for analyzing modern Internet-based communication networks and for designing algorithms for the underlying problems of transmission control, resource allocation, mechanism design, market equilibria, combinatorial auctions, and the network cost allocation				
<b>Soft skills</b>	Presentation of solutions and methods, critical discussion of applied methods and techniques				
<b>Contents</b>	<p>The most defining characteristic of the Internet is that it was not designed by a single central entity, but emerged from the complex interactions of many individual entities or economic agents, such as network operators, service providers, designers, users, etc. We aim at providing basic framework and basic techniques for analyzing and designing algorithms for the following Internet-related problems and contexts: game theoretic problems connected to the Internet and other decentralized networks, resource allocation, mechanism design, Nash and market equilibria, network economics, combinatorial auctions, cost allocations and network design.</p> <p>We will address new broadly applicable and unifying techniques that have emerged recently in the above areas and discuss new fundamental paradigms in design of the relevant algorithms.</p>				
<b>Prerequisites</b>	<b>Recommended:</b> Introductory knowledge of foundations of algorithms and complexity theory is essential.				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• D. P. Bertsekas, A. Nedic, A. E. Ozdaglar: Convex Analysis and Optimization, Athena, 2003</li> <li>• M. Karpinski, W. Rytter: Fast Parallel Algorithms for Graph Matching Problems, Oxford Univ. Press, 1998</li> <li>• D. M. Kreps: A Course in Microeconomic Theory, Princeton Univ. Press, 1990</li> <li>• N. Nisan, T. Roughgarden, E. Tardos, V.V. Vazirani (ed.): Algorithmic Game Theory, Cambridge Univ. Press, 2007</li> <li>• M. J. Osborne, A. Rubinstein: A Course in Game Theory, MIT Press, 2001</li> </ul>				

<b>Module</b> MA-INF 1302	<b>Advanced Topics in Algorithmics</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every 2 years		
<b>Module coordinator</b>	Prof. Dr. Marek Karpinski				
<b>Lecturer(s)</b>	Prof. Dr. Marek Karpinski, Prof. Dr. Norbert Blum, Prof. Dr. Joachim von zur Gathen, Prof. Dr. Rolf Klein				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Introduction to current advanced research topics in algorithmic research				
<b>Soft skills</b>	Presentation of solutions and methods, critical discussion of applied methods and techniques				
<b>Contents</b>	The topic will be announced before the start of the relevant semester.				
<b>Prerequisites</b>	<b>Recommended:</b> Introductory knowledge of foundations of algorithms and complexity theory is essential.				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	Depending on the topics varying from semester to semester, the relevant research literature will be announced before the start of the resp. semester.				

<b>Module</b> MA-INF 1303	<b>Selected Topics in Algorithmics</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every 2 years		
<b>Module coordinator</b>	Prof. Dr. Norbert Blum				
<b>Lecturer(s)</b>	Prof. Dr. Norbert Blum, Prof. Dr. Rolf Klein, Prof. Dr. Marek Karpinski				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Introduction to current advanced research topics in algorithmic research				
<b>Soft skills</b>	Presentation of own and others' solutions and methods, critical discussion of applied methods, techniques and solutions.				
<b>Contents</b>	The topic will be announced before the start of the resp. semester.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	Depending on the topics varying from semester to semester, the relevant research literature will be announced before the start of the resp. semester.				

<b>Module</b> MA-INF 1304	<b>Seminar Geometric Distance Problems</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Rolf Klein				
<b>Lecturer(s)</b>	Prof. Dr. Rolf Klein, Dr. Elmar Langetepe				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2., 3. or 4.		
<b>Technical skills</b>	To Independently study problems at research level, based on research publications, to prepare a concise summary, to present the summary in a scientific talk, to lead a critical discussion  with other seminar participants.				
<b>Soft skills</b>					
<b>Contents</b>	Current topics in Computational Geometry.				
<b>Prerequisites</b>	<b>Recommended:</b> BA-INF 114 – Grundlagen der algorithmischen Geometrie				
<b>Format</b>	<b>Teaching format</b> Seminar	<b>Group size</b> 10	<b>h/week</b> 2	<b>Workload[h]</b> 30 T / 90 S	<b>CP</b> 4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>	Multimedia projector, black board.				
<b>Literature</b>	The relevant literature will be announced.				

<b>Module</b> MA-INF 1305	<b>Graduate Seminar Chip Design</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Jens Vygen				
<b>Lecturer(s)</b>	All lecturers of Discrete Mathematics				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	Competence to understand new theoretical results and practical solutions in VLSI design and related applications, as well as presentation of such results				
<b>Soft skills</b>	Ability to read and understand research papers, abstract thinking, presentation of mathematical results in a talk				
<b>Contents</b>	Current topics in chip design and related applications				
<b>Prerequisites</b>	<b>Required:</b> At least 1 of the following: MA-INF 1102 – Combinatorial Optimization MA-INF 1202 – Chip Design				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	4	60 T / 120 S	6
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The topics and the relevant literature will be announced towards the end of the previous semester				

<b>Module</b> MA-INF 1306	<b>Seminar Combinatorial and Geometric Optimization</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Marek Karpinski				
<b>Lecturer(s)</b>	Prof. Dr. Marek Karpinski, Prof. Dr. Norbert Blum, Prof. Dr. Rolf Klein				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	Presentation of selected topics in the above area				
<b>Soft skills</b>	Ability to perform individual literature search, critical reading, understanding, and clear didactic presentation				
<b>Contents</b>	Current topics in combinatorial and geometric optimization based on latest research literature				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The relevant literature will be announced in time.				

<b>Module</b> MA-INF 1307	<b>Seminar Advanced Algorithms</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Marek Karpinski				
<b>Lecturer(s)</b>	Prof. Dr. Marek Karpinski, Prof. Dr. Norbert Blum, Prof. Dr. Rolf Klein, Prof. Dr. Heiko Röglin				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	Presentation of selected advanced topics in algorithm design and various applications				
<b>Soft skills</b>	Ability to perform individual literature search, critical reading, understanding, and clear didactic presentation				
<b>Contents</b>	Advanced topics in algorithm design based on newest research literature				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	none				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	The relevant literature will be announced in time.				



<b>Module</b> MA-INF 1308	<b>Lab Algorithms for Chip Design</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Jens Vygen				
<b>Lecturer(s)</b>	All lecturers of Discrete Mathematics				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	Competence to implement algorithms for VLSI design, efficient handling of very large instances, testing, documentation. Advanced software techniques.				
<b>Soft skills</b>	Efficient implementation of complex algorithms, abstract thinking, modelling of optimization problem in VLSI design, documentation of source code				
<b>Contents</b>	A currently challenging problem will be chosen each semester. The precise task will be explained in a meeting in the previous semester.				
<b>Prerequisites</b>	<b>Required:</b> At least 3 of the following: MA-INF 1102 – Combinatorial Optimization MA-INF 1202 – Chip Design MA-INF 1205 – Graduate Seminar Discrete Optimization MA-INF 1208 – Applications of Cryptography				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The topics and the relevant literature will be announced towards the end of the previous semester				

<b>Module</b> MA-INF 1309	<b>Lab Efficient Algorithms for Selected Problems: Design, Analysis and Implementation</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every year		
<b>Module coordinator</b>	Prof. Dr. Marek Karpinski				
<b>Lecturer(s)</b>	Prof. Dr. Marek Karpinski, Prof. Dr. Norbert Blum, Prof. Dr. Rolf Klein, Prof. Dr. Heiko Röglin				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	Ability to design, analyze and implement efficient algorithms for selected computational problems.				
<b>Soft skills</b>	ability to work on advanced algorithmic implementation projects, to work in small teams, clear didactic presentation and critical discussion of results				
<b>Contents</b>	Design of efficient exact and approximate algorithms and data structures for selected computational problems.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The relevant literature will be announced in time.				

<b>Module</b> MA-INF 1312	<b>The Art of Cryptography</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Joachim von zur Gathen				
<b>Lecturer(s)</b>	Prof. Dr. Joachim von zur Gathen, Dr. Michael Nüsken				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Insights into the theoretical foundations behind security concerns and measures, and of the interplay between computing power, and security requirements. Mastery of advanced techniques for cryptosystems and cryptanalysis.				
<b>Soft skills</b>	Oral presentation (in tutorial groups), written presentation (of exercise solutions), team collaboration in solving homework problems, critical assessment				
<b>Contents</b>	Possible topics are <ul style="list-style-type: none"> <li>• pseudorandomness and zero-knowledge,</li> <li>• security reductions,</li> <li>• lattices.</li> </ul>				
<b>Prerequisites</b>	<b>Recommended:</b> MA-INF 1103 – Cryptography				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	Varying				

<b>Module</b> MA-INF 1313	<b>Topics in Theoretical Cryptography</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Joachim von zur Gathen				
<b>Lecturer(s)</b>	Prof. Dr. Joachim von zur Gathen, Dr. Michael Nüsken				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science		<b>Mode</b> Optional	<b>Semester</b> 3.	
<b>Technical skills</b>	Gain deeper understanding in a special area of cryptography close to current research.				
<b>Soft skills</b>	Oral presentation (in tutorial groups), written presentation (of exercise solutions), team collaboration in solving homework problems, critical assessment.				
<b>Contents</b>	One varying, advanced topic related to current research in theoretical cryptography, e.g. <ul style="list-style-type: none"> <li>• elliptic curve cryptography, or</li> <li>• quantum cryptography</li> </ul>				
<b>Prerequisites</b>	<b>Required:</b> MA-INF 1103 – Cryptography and one further course in cryptography like The Art of Cryptography or eSecurity.				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	Research articles				

<b>Module</b> MA-INF 1314	<b>Online Motion Planning</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Rolf Klein				
<b>Lecturer(s)</b>	Prof. Dr. Rolf Klein, PD Dr. Elmar Langetepe				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1., 2., 3. or 4.		
<b>Technical skills</b>	To acquire fundamental knowledge on topics and methods in online motion planning;				
<b>Soft skills</b>					
<b>Contents</b>	Search and exploration in unknown environments (e.g., graphs, cellular environments, polygons, streets), online algorithms, competitive analysis, competitive complexity, functional optimization, shortest watchman route, tethered robots, marker algorithms, spiral search, approximation of optimal search paths.				
<b>Prerequisites</b>	<b>Recommended:</b> BA-INF 114 – Grundlagen der algorithmischen Geometrie				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>	Java applets of geometry lab				
<b>Literature</b>	Scientific research articles will be recommended in the lecture.				

<b>Module</b> MA-INF 1315	<b>Lab Computational Geometry</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Rolf Klein				
<b>Lecturer(s)</b>	Prof. Dr. Rolf Klein, PD Dr. Elmar Langetepe				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Ability to design, analyze, implement and document efficient algorithms for selected problems in computational geometry.				
<b>Soft skills</b>	Ability to properly present, defend and discuss design and implementation decisions, to document software according to given rules and to collaborate with other students in small groups.				
<b>Contents</b>	Various problems in computational geometry.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The relevant literature will be announced in time.				

<b>Module</b> MA-INF 1317	<b>Lab Parameterized Complexity</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Stefan Kratsch				
<b>Lecturer(s)</b>	Prof. Dr. Stefan Kratsch				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	The ability to turn theoretical results from parameterized complexity into functioning code. Engineering, testing, and evaluation of the achieved performance.				
<b>Soft skills</b>	Managing projects in small teams over a longer period of time. Presentation and discussion of obtained results.				
<b>Contents</b>	Implementation of algorithms from parameterized complexity, i.e., both fixed-parameter tractable algorithms as well as kernelization algorithms. Testing and engineering of the obtained code.  Concrete topics are subject to change.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 1318	<b>Theoretical Aspects of Intruder Search</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	PD Dr. Elmar Langetepe				
<b>Lecturer(s)</b>	PD Dr. Elmar Langetepe				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1.		
<b>Technical skills</b>	To acquire fundamental knowledge on topics and methods in theoretical and algorithmic aspects of intruder search in geometric and discrete environments;				
<b>Soft skills</b>					
<b>Contents</b>	Intruder/Evader search in geometric and discrete environments, Fire-Fighter problem, Fire Control on graphs and in the plane, Man-and-Lion problem, Two-Guards problem, Search Games, Mobile and immobile hidens, Patrolling algorithms.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	Scientific research articles will be recommended in the lecture.				



## 2 Graphics, Vision, Audio

MA-INF 2111	L2E2	6 CP	Foundations of Graphics .....	34
MA-INF 2113	L2E2	6 CP	Foundations of Audio Signal Processing .....	35
MA-INF 2201	L4E2	9 CP	Computer Vision .....	36
MA-INF 2202	L4E2	9 CP	Computer Animation .....	37
MA-INF 2203	L4E2	9 CP	Selected Topics in Signal Processing .....	38
MA-INF 2204	L2E2	6 CP	Rendering Techniques I .....	39
MA-INF 2205	L2E2	6 CP	Geometry Processing I .....	40
MA-INF 2206	Sem2	4 CP	Seminar Vision .....	41
MA-INF 2207	Sem2	4 CP	Seminar Graphics .....	42
MA-INF 2208	Sem2	4 CP	Seminar Audio .....	43
MA-INF 2209	L4E2	9 CP	Advanced Topics in Computer Graphics I .....	44
MA-INF 2210	Sem2	4 CP	Seminar Computer Animation .....	45
MA-INF 2212	L2E2	6 CP	Selected Topics in Signal Processing .....	46
MA-INF 2213	L3E1	6 CP	Computer Vision II .....	47
MA-INF 2214	L2E2	6 CP	Computational Photography .....	48
MA-INF 2215	Sem2	4 CP	Seminar Digital Material Appearance .....	49
MA-INF 2216	Lab4	9 CP	Lab Visual Computing .....	50
MA-INF 2301	L2E2	6 CP	Advanced Topics in Computer Vision .....	51
MA-INF 2302	L2E2	6 CP	Physics-based Modelling .....	52
MA-INF 2304	L2E2	6 CP	Rendering Techniques II .....	53
MA-INF 2305	L2E2	6 CP	Geometry Processing II .....	54
MA-INF 2306	L2E2	6 CP	Virtual Reality .....	55
MA-INF 2307	Lab4	9 CP	Lab Vision .....	56
MA-INF 2308	Lab4	9 CP	Lab Graphics .....	57
MA-INF 2309	Lab4	9 CP	Lab Audio .....	58
MA-INF 2310	L4E2	9 CP	Advanced Topics in Computer Graphics II .....	59
MA-INF 2311	Lab4	9 CP	Lab Computer Animation .....	60
MA-INF 2312	L3E1	6 CP	Image Acquisition and Analysis in Neuroscience .....	61

<b>Module</b> MA-INF 2111	<b>Foundations of Graphics</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Reinhard Klein				
<b>Lecturer(s)</b>	Prof. Dr. Reinhard Klein, Prof. Dr. Andreas Weber, Prof. Dr. Matthias Hullin				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1. or 2.		
<b>Technical skills</b>	Knowledge of basic mathematical techniques commonly used in Graphics with a strong emphasis on their application to real world problems.				
<b>Soft skills</b>	Research abilities, information retrieval abilities, collaboration abilities, self management, creativity.				
<b>Contents</b>	Affine and projective transformations with applications to image formation (rigid body motion, cinematic chains); Parametric curves and surfaces with applications to 3D modelling; Ordinary differential equations with applications to physical based modelling				
<b>Prerequisites</b>	<b>Required:</b> None of the following modules have been passed: MA-INF 2101 – Foundations of Graphics, Vision and Audio				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 2113	<b>Foundations of Audio Signal Processing</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	apl. Prof. Dr. Frank Kurth				
<b>Lecturer(s)</b>	apl. Prof. Dr. Frank Kurth, Prof. Dr. Michael Clausen				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1.		
<b>Technical skills</b>	<ul style="list-style-type: none"> <li>• Introduction to basic concepts of analog and digital signal processing;</li> <li>• Applications in the field of Audio Signal Processing;</li> <li>• Signal Processing Algorithms;</li> <li>• Implementing basic Signal Processing Algorithms</li> </ul>				
<b>Soft skills</b>	Solving basic Signal Processing Problems; Implementing Signal Processing Algorithms using state-of-the-art software frameworks;  Capability to analyze; Time management; Presentation skills;  Discussing own solutions and solutions of others, and working in groups.				
<b>Contents</b>	Theoretical introduction to analog and digital Signal Processing; Fourier Transforms; Analog to digital Conversion; Digital Filters; Audio Signal Processing Applications; Filter banks; Windowed Fourier Transform; 2D-Signal Processing				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>	Slides, Blackboard, Whiteboard				
<b>Literature</b>					

<b>Module</b> MA-INF 2201	<b>Computer Vision</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Juergen Gall				
<b>Lecturer(s)</b>	Prof. Dr. Juergen Gall				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1. or 2.		
<b>Technical skills</b>	Students will learn about various mathematical methods and their applications to computer vision problems.				
<b>Soft skills</b>	Productive work in small teams, development and realization of individual approaches and solutions, critical reflection of competing methods, discussion in groups.				
<b>Contents</b>	The class will cover a number of mathematical methods and their applications in computer vision. For example, linear filters, edges, derivatives, Hough transform, segmentation, graph cuts, mean shift, active contours, level sets, MRFs, expectation maximization, background subtraction, temporal filtering, active appearance models, shapes, optical flow, 2d tracking, cameras, 2d/3d features, stereo, 3d reconstruction, 3d pose estimation, articulated pose estimation, deformable meshes, RGBD vision.				
<b>Prerequisites</b>	<b>Recommended:</b> Basic knowledge of linear algebra, analysis, probability theory, C++ programming				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• R. Hartley, A. Zisserman: Multiple View Geometry in Computer Vision</li> <li>• R. Szeliski: Computer Vision: Algorithms and Applications</li> <li>• S. Prince: Computer Vision: Models, Learning, and Inference</li> </ul>				

<b>Module</b> MA-INF 2202	<b>Computer Animation</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Andreas Weber				
<b>Lecturer(s)</b>	Prof. Dr. Andreas Weber				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Students will learn fundamental paradigms used in computer animation. They will learn to use mathematical models of motions to come up with algorithmic solutions of problems of the synthesis of motions of virtual characters.				
<b>Soft skills</b>	Social competences (work in groups), communicative skills (written and oral presentation)				
<b>Contents</b>	Fundamentals of computer animation; kinematics; representations of motions; motion capturing; motion editing; motion synthesis; facial animations				
<b>Prerequisites</b>	<b>Recommended:</b> MA-INF 2111 – Foundations of Graphics				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Dietmar Jackel, Stephan Neunreither, Friedrich Wagner: Methoden der Computeranimation, Springer 2006</li> <li>• Rick Parent: Computer Animation: Algorithms and Techniques, Morgan Kaufman Publishers 2002</li> <li>• Frederic I. Parke , Keith Waters: Computer Facial Animation. A K Peters, Ltd. 1996</li> </ul>				

<b>Module</b> MA-INF 2203	<b>Selected Topics in Signal Processing</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	apl. Prof. Dr. Frank Kurth				
<b>Lecturer(s)</b>	apl. Prof. Dr. Frank Kurth, Prof. Dr. Michael Clausen				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Learning advanced as well as state of the art topics and techniques in digital signal processing. Study examples from the field of digital audio signal processing with a focus on music audio. Develop skills for analysing audio signals and designing audio features for selected application scenarios. Mathematical modelling of signal processing problems in practical applications. Design and implementation of corresponding algorithms and data structures solving those problems. Efficiency issues.				
<b>Soft skills</b>	Capability to analyze. Time management. Strength of purpose. Discussing own solutions and solutions of others.				
<b>Contents</b>	Advanced techniques for filter design, design and extraction of features describing multimedia signals, efficient DSP algorithms, general concepts for content-based analysis of multimedia signals. Selected signal processing applications, for example content-based music analysis, signal compression, denoising, source separation.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Lecture script and selected research publications</li> <li>• Hayes: Statistical Digital Signal Processing and Modelling, John Wiley, 1996</li> <li>• Proakis, Manolakis: Digital Signal Processing, Prentice Hall, 1996</li> <li>• Klapuri, Davy: Signal Processing, Methods for Music Transcription, Springer, 2006</li> </ul>				

<b>Module</b> MA-INF 2204	<b>Rendering Techniques I</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Reinhard Klein				
<b>Lecturer(s)</b>	Prof. Dr. Reinhard Klein				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science		<b>Mode</b> Optional	<b>Semester</b> 2.	
<b>Technical skills</b>	Analytical formulation of problems related to image synthesis and knowledge of techniques and algorithms for the generation of photorealistic image data. Knowledge of the major algorithms for the simulation of light distributions in 3D-scences and volume data sets. Self-dependent implementation of the basic algorithms.				
<b>Soft skills</b>	Analytical problem description, creativity, self-dependent solution of practical problems in the area of rendering, presentation of solution strategies and implementations, self-dependent literature research, collaboration abilities, self-management				
<b>Contents</b>	Topics among others will be: models for the description of optical material properties and light sources; transport, volume visualization and rendering equation; algorithms and techniques for the solution of the volume visualization and rendering equation; advanced methods for photorealistic image generation in real-time applications like 3D games. In addition, results from state of the art research will be presented.				
<b>Prerequisites</b>	<b>Recommended:</b> Algorithms and data structures, basic knowledge on multidimensional analysis und linear algebra, basic knowledge in stochastics and statistics, numerical analysis and numerical linear algebra, C++				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• L. Szirmay-Kalos: Monte-Carlo Methods in Global Illumination, Institute of Computer Graphics, Vienna University of Technology, Vienna. URL: <a href="http://citeseer.ist.psu.edu/szirmay-kalos00montecarlo.html">citeseer.ist.psu.edu/szirmay-kalos00montecarlo.html</a>, 1999/</li> <li>• P. Dutre, K. Bala, P. Bekaert: Advanced Global Illumination, 2nd ed., B&amp;T, 2006</li> <li>• M. Pharr, G. Humphreys: Physically Based Rendering, Elsevier, 2004</li> <li>• J. Kautz, J. Lehtinen, P.-P. Sloan: Precomputed Radiance Transfer: Theory and Practice, Siggraph Course Notes, 2005</li> </ul>				

<b>Module</b> MA-INF 2205	<b>Geometry Processing I</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Reinhard Klein				
<b>Lecturer(s)</b>	Prof. Dr. Reinhard Klein				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Analytical formulation of problems related to geometry processing and knowledge of techniques and algorithms to optimize, process and store geometry data. Especially, learning of techniques to generate highly detailed three-dimensional digital models of real objects and to implement current geometry processing algorithms.				
<b>Soft skills</b>	Analytical problem description, creativity, self-dependent solution of practical problems in the area of mesh processing, presentation of solution strategies and implementations, self-dependent literature research, collaboration abilities, self-management				
<b>Contents</b>	Topics among other will be: Methods for the generation of polygonal meshes (Laser scanning, registration and integration of single mesh parts, etc.), Point based representations, Reconstruction techniques, Efficient mesh data structures and mesh compression, Optimization: denoising and smoothing, Mesh decimation and refinement, Hierarchical representations: coarse-to-fine und fine-to-coarse, Editing of polygonal meshes. In addition results from state of the art research will be presented.				
<b>Prerequisites</b>	<b>Recommended:</b> Algorithms and data structures or knowledge of basic discrete differential geometry, knowledge on multidimensional analysis und linear algebra as well as numerical analysis and numerical linear algebra, C++				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• R. Scopigno, C. Andujar, M. Goesele, H. Lensch: 3D Data Acquisition, Eurographics Tutorial, 2002</li> <li>• E. Grinspun, M. Desbrun (organizers): Discrete Differential Geometry: An Applied Introduction, Siggraph Course Notes, 2006</li> <li>• M. Botsch, M. Pauly: Geometric Modeling Based on Triangle Meshes, Siggraph Course Notes, 2006</li> </ul>				



<b>Module</b> MA-INF 2206	<b>Seminar Vision</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Juergen Gall				
<b>Lecturer(s)</b>	Prof. Dr. Juergen Gall				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers.				
<b>Prerequisites</b>	<b>Required:</b> MA-INF 2201 – Computer Vision				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 2207	<b>Seminar Graphics</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Reinhard Klein				
<b>Lecturer(s)</b>	Prof. Dr. Reinhard Klein				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers.				
<b>Prerequisites</b>	<b>Recommended:</b> Mathematical background (multidimensional analysis and linear algebra, basic numerical methods) Basic knowledge in Computer Graphics				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 2208	<b>Seminar Audio</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	apl. Prof. Dr. Frank Kurth				
<b>Lecturer(s)</b>	apl. Prof. Dr. Frank Kurth, Dr. Michael Clausen				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 2209	<b>Advanced Topics in Computer Graphics I</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Reinhard Klein				
<b>Lecturer(s)</b>	Prof. Dr. Reinhard Klein				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Analytical formulation of problems related to geometry processing and rendering. Knowledge of techniques and algorithms to optimize, process, analyze and store geometry and reflectance data as well as knowledge of the major algorithms for the simulation of light distributions in 3D-scences and volume data sets. Self-dependent implementation of the basic algorithms.				
<b>Soft skills</b>	Based on the knowledge and skills acquired students should be able to <ul style="list-style-type: none"> <li>• read and judge current scientific literature in the area of geometry processing and rendering</li> <li>• identify the major literature concerning a given problem in geometry processing or rendering and gain an overview of the current state of the art</li> <li>• discuss problems concerning geometry processing or rendering with researchers from different application fields</li> <li>• present and propose different solutions and work in a team to solve a mesh processing or rendering problem</li> <li>• and should have acquired key-competences like motivation to deliver results, flexibility, scientific integrity, ability to adapt to changes and ability to communicate</li> </ul>				
<b>Contents</b>	Topics among other will be: <ul style="list-style-type: none"> <li>• methods for the generation of polygonal meshes from point clouds</li> <li>• efficient mesh data structures and mesh compression</li> <li>• mesh optimization techniques: denoising, smoothing, decimation, refinement</li> <li>• mesh editing techniques</li> <li>• optical material properties and light sources</li> <li>• light transport and rendering equation</li> <li>• algorithms and techniques for the solution of the rendering equation</li> <li>• advanced methods for photorealistic image generation.</li> </ul> In addition, results from state of the art research will be presented.				
<b>Prerequisites</b>	<b>Required:</b> Basic knowledge in computer graphics, data structures, multidimensional analysis und linear algebra, numerical analysis and numerical linear algebra, C++				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• M. Botsch, L. Kobbelt, M. Pauly, P. Alliez, B. Levy, Polygon Mesh Processing, A K Peters (7. Oktober 2010)</li> <li>• M. Gross, HP. Pfister, Point-Based Graphics, Morgan Kaufmann (21. Juni 2007)</li> <li>• R. Scopigno, C. Andujar, M. Goesele, H. Lensch: 3D Data Acquisition, Eurographics Tutorial, 2002</li> <li>• E. Grinspun, M. Desbrun (organizers): Discrete Differential Geometry: An Applied Introduction, Siggraph Course Notes, 2006</li> <li>• L. Szirmay-Kalos: Monte-Carlo Methods in Global Illumination, Institute of Computer Graphics, Vienna University of Technology, Vienna. URL: <a href="http://citeseer.ist.psu.edu/szirmay-kalos00montecarlo.html">citeseer.ist.psu.edu/szirmay-kalos00montecarlo.html</a>, 1999/</li> <li>• P. Dutre, K. Bala, P. Bekaert: Advanced Global Illumination, 2nd ed., B&amp;T, 2006</li> <li>• M. Pharr, G. Humphreys: Physically Based Rendering, Elsevier, 2nd revised edition. (26. August 2010)</li> </ul>				

<b>Module</b> MA-INF 2210	<b>Seminar Computer Animation</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Andreas Weber				
<b>Lecturer(s)</b>	Prof. Dr. Andreas Weber				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers.				
<b>Prerequisites</b>	<b>Recommended:</b> At least 1 of the following: MA-INF 2202 – Computer Animation MA-INF 2311 – Lab Computer Animation				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 2212	<b>Selected Topics in Signal Processing</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	apl. Prof. Dr. Frank Kurth				
<b>Lecturer(s)</b>	apl. Prof. Dr. Frank Kurth, Prof. Dr. Michael Clausen				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	<ul style="list-style-type: none"> <li>• Introduction into selected topics of digital signal processing;</li> <li>• Applications in the field of Audio Signal Processing;</li> <li>• Methods of Automatic Pattern Recognition</li> </ul>				
<b>Soft skills</b>	<p>Audio Signal Processing Applications; Extended programming skills</p> <p>for signal processing applications;</p> <p>Capability to analyze; Time management; Presentation skills;</p> <p>Discussing own solutions and solutions of others, and working in groups.</p>				
<b>Contents</b>	The lecture is presented in modular form, where each module is motivated from the application side. The presented topics are: Windowed Fourier transforms; Audio Identifications; Audio Matching; Signal Classification; Hidden Markov Models; Support Vector Machines				
<b>Prerequisites</b>	<b>Required:</b> None of the following modules have been passed: MA-INF 2203 – Selected Topics in Signal Processing				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>	Slides, Blackboard, Whiteboard				
<b>Literature</b>					

<b>Module</b> MA-INF 2213	<b>Computer Vision II</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Juergen Gall				
<b>Lecturer(s)</b>	Prof. Dr. Juergen Gall				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Students will learn about various learning methods and their applications to computer vision problems.				
<b>Soft skills</b>	Productive work in small teams, development and realization of individual approaches and solutions, critical reflection of competing methods, discussion in groups.				
<b>Contents</b>	The class will cover a number of learning methods and their applications in computer vision. For example, linear methods for classification and regression, boosting, random forests, neural networks, SVMs, prototype methods, nearest neighbors, Gaussian processes, Dirichlet processes, image classification, object detection, action recognition, pose estimation, face analysis.				
<b>Prerequisites</b>	<b>Required:</b> MA-INF 2201 – Computer Vision				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	3	45 T / 45 S	3
	Exercises	30	1	15 T / 75 S	3
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• T. Hastie, R. Tibshirani, J. Friedman: The Elements of Statistical Learning: Data Mining, Inference, and Prediction</li> <li>• C. Bishop: Pattern Recognition and Machine Learning</li> </ul>				

<b>Module</b> MA-INF 2214	<b>Computational Photography</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Matthias Hullin				
<b>Lecturer(s)</b>					
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Foundations in optics and image sensors. Signal processing and inverse problems in imaging. Color spaces and perception. Image alignment and blending. High-dimensional representations of light transport (light fields, reflectance fields, reflectance distributions). Computational illumination.				
<b>Soft skills</b>	<p>Students learn</p> <ul style="list-style-type: none"> <li>• to read and understand current literature in the field</li> <li>• to implement standard computational photography techniques</li> <li>• to propose and implement solutions to a given problem</li> <li>• to follow good scientific practice by planning, documenting and communicating their work</li> </ul>				
<b>Contents</b>	<p>Topics:</p> <ul style="list-style-type: none"> <li>• Image sensors</li> <li>• Optics</li> <li>• Panoramas</li> <li>• Light fields</li> <li>• Signal processing and inverse problems</li> <li>• Color, perception and HDR</li> <li>• Reflectance fields and light transport matrices</li> </ul>				
<b>Prerequisites</b>	<p><b>Required:</b> Basic knowledge in computer graphics, data structures, multidimensional analysis und linear algebra, numerical analysis and numerical linear algebra, C++ or MATLAB</p>				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					



<b>Module</b> MA-INF 2215	<b>Seminar Digital Material Appearance</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Matthias Hullin				
<b>Lecturer(s)</b>					
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 2216	<b>Lab Visual Computing</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Jun-Prof. Dr. Angela Yao				
<b>Lecturer(s)</b>	Jun-Prof. Dr. Angela Yao				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1., 2., 3. or 4.		
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of computer vision, including test and documentation of the implemented software/system.				
<b>Soft skills</b>	Ability to properly present and defend design decisions, to prepare readable documentation of software; skills in constructively collaborating with others in small teams over a longer period of time; ability to classify ones own results into the state-of-the-art of the resp. area				
<b>Contents</b>	This lab introduces computer vision methods and applications. You will get a chance to study the methods in depth by implementing them and running experiments. At the end of the semester, you will present the method, give a short demonstration and hand in a report describing the method and experimental outcomes.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 2301	<b>Advanced Topics in Computer Vision</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	NN				
<b>Lecturer(s)</b>					
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	Advanced computer vision methods				
<b>Soft skills</b>	Productive work in small teams, development and realization of individual approaches and solutions, critical reflection of competing methods, discussion in groups.				
<b>Contents</b>	The class focuses on advanced topics in the fields of computer vision and image processing. In particular, it will make students familiar with recent developments in computer vision research.				
<b>Prerequisites</b>	<b>Recommended:</b> MA-INF 2201 – Computer Vision				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	Latest topic-related research articles and literature will be announced in advance of the lecture.				

<b>Module</b> MA-INF 2302	<b>Physics-based Modelling</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every 2 years		
<b>Module coordinator</b>	Prof. Dr. Andreas Weber				
<b>Lecturer(s)</b>	Prof. Dr. Andreas Weber				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	Students learn the fundamental techniques of physics-based modelling for computer graphics and computer animation. The students shall be able to choose appropriate mathematical models. Knowing the algorithmic techniques and algorithmic issues, they shall be able to come up with software solutions for specific problems.				
<b>Soft skills</b>	Social competences (work in groups), communicative skills (written and oral presentation)				
<b>Contents</b>	Initial value problems; particle simulation; rigid body simulation; multi-body-systems; collision detection; collisions response; cloth modelling; hair modelling; physics-based motion synthesis				
<b>Prerequisites</b>	<b>Recommended:</b> all of the following: MA-INF 2111 – Foundations of Graphics – ???				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Dietmar Jackel, Stephan Neunreither, Friedrich Wagner: Methoden der Computeranimation, Springer 2006</li> <li>• David M. Bourg: Physics for Game Developers, O'Reilly</li> <li>• Advanced course notes on physics-based modelling</li> </ul>				

<b>Module</b> MA-INF 2304	<b>Rendering Techniques II</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Reinhard Klein				
<b>Lecturer(s)</b>	Prof. Dr. Reinhard Klein				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science		<b>Mode</b> Optional	<b>Semester</b> 3.	
<b>Technical skills</b>	Analytical formulation of problems related to image based rendering and knowledge of advanced techniques in the field of rendering. Knowledge of methods and models for the acquisition and description of light sources and optical material properties for Computer Graphics applications. Knowledge of methods and models for the acquisition and description of image based rendering techniques and digital photography. Self-dependent implementation of the basic algorithms.				
<b>Soft skills</b>	Analytical problem description, creativity, self-dependent solution of practical problems in the area of image based rendering and digital photography, presentation of solution strategies and implementations, self-dependent literature research, collaboration abilities, self-management				
<b>Contents</b>	Topics among others will be: advanced material acquisition and modelling techniques; algorithms and techniques of image based rendering; digital photography for image based scene modelling and rendering; computational photography				
<b>Prerequisites</b>	<b>Recommended:</b> Algorithms and data structures, basic knowledge on multidimensional analysis und linear algebra, basic knowledge in stochastic and statistics, numerical analysis and numerical linear algebra, C++				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• H.P.A. Lensch, M. Goesele (organizers): Realistic Materials in Computer Graphics, Siggraph Course Notes, 2005</li> <li>• P. Debevec, E. Reinhard (organizers): High-Dynamic-Range Imaging: Theory and Applications, Siggraph Course Notes, 2006</li> <li>• N. Hoffman (organizer): Physically Based Reflectance for Games, Siggraph Course Notes, 2006</li> <li>• R. Raskar, J. Tumblin (organizers): Computational Photography, Siggraph Course Notes, 2006</li> </ul>				

<b>Module</b> MA-INF 2305	<b>Geometry Processing II</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Reinhard Klein				
<b>Lecturer(s)</b>	Prof. Dr. Reinhard Klein				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	Analytical formulation of problems related to geometry processing, shape analysis and shape retrieval as well as knowledge of advanced algorithms and techniques from these fields. Self-dependent implementation of the algorithms.				
<b>Soft skills</b>	Analytical problem description, creativity, self-dependent solution of practical problems in the area of image based rendering and digital photography, presentation of solution strategies and implementations, self-dependent literature research, collaboration abilities, self-management				
<b>Contents</b>	<p>This class is focussed on advanced topics in the field of geometry processing. Students will get familiar with recent developments in the area of shape analysis and shape retrieval. Topics among others will be</p> <ul style="list-style-type: none"> <li>• Parameterization of surfaces</li> <li>• Shape segmentation and shape similarity</li> <li>• Shape classification and content based retrieval</li> <li>• Shape spaces and statistical shape analysis</li> </ul>				
<b>Prerequisites</b>	<p><b>Recommended:</b> Algorithms and data structures, basic knowledge on multidimensional analysis und linear algebra, basic knowledge in stochastic and statistics, numerical analysis and numerical linear algebra, C++</p>				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• T. Funkhouser, M. Kazhdan, Shape-Based Retrieval and Analysis of 3D-Models, Siggraph Course Notes, 2004</li> <li>• L. Dryden, K.V. Mardia, Statistical Shape Analysis, John Wiley &amp; Sons, 1998</li> <li>• H. Krim, Jr, A. Yezzi (editors): Statistics and Analysis of Shapes (Modeling an Simulation in Science, Engineering and Technology), Birkhäuser Boston, 2006</li> </ul>				

<b>Module</b> MA-INF 2306	<b>Virtual Reality</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Reinhard Klein				
<b>Lecturer(s)</b>	Prof. Dr. Reinhard Klein				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	Basic knowledge of hard- and software components of current VR-Systems, Broad knowledge of tracking-, collision detection- and real-time rendering algorithms, knowledge of methods to integrate haptic and sound, knowledge of GPU programming with emphasis on special effect generation, ability to implement components of a VR-System				
<b>Soft skills</b>	Analytical problem description, creativity, self-dependent solution of practical problems in the area of Virtual Reality, presentation of solution strategies and implementations, self-dependent literature research, collaboration abilities, self-management				
<b>Contents</b>	Scene Graphs, Stereo Seeing (HW, SW), Tracking (HW, SW), Acceleration Techniques (LOD; Culling), Collision detection, Haptics, Sound, Special effects (GPU-Programming)				
<b>Prerequisites</b>	<b>Recommended:</b> Mathematical background (multidimensional analysis and linear algebra, foundations of numerical methods), good knowledge of the foundations of computer graphics				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• K. Stanney (ed.): Handbook of Virtual Environments. Lawrence Erlbaum Associates, 2002</li> <li>• W. Sherman, A. Craig: Understanding Virtual Reality. Morgan Kaufman, 2002</li> <li>• D. Pape: Commodity-Based Projection VR, Siggraph Course Notes, 2006</li> <li>• N. Tatarchuk (organizer): Advanced Real-Time Rendering in gD Graphics and Games, Siggraph Course Notes, 2006</li> </ul>				

<b>Module</b> MA-INF 2307	<b>Lab Vision</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Juergen Gall				
<b>Lecturer(s)</b>	Prof. Dr. Juergen Gall				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of RGB-D cameras.				
<b>Soft skills</b>	Ability to properly present and defend design decisions, to prepare readable documentation of software; skills in constructively collaborating with others in small teams over a longer period of time; ability to classify ones own results into the state-of-the-art of the resp. area				
<b>Contents</b>	RGBD cameras: research topics and applications				
<b>Prerequisites</b>	<b>Required:</b> MA-INF 2201 – Computer Vision Good C++ programming skills				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	A. Fossati, J. Gall, H. Grabner, X. Ren, K. Konolige. Consumer Depth Cameras for Computer Vision: Research Topics and Applications				



<b>Module</b> MA-INF 2308	<b>Lab Graphics</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Reinhard Klein				
<b>Lecturer(s)</b>	Prof. Dr. Reinhard Klein				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of  geometry processing, rendering, scientific visualization or human computer interaction, including test and documentation of the implemented software/system.				
<b>Soft skills</b>	Ability to properly present and defend design decisions, to prepare  readable documentation of software; skills in constructively collaborating with others in small teams over a longer period of time; ability to classify ones own results into the state-of-the-art of the resp. area				
<b>Contents</b>	Varying selected topics close to current research in the area of geometry processing, rendering, scientific visualization or human computer interaction.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 2309	<b>Lab Audio</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	apl. Prof. Dr. Frank Kurth				
<b>Lecturer(s)</b>	apl. Prof. Dr. Frank Kurth, Prof. Dr. Michael Clausen				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science		<b>Mode</b> Optional	<b>Semester</b> 3.	
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of audio and music processing, including test and documentation of the implemented software/system.				
<b>Soft skills</b>	Ability to properly present and defend design decisions, to prepare readable documentation of software; skills in constructively collaborating with others in small teams over a longer period of time; ability to classify ones own results into the state-of-the-art of the resp. area.				
<b>Contents</b>					
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 2310	<b>Advanced Topics in Computer Graphics II</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Reinhard Klein				
<b>Lecturer(s)</b>					
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	<p>On completion students should be able to</p> <ul style="list-style-type: none"> <li>• apply methods of geometry and digital appearance processing to real world problems and design and implement novel application software in these areas</li> <li>• apply methods of shape segmentation and shape similarity to novel problems</li> <li>• design novel shape retrieval applications</li> <li>• apply basic concepts of statistical shape analysis and shape spaces to real world applications</li> <li>• apply geometric and radiometric calibration algorithms to camera based acquisition systems</li> <li>• select and apply light source and optical material models for computer graphics applications</li> </ul> <p>incorporate basic image based algorithms into rendering applications</p> <ul style="list-style-type: none"> <li>• and should have acquired soft skills like analytical problem description, creativity, self-dependent solution of practical problems, presentation of solution strategies and implementations, self-dependent literature research, collaboration abilities, self-management.</li> </ul>				
<b>Soft skills</b>					
<b>Contents</b>	<p>Topics among others will be:</p> <p>This class is focussed on advanced topics in the field of geometry and digital appearance processing. Students will get familiar with recent developments in the area of shape analysis, shape retrieval, material acquisition and modeling techniques. Topics among others will be</p> <ul style="list-style-type: none"> <li>• Parameterization of surfaces</li> <li>• Shape segmentation and shape similarity</li> <li>• Shape classification and content based retrieval</li> <li>• Shape spaces and statistical shape analysis</li> <li>• Optical material acquisition and modelling techniques</li> <li>• Algorithms and techniques of image based rendering</li> <li>• Digital photography for image based scene modelling and rendering</li> <li>• Basic computational photography</li> </ul>				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 2311	<b>Lab Computer Animation</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every year		
<b>Module coordinator</b>	Prof. Dr. Andreas Weber				
<b>Lecturer(s)</b>	Prof. Dr. Andreas Weber				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of computer animation, including test and documentation of the implemented software/system.				
<b>Soft skills</b>	Ability to properly present and defend design decisions, to prepare readable documentation of software; skills in constructively collaborating with others in small teams over a longer period of time; ability to classify ones own results into the state-of-the-art of the resp. area				
<b>Contents</b>	Varying selected topics close to current research in the area of computer animation.				
<b>Prerequisites</b>	<b>Recommended:</b> At least 1 of the following: MA-INF 2202 – Computer Animation MA-INF 2302 – Physics-based Modelling				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 2312	<b>Image Acquisition and Analysis in Neuroscience</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every 2 years		
<b>Module coordinator</b>	Jun.-Prof. Dr. Thomas Schultz				
<b>Lecturer(s)</b>	Jun.-Prof. Dr. Thomas Schultz				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1.-4..		
<b>Technical skills</b>	Students will learn about image acquisition and analysis pipelines which are used in neuroscience. They will understand algorithms for image reconstruction, artifact removal, image registration and segmentation, as well as relevant statistical and machine learning techniques. A particular focus will be on data from Magnetic Resonance Imaging and on mathematical models for functional and diffusion MRI data.				
<b>Soft skills</b>	Productive work in small teams, self-dependent solution of practical problems in the area of biomedical image processing, presentation of solution strategies and implementations, self management, critical reflection of conclusions drawn from complex experimental data.				
<b>Contents</b>	This course covers the full image formation and analysis pipeline that is typically used in biomedical studies, from image acquisition to image processing and statistical analysis.				
<b>Prerequisites</b>	<b>Recommended:</b> Mathematical background (calculus, linear algebra, statistics); imperative programming.				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	3	45 T / 45 S	3
	Exercises	30	1	15 T / 75 S	3
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• B. Preim, C. Botha: Visual Computing for Medicine: Theory, Algorithms, and Applications. Morgan Kaufmann, 2014</li> <li>• R.A. Poldrack, J.A. Mumford, T.E. Nichols: Handbook of Functional MRI Data Analysis. Cambridge University Press, 2011</li> <li>• D.K. Jones: Diffusion MRI: Theory, Method, and Applications, Oxford University Press, 2011</li> </ul>				

### 3 Information and Communication Management

MA-INF 3104	L2E2	6 CP	Intelligent Analysis of Data Streams	63
MA-INF 3105	L2E2	6 CP	Principles of Distributed Systems	64
MA-INF 3106	L2E2	6 CP	Privacy in Ubiquitous Computing	65
MA-INF 3201	L2E2	6 CP	Network Security	66
MA-INF 3202	L2E2	6 CP	Mobile Communication	67
MA-INF 3203	L2E2	6 CP	Intelligent Information Systems	68
MA-INF 3207	L2E2	6 CP	Advanced Logic Programming	69
MA-INF 3209	Sem2	4 CP	Seminar Selected Topics in Communication Management	70
MA-INF 3210	Sem2	4 CP	Seminar Intelligent Information Systems	71
MA-INF 3213	L2E2	6 CP	Advanced Topics in Information Systems	72
MA-INF 3214	Sem2	4 CP	Seminar Selected Topics in Information Management	73
MA-INF 3215	Sem2	4 CP	Seminar Selected Topics in Malware Analysis and Computer/Network Security	74
MA-INF 3216	Sem2	4 CP	Seminar Sensor Data Fusion	75
MA-INF 3218	Sem2	4 CP	Seminar Model-Driven Software Engineering	76
MA-INF 3219	Lab4	9 CP	Lab Model-Driven Software Engineering	77
MA-INF 3222	L4E2	9 CP	eSecurity	78
MA-INF 3228	L2E2	6 CP	Foundations of Information Systems Security	79
MA-INF 3229	Lab4	9 CP	Lab IT-Security	80
MA-INF 3230	L2E2	6 CP	Enterprise Information Systems	81
MA-INF 3231	Sem2	4 CP	Seminar Enterprise Information Systems	82
MA-INF 3232	Lab4	9 CP	Lab Enterprise Information Systems	83
MA-INF 3233	L2E2	6 CP	Advanced Sensor Data Fusion in Distributed Systems	84
MA-INF 3234	Lab4	9 CP	Lab Mobile Sensing Systems	85
MA-INF 3235	L2E2	6 CP	Usable Security and Privacy	86
MA-INF 3236	L2E2	6 CP	IT Security	87
MA-INF 3302	L2E2	6 CP	Temporal Information Systems	88
MA-INF 3304	Lab4	9 CP	Lab Communication and Communicating Devices	89
MA-INF 3305	Lab4	9 CP	Lab Information Systems	90
MA-INF 3309	Lab4	9 CP	Lab Malware Analysis	91
MA-INF 3310	L2E2	6 CP	Introduction to Sensor Data Fusion - Methods and Applications	92
MA-INF 3311	L4E2	9 CP	Topics in Applied Cryptography	93
MA-INF 3312	Lab4	9 CP	Lab Sensor Data Fusion	94
MA-INF 3313	Lab4	9 CP	Lab Intelligent Information Systems	95
MA-INF 3314	L2E2	6 CP	Advanced Topics in Information Systems Security	96
MA-INF 3315	Sem2	4 CP	Seminar Advanced Information Systems Security	97
MA-INF 3316	Lab4	9 CP	Lab Techniques in Information Systems Security	98
MA-INF 3317	Sem2	4 CP	Seminar Selected Topics in IT Security	99
MA-INF 3318	Sem2	4 CP	Seminar Verification of Complex Systems	100
MA-INF 3319	Lab4	9 CP	Lab Usable Security and Privacy	101
MA-INF 3320	Lab4	9 CP	Lab Security in Distributed Systems	102
MA-INF 3321	Sem2	4 CP	Seminar Usable Security and Privacy	103

<b>Module</b> MA-INF 3104	<b>Intelligent Analysis of Data Streams</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	PD Dr. Andreas Behrend				
<b>Lecturer(s)</b>	PD Dr. Andreas Behrend				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science		<b>Mode</b> Optional	<b>Semester</b> 1.	
<b>Technical skills</b>					
<b>Soft skills</b>					
<b>Contents</b>					
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3105	<b>Principles of Distributed Systems</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Peter Martini				
<b>Lecturer(s)</b>	Dr. Markus Esch				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1., 2. or 3.		
<b>Technical skills</b>	The students learn fundamental principles of distributed computer systems and learn to apply them in practice. This includes architectures of distributed systems, key concepts like fault tolerance and consistency as well as important algorithms for synchronization, distributed mutual exclusion, election etc. Moreover concepts of structured and unstructured overlay networks as self-organization, overlay routing, modeling of complex random networks etc. will be taught.				
<b>Soft skills</b>	Theoretical exercises are given in order to support in-depth understanding of the lecture topics. In the course of these exercises students learn to present their results and discuss their own and others' solutions. In the course of practical assignments that need to be solved in small teams the students learn teamwork, time management, targeted organization of practical work as well as presentation and discussion of their solutions.				
<b>Contents</b>	<ul style="list-style-type: none"> <li>• Architectures of distributed systems</li> <li>• Physical clock synchronization and logical clocks</li> <li>• Distributed termination</li> <li>• Distributed mutual exclusion</li> <li>• Election in distributed systems</li> <li>• Fault tolerance of distributed systems</li> <li>• Consistency in distributed systems</li> <li>• Structured and unstructured overlays</li> <li>• Distributed hash tables</li> <li>• Modeling and characteristics of complex random networks</li> <li>• Overlay routing</li> </ul>				
<b>Prerequisites</b>	<b>Recommended:</b> BA-INF 101 "Kommunikation in Verteilten Systemen", or Bachelor-level knowledge of Data Communication and Internet Technology				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	<p>Scientific articles as mentioned on the lecture slides</p> <p>Tanenbaum, van Steen: Distributed Systems: Principles and Paradigms (2nd Edition), Prentice Hall, 2007; Steinmetz, Wehrle (Eds.): Peer-to-Peer Systems and Applications, Springer, 2005; Barrat, Barthelemy, Vespignani, Dynamical Processes on Complex Networks, Cambridge University Press, 2008</p>				



<b>Module</b> MA-INF 3106	<b>Privacy in Ubiquitous Computing</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Jun.-Prof. Dr. Delphine Christin				
<b>Lecturer(s)</b>	Jun.-Prof. Dr. Delphine Christin				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1., 2. or 3.		
<b>Technical skills</b>	Students gain knowledge about key concepts of privacy (including legal and economical aspects) and field of ubiquitous computing. They are able to identify threats to privacy in given application scenarios. They learn fundamental techniques to protect users' privacy. Relying on this background, they are able to understand and analyze cutting-edge solutions.				
<b>Soft skills</b>	Written and oral communicative skills, critical thinking and problem solving skills, teamwork, and time management				
<b>Contents</b>	Introduction to privacy and ubiquitous computing, privacy threats, privacy-enhancing systems in selected scenarios, usable privacy				
<b>Prerequisites</b>	<b>Recommended:</b> MA-INF 3202 – Mobile Communication				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<p>John Krumm, Ubiquitous Computing Fundamentals, Crc Pr Inc, 2009</p> <p>Alessandro Acquisti, Stefans Gritzalis, Costos Lambrinouidakis, Digital Privacy: Theory, Technologies, and Practices, Auerbach Pubn, 2007</p> <p>Mireille Hildebrandt, Kieron O'Hara, Michael Waidner, Robert Madelin, Digital Enlightenment Yearbook 2013: The Value of Personal Data, Ios Press, 2013</p> <p>Jan Camenisch, Simone Fischer-Hübner, Kai Rannenber, Privacy and Identity Management for Life, Springer, 2011</p> <p>Additional research literature will be announced during the lecture</p>				

<b>Module</b> MA-INF 3201	<b>Network Security</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Peter Martini				
<b>Lecturer(s)</b>	Prof. Dr. Peter Martini, Dr. Jens Tölle				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	The students learn fundamental concepts of network security. This includes risks and vulnerabilities of today's computer networks, concepts to increase the level of security in these networks, and a real-life oriented introduction to encryption techniques, their applications and their weaknesses.				
<b>Soft skills</b>	Theoretical exercises to support in-depth understanding of lecture topics and to stimulate discussions, practical exercises in teamwork to support time management, targeted organisation of practical work and critical discussion of own and others' results				
<b>Contents</b>	Threats and attack scenarios, organizational aspects, technical aspects: securing networks using different firewall concepts, IDS and IPS (intrusion detection systems and intrusion prevention systems), security protocols for different protocol layers, integrity protection: hash functions and their weaknesses, certificates, privacy protection, encryption.				
<b>Prerequisites</b>	<b>Recommended:</b> Bachelor level knowledge of basics of communication systems (e.g. BA-INF 101 "Kommunikation in Verteilten Systemen" (German Bachelor Programme Informatik, English lecture slides available) and/or MA-INF 3105 – Principles of Distributed Systems				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Christoph Busch, Stephen D. Wolthusen: Netzwerksicherheit, Spektrum Akademischer Verlag</li> <li>• Matt Bishop: Introduction to Computer Security, Addison Wesley</li> </ul>				

<b>Module</b> MA-INF 3202	<b>Mobile Communication</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Peter Martini				
<b>Lecturer(s)</b>	Prof. Dr. Peter Martini, Dr. Matthias Frank				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Knowledge about key concepts of mobile communication including mobility management (both technology independent and technology dependent), knowledge about wireless technologies and their interaction with other protocol layers and/or other network technologies, ability to evaluate and assess scenarios with communication of mobile devices. In-depth understanding of communication paradigms of wireless/mobile systems and network elements, productive work in small groups, strengthening skills on presentation and discussion of solutions to current challenges				
<b>Soft skills</b>	Theoretical exercises to support in-depth understanding of lecture topics and to stimulate discussions, practical exercises in teamwork to support time management, targeted organisation of practical work and critical discussion of own and others' results				
<b>Contents</b>	Mobility Management in the Internet, Wireless Communication Basics, Wireless Networking Technologies, Cellular/Mobile Communication Networks (voice and data communication), Ad-hoc and Sensor Networks.				
<b>Prerequisites</b>	<b>Recommended:</b> Bachelor level knowledge of basics of communication systems (e.g. BA-INF 101 "Kommunikation in Verteilten Systemen" (German Bachelor Programme Informatik, English lecture slides available) and/or MA-INF 3105 – Principles of Distributed Systems				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Jochen Schiller: Mobile Communications, Addison-Wesley, 2003</li> <li>• William Stallings: Wireless Communications and Networking, Prentice Hall, 2002</li> <li>• Further up-to-date literature will be announced in due course before the beginning of the lecture</li> </ul>				

<b>Module</b> MA-INF 3203	<b>Intelligent Information Systems</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Rainer Manthey				
<b>Lecturer(s)</b>	Prof. Dr. Rainer Manthey				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Students master the principles of management of derived data both theoretically and in practical systems development and application modeling. They are able to understand and classify the state-of-the-art in research in deductive databases.				
<b>Soft skills</b>	Communicative skills (oral/written presentation, “defending“ solutions), self-competence (time management, self-organisation, creativity), social skills (constructive discussion, sharing work in small teams)				
<b>Contents</b>	Syntax and semantics of deductive rules (views); efficient query processing in deductive DB; rule-based change management; IS design for rule-based applications				
<b>Prerequisites</b>	<b>Recommended:</b> Good knowledge of the foundations of SQL, predicate logic and set theory				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• C. Zaniolo, S. Ceri et al.: Advanced Database Systems, Morgan Kaufmann, San Francisco/USA, 1997</li> <li>• E. Bertino, G. Zarri, B. Catania: Intelligent Database Systems, Addison Wesley, 2001</li> </ul>				

<b>Module</b> MA-INF 3207	<b>Advanced Logic Programming</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Dr. Günter Kniesel				
<b>Lecturer(s)</b>	Dr. Günter Kniesel, Jun.-Prof. Dr. Janis Voigtländer				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Ability to master advanced logic programming techniques and to write clean but highly efficient Prolog programs using these techniques; competence in problem solving using the declarative paradigm; competence in using the non-logical features of Prolog;				
<b>Soft skills</b>	Skills in written and oral presentation of the solutions to programming assignments, collaboration with other students in small teams				
<b>Contents</b>	Quick refresh of logic programming basics and a Prolog development environment, searching, understanding backtracking and the cut, context arguments, difference lists, data structures, constraint programming, meta-programming, meta-interpreters, partial evaluation, partial evaluation of meta-interpreters, efficient Prolog programming, logic program analysis.				
<b>Prerequisites</b>	<b>Recommended:</b> Good knowledge of the foundations of Logic Programming				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	W. Clocksin, C. Mellish: Programming in Prolog, Springer. • L. Sterling, E. Shapiro (ed.): The Art of Prolog (2nd ed.) MIT Press. • Richard O’Keefe: The Craft of Prolog, MIT Press.				

<b>Module</b> MA-INF 3209	<b>Seminar Selected Topics in Communication Management</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every year		
<b>Module coordinator</b>	Prof. Dr. Peter Martini				
<b>Lecturer(s)</b>	Prof. Dr. Peter Martini, Prof. Dr. Michael Meier				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers, current standardization drafts				
<b>Prerequisites</b>	<b>Required:</b> Successful completion of at least one of the following lectures: Principles of Distributed Systems (MA-INF3105), Network Security (MA-INF3201), Mobile Communication (MA-INF3202), IT Security (MA-INF3236)				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The relevant literature will be announced towards the end of the previous semester				

<b>Module</b> MA-INF 3210	<b>Seminar Intelligent Information Systems</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every year		
<b>Module coordinator</b>	Prof. Dr. Rainer Manthey				
<b>Lecturer(s)</b>	Prof. Dr. Rainer Manthey				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Ability to acquire and evaluate advanced scientific literature; skills in didactic preparation as well as oral presentation of complex matters and latest research results; ability to evaluate and discuss presentations of fellow students, and to constructively deal with critical feedback of others				
<b>Soft skills</b>					
<b>Contents</b>	Varying selected topics in intelligent information systems based on modern research literature				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The relevant literature will be announced towards the end of the previous semester.				

<b>Module</b> MA-INF 3213	<b>Advanced Topics in Information Systems</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Jun.-Prof. Dr. Alexander Markowetz				
<b>Lecturer(s)</b>	Jun.-Prof. Dr. Alexander Markowetz				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1., 2. or 3.		
<b>Technical skills</b>	An in-depth understanding of the topic under investigation. A command of the concepts and terminologies, in order to discuss and compare the various systems, algorithms and approaches. The ability to implement the presented systems and algorithms. The ability to dissect (i) the logic of arguments and (ii) experimental setups deployed by publications in this area.				
<b>Soft skills</b>	<ul style="list-style-type: none"> <li>• Oral discussion and presentation in classes and tutorials.</li> <li>• Written presentation of exercise solutions.</li> <li>• Team collaboration in solving theoretical and practical problems.</li> <li>• Critical assessment of literature, systems, algorithms and approaches.</li> </ul>				
<b>Contents</b>	In depth coverage of a selected topic in Information Systems, in particular focusing on recent system implementations and novel algorithms. Example subjects may consist of: Web Information Systems, Information Retrieval, Management of Spatial Data, Management of Stream Data, or Data Warehousing.				
<b>Prerequisites</b>	<b>Required:</b> A thorough understanding of Database Management Systems, such as laid out in the text book by Ramakrishnan and Gehrke. Solid skills in developing OO software. In depth knowledge of Algorithms, such as summarized by the introductory book of Cormen et al.				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	Recent scientific publications, and selected chapters of advanced textbooks.				



<b>Module</b> MA-INF 3214	<b>Seminar Selected Topics in Information Management</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Jun.-Prof. Dr. Alexander Markowetz				
<b>Lecturer(s)</b>	Jun.-Prof. Dr. Alexander Markowetz				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>					
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3215	<b>Seminar Selected Topics in Malware Analysis and Computer/Network Security</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every year		
<b>Module coordinator</b>	Prof. Dr. Peter Martini				
<b>Lecturer(s)</b>	Prof. Dr. Peter Martini, Prof. Dr. Michael Meier				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers, current standardization drafts - with a specific topic focus on Malware Analysis, Computer and Network Security				
<b>Prerequisites</b>	<p><b>Required:</b> Successful completion of at least one of the following lectures: Principles of Distributed Systems (MA-INF3105), Network Security (MA-INF3201), Mobile Communication (MA-INF3202), IT Security (MA-INF3236)</p> <p><b>Recommended:</b></p>				
<b>Format</b>	<b>Teaching format</b> Seminar	<b>Group size</b> 10	<b>h/week</b> 2	<b>Workload[h]</b> 30 T / 90 S	<b>CP</b> 4
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3216	<b>Seminar Sensor Data Fusion</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	P.D. Dr. Wolfgang Koch				
<b>Lecturer(s)</b>	P.D. Dr. Wolfgang Koch				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b> Seminar	<b>Group size</b> 10	<b>h/week</b> 2	<b>Workload[h]</b> 30 T / 90 S	<b>CP</b> 4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The relevant literature will be announced at the beginning of the seminar.				

<b>Module</b> MA-INF 3218	<b>Seminar Model-Driven Software Engineering</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Dr. Günter Kniesel				
<b>Lecturer(s)</b>	Dr. Günter Kniesel				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	<p>On successful completion of this module, students should be able to:</p> <ul style="list-style-type: none"> <li>• Understand the differences between model driven and traditional software development</li> <li>• Describe the common features and peculiarities of different model driven development approaches</li> <li>• Assess the suitability of a model driven approach for a given project</li> <li>• Select appropriate tools for model driven development tasks</li> <li>• Explain the individual scientific topic prepared</li> </ul>				
<b>Soft skills</b>	<p>On successful completion of this module, students should have refined their scientific writing and presentation skills and should be able to:</p> <ul style="list-style-type: none"> <li>• Mine for profound knowledge about a given subject</li> <li>• Distill and communicate the summary of a computer science topic orally</li> <li>• Evaluate the scientific integrity of a written summary</li> <li>• Use modern presentation software</li> </ul>				
<b>Contents</b>	<p>Inhalte</p> <p>Model driven software development concepts, tools and methods.</p> <p>In particular:</p> <ul style="list-style-type: none"> <li>• Models, meta-models and meta-meta-models (General, MOF, EMOF, ECORE)</li> <li>• Text to model, model to model, model to text transformation</li> <li>• Imperative versus declarative model transformation</li> <li>• Model-driven versus other software development approaches</li> <li>• Best practice and research issues in model based development</li> </ul>				
<b>Prerequisites</b>	<b>Recommended:</b> MA-INF 3207 – Advanced Logic Programming				
<b>Format</b>	<b>Teaching format</b> Seminar	<b>Group size</b> 10	<b>h/week</b> 2	<b>Workload[h]</b> 30 T / 90 S	<b>CP</b> 4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>	<ul style="list-style-type: none"> <li>• Web page: <a href="https://sewiki.iai.uni-bonn.de/teaching/seminars/start">https://sewiki.iai.uni-bonn.de/teaching/seminars/start</a></li> <li>• Slides (Powerpoint/PDF)</li> <li>• Mailing list for students</li> </ul>				
<b>Literature</b>	<ul style="list-style-type: none"> <li>• "Model-Driven Software Development: Technology, Engineering, Management". Thomas Stahl, Markus Voelter, Wiley 2006.</li> <li>• "Model-Driven Software Development". Sami Beydeda , Matthias Book, Volker Gruhn (Eds), ISBN 978-3-540-25613-7, Springer 2005</li> <li>• David S. Frankel: Model Driven Architecture: Applying MDA to Enterprise Computing, John Wiley</li> </ul>				

<b>Module</b> MA-INF 3219	<b>Lab Model-Driven Software Engineering</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Dr. Günter Kniesel				
<b>Lecturer(s)</b>	Dr. Günter Kniesel				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	<p>On successful completion of this module, students should be able to:</p> <ul style="list-style-type: none"> <li>• Describe the process of model driven software development (MDSO) and support this description with personal experiences</li> <li>• Connect model driven software development guidelines to concrete practical examples</li> <li>• Be able to use one or several concrete MDSO tools and techniques and explain their use to others</li> </ul>				
<b>Soft skills</b>	<p>Students should be able to:</p> <ul style="list-style-type: none"> <li>• Run a software project based on MDSO tools, techniques and methods</li> <li>• Establish and iteratively evolve a project plan</li> <li>• Collaborate in a team</li> <li>• Estimate the required time and other resources for given tasks</li> <li>• Manage a software development project with time constraints</li> </ul>				
<b>Contents</b>	<p>Model driven software development methods are the key to a new level of automation and tool integration in software development. Students will learn how MDSE concepts, tools and methods boost the development of general purpose and domain specific languages, leverage software quality analysis tools and foster automated software improvement.</p>				
<b>Prerequisites</b>	<p><b>Required:</b> MA-INF 3218 – Seminar Model-Driven Software Engineering The seminar lays the conceptual foundations for the work in the lab.</p>				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>	<ul style="list-style-type: none"> <li>• Web page: <a href="https://sewiki.iai.uni-bonn.de/teaching/labs/start">https://sewiki.iai.uni-bonn.de/teaching/labs/start</a></li> <li>• Slides (Powerpoint/PDF)</li> <li>• Wiki as a shared knowledge base</li> <li>• Task Tracking System (Electronical or Physical)</li> <li>• Shared repository for source code and development documents</li> <li>• Mailing list</li> </ul>				
<b>Literature</b>	<ul style="list-style-type: none"> <li>• "Model-Driven Software Development: Technology, Engineering, Management". Thomas Stahl, Markus Voelter, Wiley 2006.</li> <li>• "Model-Driven Software Development". Sami Beydeda, Matthias Book, Volker Gruhn (Eds), ISBN 978-3-540-25613-7, Springer 2005</li> <li>• David S. Frankel: Model Driven Architecture: Applying MDA to Enterprise Computing, John Wiley</li> <li>• Modellgetriebene Softwareentwicklung, Techniken, Engineering, Management. dPunkt, 2005</li> </ul>				

<b>Module</b> MA-INF 3222	<b>eSecurity</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Joachim von zur Gathen				
<b>Lecturer(s)</b>	Prof. Dr. Joachim von zur Gathen, Dr. Michael Nüsken				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Understanding of security concerns and measures, and of the interplay between computing power and security requirements in the realm of real-world applications, in particular internet-based ones. Mastery of advanced techniques for the design of cryptosystems and practical cryptanalysis.				
<b>Soft skills</b>	Oral presentation (in tutorial groups), written presentation (of exercise solutions), team collaboration in solving homework problems, critical assessment.				
<b>Contents</b>	First focus: security on the internet and secure protocols. Furthermore: at least one real world application, for example <ul style="list-style-type: none"> <li>• electronic health cards,</li> <li>• electronic elections, or</li> <li>• electronic passports.</li> </ul>				
<b>Prerequisites</b>	<b>Required:</b> MA-INF 1103 – Cryptography				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	Varying according to the selected topic				

<b>Module</b> MA-INF 3228	<b>Foundations of Information Systems Security</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	PD Dr. Adrian Spalka				
<b>Lecturer(s)</b>	PD Dr. Adrian Spalka				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1.		
<b>Technical skills</b>					
<b>Soft skills</b>					
<b>Contents</b>	The security of networked information systems depends on four factors: authenticity, availability, confidentiality and integrity. This lecture examines their theoretical foundations and practical implementation. Along the historical development, the emphasis is put on modern information systems, such as those in the cloud.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>	Most content will be hand-written on the board with the supplement of a few slides. There are no handouts.				
<b>Literature</b>	A text-book on cryptography is advisable.				

<b>Module</b> MA-INF 3229	<b>Lab IT-Security</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Michael Meier				
<b>Lecturer(s)</b>	Prof. Dr. Michael Meier				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of IT Security, including test and documentation of the implemented software/system.				
<b>Soft skills</b>	Ability to properly present and defend design decisions, to prepare readable documentation of software; skills in constructively collaborating with others in small teams over a longer period of time; ability to classify ones own results into the state-of-the-art of the resp. area				
<b>Contents</b>					
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	none				(not graded)
<b>Forms of media</b>					
<b>Literature</b>					



<b>Module</b> MA-INF 3230	<b>Enterprise Information Systems</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Sören Auer				
<b>Lecturer(s)</b>	Prof. Dr. Sören Auer				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1.		
<b>Technical skills</b>	Students acquire knowledge in the design, development and use of information systems in companies and organizations in general but also in online communities, and inter-enterprise value chains.				
<b>Soft skills</b>					
<b>Contents</b>	<ul style="list-style-type: none"> <li>• Information systems in the enterprise, in particular Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Supply Chain Management (SCM), data warehouse / business intelligence, e-commerce, geographic information systems.</li> <li>• technologies for the implementation of modern information systems and information system environments: in particular, service-oriented information system architectures, workflow management (BPEL), semantic-based data integration, business process management,</li> <li>• Information systems for the processing of Big Data in particular transactions (OLTP) and analytical information systems (OLAP) for decision support. Data Warehousing and Data Mining.</li> </ul>				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3231	<b>Seminar Enterprise Information Systems</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Sören Auer				
<b>Lecturer(s)</b>	Prof. Dr. Sören Auer				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers and technologies in the area of Enterprise Information Systems.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Recent conference and journal papers Technologies such as ERP, CRM, SCM, database and data warehousing systems				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3232	<b>Lab Enterprise Information Systems</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Sören Auer				
<b>Lecturer(s)</b>	Prof. Dr. Sören Auer				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of Enterprise Information Systems, including test and documentation of the implemented software/system.				
<b>Soft skills</b>	Ability to properly present and defend design decisions, to prepare readable documentation of software; skills in constructively collaborating with others in small teams over a longer period of time; ability to classify own results into the state-of-the-art in the area of				
<b>Contents</b>					
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	none				(not graded)
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3233	<b>Advanced Sensor Data Fusion in Distributed Systems</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	PD Dr. Wolfgang Koch				
<b>Lecturer(s)</b>	Dr. Felix Govaers				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	For challenging state estimation tasks, algorithms which enhance the situational awareness by fusing sensor information are inevitable. Nowadays it has become very popular to improve the performance of systems by linking multiple sensors. This implies some challenges to the sensor data fusion methodologies such as sensor registration, communication delays, and correlations of estimation errors. In particular, if the communication links have limited bandwidth, data reduction techniques have to be applied at the sensor sites, that is local tracks have to be computed. Once received at a fusion center (FC), the tracks then are fused to reconstruct a global estimate. In this lecture, methodologies to achieve a distributed state estimation are considered. Among these are tracklet fusion, the Bar-Shalom-Campo formula, the Federated Kalman Filter, naive fusion, the distributed Kalman filter and the least squares estimate.				
<b>Soft skills</b>	Mathematical derivation of algorithms, application of mathematical results on estimation theory.				
<b>Contents</b>	tracklet fusion, the Bar-Shalom-Campo formula, the Federated Kalman Filter, naive fusion, the distributed Kalman filter and the least squares estimate, Accumulated State Densities, Decorrelated fusion, product representation				
<b>Prerequisites</b>	<b>Recommended:</b> At least 1 of the following: BA-INF 137 – Einführung in die Sensordatenfusion MA-INF 3310 – Introduction to Sensor Data Fusion - Methods and Applications				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>	Power Point				
<b>Literature</b>	W. Koch: "Tracking and Sensor Data Fusion: Methodological Framework and Selected Applications", Springer, 2014. D. Hall, C.-Y. Chong, J. Llinas, and M. L. II: "Distributed Data Fusion for Network-Centric Operations", CRC Press, 2014.				

<b>Module</b> MA-INF 3234	<b>Lab Mobile Sensing Systems</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Jun.-Prof. Dr. Delphine Christin				
<b>Lecturer(s)</b>	Jun.-Prof. Dr. Delphine Christin				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science		<b>Mode</b> Optional	<b>Semester</b> 2. or 3.	
<b>Technical skills</b>	The students will design and implement practical solutions specially tailored to the requirements of mobile sensing systems, including programming mobile devices and the corresponding infrastructure.				
<b>Soft skills</b>	Organized in small teams, the students will interact and cooperate to fulfill the assignment. They will analyze the design space and make design decisions based on this analysis. The design decisions and the resulting solution will be documented in a written report and presented to other students.				
<b>Contents</b>	<p>Mobile sensing systems leverage mobile phones as a new generation of sensing platforms. Embedded sensors, such as cameras, microphone, GPS, and accelerometers, are used to capture contextual information about the users and their surrounding environment. Within the scope of this lab, the students will explore and contribute to this challenging research field by addressing selected topics, such as:</p> <ul style="list-style-type: none"> <li>• New mobile sensing scenarios and applications</li> <li>• Reputation mechanisms to identify erroneous contributions</li> <li>• Incentive schemes to encourage users' contributions</li> <li>• Usable privacy interfaces</li> </ul>				
<b>Prerequisites</b>	<b>Recommended:</b> MA-INF 3202 – Mobile Communication				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	none				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	<p>Burke, J., Estrin, D., Hansen, M., Parker, A., Ramanathan, N., Reddy, S., Srivastava, M., 2006. Participatory sensing. In: Proceedings of the 1st Workshop on World- Sensor-Web (WSW), pp. 1–5.</p> <p>Campbell, A., Eisenman, S., Lane, N., Miluzzo, E., Peterson, R., 2006. People-centric urban sensing. In: Proceedings of the 2nd Annual International Wireless Internet Conference (WICON), pp. 18–31.</p> <p>Campbell, A., Eisenman, S., Lane, N., Miluzzo, E., Peterson, R., Lu, H., Zheng, X., Musolesi, M., Fodor, K., Eisenman, S., Ahn, G., 2008. The rise of people-centric sensing. IEEE Internet Computing 12, 12–21.</p> <p>Christin, D., Reinhardt, A., Kanhere, S., Hollick, M., A survey on privacy in mobile participatory sensing applications, Journal of Systems and Software, Volume 84, Issue 11, 2011,1928-1946.</p>				

<b>Module</b> MA-INF 3235	<b>Usable Security and Privacy</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Matthew Smith				
<b>Lecturer(s)</b>	Prof. Dr. Matthew Smith				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1.		
<b>Technical skills</b>	Students will be familiar with usability problems of IT security and privacy mechanisms, understand methods for exploring usability of IT security and privacy mechanisms as well being able to design and execute usability studies.				
<b>Soft skills</b>	<ul style="list-style-type: none"> <li>• Working with scientific literature</li> <li>• Communication skills</li> <li>• Team working skills</li> </ul>				
<b>Contents</b>	<p>The lecture on Usable Security and Privacy deals with many aspects of human factors and usability in the context of security and privacy. The lecture includes both the foundations of usable security and privacy as well as a selection of cutting edge international research in this area. Topics include:</p> <ul style="list-style-type: none"> <li>• Evaluation of usability issues of existing security &amp; privacy models or technology</li> <li>• Design and evaluation of new usable security &amp; privacy technology</li> <li>• Impact of organizational policy on security and privacy interaction</li> <li>• Lessons learned from designing, deploying, managing or evaluating security &amp; privacy technologies</li> <li>• Foundations of usable security &amp; privacy</li> <li>• Methodology for usable security &amp; privacy research</li> <li>• Ethical, psychological, sociological and economic aspects of security &amp; privacy technologies</li> </ul>				
<b>Prerequisites</b>	<p><b>Required:</b> Knowledge about IT Security is advantageous but not mandatory.</p> <p><b>Recommended:</b> At least 1 of the following: BA-INF 138 – IT-Sicherheit BA-INF 136 – Reaktive Sicherheit MA-INF 1103 – Cryptography MA-INF 3229 – Lab IT-Security</p>				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	Die Übung wird als Blockübung absolviert T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3236	<b>IT Security</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Michael Meier				
<b>Lecturer(s)</b>	Prof. Dr. Michael Meier				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1. or 2.		
<b>Technical skills</b>	Students are introduced to selected active research fields of IT security and gain deep knowledge of the research literature. Students learn selected aspects of IT security. This includes risks and vulnerabilities of today's information technology as well as concepts to increase the level of IT security, their applications and their weaknesses.				
<b>Soft skills</b>	Theoretical exercises to support in-depth understanding of lecture topics and to stimulate discussions, practical exercises in teamwork to support time management, targeted organization of practical work and critical discussion of own and others' results.				
<b>Contents</b>	<ul style="list-style-type: none"> <li>• security threats</li> <li>• advanced network security: internet routing security, network attack detection, network information hiding</li> <li>• cryptographic key management</li> <li>• building automation security</li> <li>• advanced host security</li> <li>• security patterns</li> <li>• privacy and pseudonymization</li> </ul>				
<b>Prerequisites</b>	<b>Required:</b> Fundamental knowledge in the following areas: operating systems, networks, security				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3302	<b>Temporal Information Systems</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Rainer Manthey				
<b>Lecturer(s)</b>	Prof. Dr. Rainer Manthey				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>					
<b>Soft skills</b>	Communicative skills (oral/written presentation, “defending“ solutions), self-competence (time management, self-organisation, creativity), social skills (constructive discussion, sharing work in small teams)				
<b>Contents</b>					
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>					



<b>Module</b> MA-INF 3304	<b>Lab Communication and Communicating Devices</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Peter Martini				
<b>Lecturer(s)</b>	Prof. Dr. Peter Martini, Prof. Dr. Michael Meier				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of communication systems, including test and documentation of the implemented software/system.				
<b>Soft skills</b>	Work in small teams and cooperate with other teams in a group; ability to make design decisions in a practical task; present and discuss (interim and final) results in the team/group and to other students; prepare written documentation of the work carried out				
<b>Contents</b>	Selected topics close to current research in the area of communication systems, network security, mobile communication and communicating devices.				
<b>Prerequisites</b>	<b>Required:</b> Successful completion of at least one of the following lectures: Principles of Distributed Systems (MA-INF3105), Network Security (MA-INF3201), Mobile Communication (MA-INF3202), IT Security (MA-INF3236)				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The relevant literature will be announced towards the end of the previous semester.				

<b>Module</b> MA-INF 3305	<b>Lab Information Systems</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every year		
<b>Module coordinator</b>	Prof. Dr. Rainer Manthey				
<b>Lecturer(s)</b>	Prof. Dr. Rainer Manthey, Dr. Thomas Bode				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of information systems, including test and documentation of the implemented software/system.				
<b>Soft skills</b>	Ability to properly present and defend design decisions, to prepare readable documentation of software; skills in constructively collaborating with others in small teams over a longer period of time; ability to classify ones own results into the state-of-the-art of the resp. area				
<b>Contents</b>	Varying selected topics close to current research in the area of database- and information systems.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The relevant literature will be announced towards the end of the previous semester.				

<b>Module</b> MA-INF 3309	<b>Lab Malware Analysis</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Peter Martini				
<b>Lecturer(s)</b>	Prof. Dr. Peter Martini, Prof. Dr. Michael Meier				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of communication systems with a specific topic focus on Malware Analysis and Computer/Network Security, including test and documentation of the implemented software/system.				
<b>Soft skills</b>	Work in small teams and cooperate with other teams in a group; ability to make design decisions in a practical task; present and discuss (interim and final) results in the team/group and to other students; prepare written documentation of the work carried out				
<b>Contents</b>	Selected topics close to current research in the area of communication systems, malware analysis, computer and network security.				
<b>Prerequisites</b>	<b>Required:</b> Successful completion of at least one of the following lectures: Principles of Distributed Systems (MA-INF3105), Network Security (MA-INF3201), Mobile Communication (MA-INF3202), IT Security (MA-INF3236)				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3310	<b>Introduction to Sensor Data Fusion - Methods and Applications</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	P.D. Dr. Wolfgang Koch				
<b>Lecturer(s)</b>	P.D. Dr. Wolfgang Koch				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	<p>All participants shall get known to the basic theory of sensor data fusion. The lecture starts with preliminaries on how to handle uncertain data and knowledge within analytical calculus. Then, the fundamental and well-known Kalman filter is derived. Based on this tracking scheme, further approaches to a wide spectrum of applications will be shown. All algorithms will be motivated by examples from ongoing research projects, industrial cooperations, and impressions of current demonstration hardware.</p> <p>Because of inherent practical issues, every sensor measures certain properties up to an error. This lecture shows how to model and overcome this error by an application of theoretical tools such as Bayes' rule and further derivations. Moreover, solutions to possible false-alarms, miss-detections, maneuvering phases, and much more will be presented.</p>				
<b>Soft skills</b>	Mathematical derivation of algorithms, application of mathematical results on estimation theory.				
<b>Contents</b>	Gaussian probability density functions, Kalman filter, Multi-Hypothesis-Tracker, Interacting Multiple Model Filter, Retrodiction, Smoothing, Maneuver Modeling				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<p>W. Koch: "Tracking and Sensor Data Fusion: Methodological Framework and Selected Applications", Springer, 2014.</p> <p>Y. Bar-Shalom: "Estimation with Applications to Tracking and Navigation", Wiley-Interscience, 2001.</p>				

<b>Module</b> MA-INF 3311	<b>Topics in Applied Cryptography</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Joachim von zur Gathen				
<b>Lecturer(s)</b>	Prof. Dr. Joachim von zur Gathen, Dr. Michael Nüsken				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	Gain deeper understanding in a special area of cryptography close to current research.				
<b>Soft skills</b>	Oral presentation (in tutorial groups), written presentation (of exercise solutions), team collaboration in solving homework problems, critical assessment.				
<b>Contents</b>	One varying, advanced topic related to current research in applied cryptography, e.g. <ul style="list-style-type: none"> <li>• mobile security, or</li> <li>• design and analysis of hash functions.</li> </ul>				
<b>Prerequisites</b>	<b>Required:</b> MA-INF 1103 – Cryptography and one further course in cryptography like The Art of Cryptography or eSecurity.				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3312	<b>Lab Sensor Data Fusion</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	P.D. Dr. Wolfgang Koch				
<b>Lecturer(s)</b>	P.D. Dr. Wolfgang Koch				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science		<b>Mode</b> Optional	<b>Semester</b> 3.	
<b>Technical skills</b>	The students will work together on a data fusion project using various sensor hardware. Latest algorithms for fusing information from several nodes will be implemented.				
<b>Soft skills</b>	The students shall work together in a team. Everyone is responsible for a specific part in the context of a main goal. Results will be exchanged and integrated via software interfaces.				
<b>Contents</b>	Varying selected topics on sensor data fusion.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	none				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	The relevant literature will be announced at the beginning of the lab.				

<b>Module</b> MA-INF 3313	<b>Lab Intelligent Information Systems</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Rainer Manthey				
<b>Lecturer(s)</b>	Prof. Dr. Rainer Manthey				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science		<b>Mode</b> Optional	<b>Semester</b> 3.	
<b>Technical skills</b>					
<b>Soft skills</b>					
<b>Contents</b>					
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	none				(not graded)
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3314	<b>Advanced Topics in Information Systems Security</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	PD Dr. Adrian Spalka				
<b>Lecturer(s)</b>	PD Dr. Adrian Spalka				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1.		
<b>Technical skills</b>					
<b>Soft skills</b>					
<b>Contents</b>	The content of the lecture focuses on state-of-the-art findings and techniques, and on present threats and security problems. Current examples are: an axiomatic view of authentication with application to user-centric environments and key management for cloud-applications.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>	Most content will be hand-written on the board with the supplement of a few slides. There are no handouts.				
<b>Literature</b>	A text-book on cryptography is advisable.				



<b>Module</b> MA-INF 3315	<b>Seminar Advanced Information Systems Security</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	PD Dr. Adrian Spalka				
<b>Lecturer(s)</b>	PD Dr. Adrian Spalka				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3316	<b>Lab Techniques in Information Systems Security</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	PD Dr. Adrian Spalka				
<b>Lecturer(s)</b>	PD Dr. Adrian Spalka				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of xxxxxx, including test and documentation of the implemented software/system.				
<b>Soft skills</b>	Ability to properly present and defend design decisions, to prepare readable documentation of software; skills in constructively collaborating with others in small teams over a longer period of time; ability to classify ones own results into the state-of-the-art of the resp. area				
<b>Contents</b>					
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3317	<b>Seminar Selected Topics in IT Security</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Michael Meier				
<b>Lecturer(s)</b>	Prof. Dr. Michael Meier, Prof. Dr. Peter Martini				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3318	<b>Seminar Verification of Complex Systems</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every 2 years		
<b>Module coordinator</b>	Jun.-Prof. Dr. Janis Voigtländer				
<b>Lecturer(s)</b>	Jun.-Prof. Dr. Janis Voigtländer				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	<p>Knowledge in topics in the area of specifying and verifying behaviour of complex systems such as software. Competence to mine for profound knowledge about a given subject, in particular acquiring and studying original literature. Understanding scientific publications, often written tersely. Distilling this into suitable presentations; determination of relevant vs. irrelevant material. Presenting research results to others, in writing and in oral presentations, and discussing them with an audience. Ability to discuss and evaluate presentations of fellow students, and to constructively deal with critical feedback by others.</p>				
<b>Soft skills</b>	<p>Communication skills (preparing and presenting talks, using visual media, preparing a structured written document), social skills (motivating other students, ability to accept and formulate criticism), self competences (time management with long-ranging deadlines, self-study, ability to analyse, creativity).</p>				
<b>Contents</b>	<p>Techniques for analyzing the correctness of complex systems such as software. Theoretical foundations for such techniques, as well as consideration of practical tools. Spectrum ranging from formal to semi-formal; positioning of techniques within this spectrum. Specific themes of interest include:</p> <ul style="list-style-type: none"> <li>• Specification formalisms and languages</li> <li>• Decision problems</li> <li>• Modelling desired properties of a system</li> <li>• Model checking</li> <li>• Theorem proving</li> <li>• Static (flow) analysis, abstract interpretation</li> <li>• Code analysis using heuristics</li> <li>• Testing (approaches, frameworks, coverage criteria)</li> <li>• Runtime verification (instrumentation, monitoring)</li> <li>• Applications and pragmatics of verification</li> </ul> <p>A selection of topics will be made in each semester.</p>				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b> Seminar	<b>Group size</b> 10	<b>h/week</b> 2	<b>Workload[h]</b> 30 T / 90 S	<b>CP</b> 4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	The relevant literature will be announced in time.				

<b>Module</b> MA-INF 3319	<b>Lab Usable Security and Privacy</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Matthew Smith				
<b>Lecturer(s)</b>	Prof. Dr. Matthew Smith				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of usable security and privacy, including user studies.				
<b>Soft skills</b>	Ability to create and defend a scientific user study				
<b>Contents</b>	Students have a great degree of freedom to chose their own topics within the context of human aspects of security and privacy.				
<b>Prerequisites</b>	<b>Required:</b> MA-INF 3235 – Usable Security and Privacy				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	none				(not graded)
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3320	<b>Lab Security in Distributed Systems</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Matthew Smith				
<b>Lecturer(s)</b>	Prof. Dr. Matthew Smith				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of distributed security, including documentation of the implemented software/system. Strong programming skills required.				
<b>Soft skills</b>	Ability to properly present and defend design decisions, to prepare readable documentation of software; skills in constructively collaborating with others in small teams over a longer period of time; ability to classify ones own results into the state-of-the-art of the resp. area				
<b>Contents</b>	Security in distributed systems, including amongst others: <ul style="list-style-type: none"> <li>• Secure Messaging</li> <li>• App Security</li> <li>• SSL/HTTPS</li> <li>• API Security</li> <li>• Machine Learning for Security</li> <li>• Passwords</li> <li>• Intrusion Detection Systems</li> <li>• Anomaly Detection</li> <li>• Security Visualisation</li> </ul>				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	none				(not graded)
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 3321	<b>Seminar Usable Security and Privacy</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Matthew Smith				
<b>Lecturer(s)</b>	Prof. Dr. Matthew Smith				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

## 4 Intelligent Systems

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MA-INF 4217	Sem2	4	CP	Seminar Machine Learning Methods in Systems Biology .....	123
MA-INF 4218	Lab4	9	CP	Lab Modeling and Simulation .....	124
MA-INF 4302	L2E2	6	CP	Advanced Learning Systems .....	125
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MA-INF 4306	Lab4	9	CP	Lab Development and Application of Data Mining and Learning Systems .....	128
MA-INF 4307	Lab4	9	CP	Lab Field Programmable Gate Arrays .....	129
MA-INF 4308	Lab4	9	CP	Lab Vision Systems .....	130
MA-INF 4309	Lab4	9	CP	Lab Sensor Data Interpretation .....	131
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<b>Module</b> MA-INF 4111	<b>Intelligent Learning and Analysis Systems: Machine Learning</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Stefan Wrobel				
<b>Lecturer(s)</b>	Prof. Dr. Stefan Wrobel				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1. or 2.		
<b>Technical skills</b>	This module is one of two complementary modules in which students gain an understanding of the most important paradigms and methods of intelligent learning systems as they are used in data analysis and/or for implementing adaptive behaviour (machine learning, data mining, knowledge discovery in databases). This module concentrates on the core task of predictive learning from examples and on agent learning, and teaches the main classes of algorithms for these tasks. At the end of the module, students will be capable of choosing appropriate methods and systems for particular predictive learning applications and use them to arrive at convincing results, and will know where to start whenever adaptation or further development of algorithms and systems is necessary. This module complements MA-INF 4112 and can be taken before or after that module.				
<b>Soft skills</b>	Communicative skills (oral and written presentation of solutions, discussions in small teams), self competences (ability to accept and formulate criticism, ability to analyze problems)				
<b>Contents</b>	Types of learning and analysis tasks, most important non-parametric and parametric methods for supervised learning (e.g., decision trees, rules, linear methods, neural networks, neighbourhood methods, kernel methods, probabilistic approaches), reinforcement learning, evaluation and learning theory.				
<b>Prerequisites</b>	<b>Recommended:</b> Prior knowledge of probability theory, linear algebra, artificial intelligence, information systems and data bases  <b>Required:</b> None of the following modules have been passed: MA-INF 4102 – Intelligent Learning and Analysis Systems				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>	Lectures, exercises, software packages				
<b>Literature</b>	- Tom Mitchell, Machine Learning, McGraw-Hill, 1997 - Ian Witten, Eibe Frank, Data Mining, Morgan Kauffmann, 2000				

<b>Module</b> MA-INF 4112	<b>Intelligent Learning and Analysis Systems: Data Mining and Knowledge Discovery</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Stefan Wrobel				
<b>Lecturer(s)</b>	Prof. Dr. Wrobel				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1. or 2.		
<b>Technical skills</b>	This module is one of two complementary modules in which students gain an understanding of the most important paradigms and methods of intelligent learning systems as they are used in data analysis and/or for implementing adaptive behaviour (machine learning, data mining, knowledge discovery in databases). This module concentrates on the core tasks of pattern discovery in databases and teaches the main classes of algorithms for this task (subgroups discovery. At the end of the module, students will be capable of choosing appropriate methods and systems for particular pattern discovery applications and use them to arrive at convincing results, and will know where to start whenever adaptation or further development of algorithms and systems is necessary. This module complements MA-INF 4111 and can be taken before or after that module.				
<b>Soft skills</b>	Communicative skills (oral and written presentation of solutions, discussions in small teams), self competences (ability to accept and formulate criticism, ability to analyze problems)				
<b>Contents</b>	Types of learning and analysis tasks, scalability techniques, descriptive data mining methods, association rules, subgroups, clustering, pre- and postprocessing, data storage (data warehouses, OLAP), special data types (spatial, network, text, multimedia data), interactive and visual systems.				
<b>Prerequisites</b>	<b>Recommended:</b> Prior knowledge of probability theory, linear algebra, artificial intelligence, information systems and data bases  <b>Required:</b> None of the following modules have been passed: MA-INF 4102 – Intelligent Learning and Analysis Systems				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>	Lectures, exercises, software packages				
<b>Literature</b>	- Ian Witten, Eibe Frank, Data Mining, Morgan Kauffmann, 2000 - Jiawei Han, Micheline Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann, 2000				

<b>Module</b> MA-INF 4113	<b>Cognitive Robotics</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Sven Behnke				
<b>Lecturer(s)</b>	Prof. Dr. Sven Behnke				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1. or 2.		
<b>Technical skills</b>	<p>This lecture is one of two introductory lectures of the intelligent systems track. The lecture covers cognitive capabilities of robots, like self-localization, mapping, object perception, and action-planning in complex environments.</p> <p>This module complements MA-INF 4114 and can be taken before or after that module.</p>				
<b>Soft skills</b>	Communicative skills (oral and written presentation of solutions, discussions in small teams), self competences (ability to accept and formulate criticism, ability to analyze problems)				
<b>Contents</b>	Probabilistic approaches to state estimation (Bayes Filters, Kalman Filter, Particle Filter), motion models, sensor models, self-localization, mapping with known poses, simultaneous mapping and localization (SLAM), iterated closest-point matching, path planning, place- and person recognition, object recognition.				
<b>Prerequisites</b>	<b>Required:</b> None of the following modules have been passed: MA-INF 4101 – Theory of Sensorimotor Systems				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics. MIT Press, 2005.</li> <li>• B. Siciliano, O. Khatib (Eds.): Springer Handbook of Robotics, 2008.</li> <li>• R. Szeliski: Computer Vision: Algorithms and Applications, Springer 2010.</li> </ul>				

<b>Module</b> MA-INF 4114	<b>Robot Learning</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Sven Behnke				
<b>Lecturer(s)</b>	Prof. Dr. Sven Behnke, Dr. Nils Goerke				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1. or 2.		
<b>Technical skills</b>	<p>This lecture is one of two introductory lectures of the intelligent systems track. Creating autonomous robots that can learn to assist humans in situations of daily life is a fascinating challenge for machine learning.</p> <p>The lecture covers key ingredients for a general robot learning approach to get closer towards human-like performance in robotics, such as reinforcement learning, learning models for control, learning motor primitives, learning from demonstrations and imitation learning, and interactive learning.</p> <p>This module complements MA-INF 4113 and can be taken before or after that module.</p>				
<b>Soft skills</b>	Communicative skills (oral and written presentation of solutions, discussions in small teams), self competences (ability to accept and formulate criticism, ability to analyze problems)				
<b>Contents</b>	Reinforcement learning, Markov decision processes, dynamic programming, Monte Carlo methods, temporal-difference methods, function approximation, linear quadratic regulation, differential dynamic programming, partially observable MDPs, policy gradient methods, inverse reinforcement learning, imitation learning, learning kinematic models, perceiving and handling of objects.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• R. Sutton and A. Barto: Reinforcement Learning, MIT-Press, 1998.</li> <li>• O. Sigaud and J. Peters (Eds.): From Motor Learning to Interaction Learning in Robots. Springer, 2010.</li> </ul>				

<b>Module</b> MA-INF 4201	<b>Artificial Life</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Sven Behnke				
<b>Lecturer(s)</b>	Prof. Dr. Sven Behnke, Dr. Nils Goerke				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1., 2. or 3.		
<b>Technical skills</b>	Detailed understanding of the most important approaches and principles of artificial life. Knowledge and understanding of the current state of research in the field of artificial life				
<b>Soft skills</b>	Capability to identify the state of the art in artificial life, and to present and defend the found solutions within the exercises in front of a group of students. Critical discussion of the results of the homework.				
<b>Contents</b>	Foundations of artificial life, cellular automata, Conway's "Game of Life"; mechanisms for structural development; foundations of nonlinear dynamical systems, Lindenmeyer-systems, evolutionary methods and genetic algorithms, reinforcement learning, artificial immune systems, adaptive behaviour, self-organising criticality, multi-agent systems, and swarm intelligence, particle swarm optimization.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>	Pencil and paper work, explain solutions in front of the exercise group, implementation of small programs, use of simple simulation tools.				
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Christoph Adami: Introduction to Artificial Life, The Electronic Library of Science, TELOS, Springer-Verlag</li> <li>• Eric Bonabeau, Marco Dorigo, Guy Theraulaz: Swarm Intelligence: From Natural to Artificial Systems, Oxford University Press, Santa Fe Institute Studies in the Science of Complexity.</li> <li>• Andrzej Osyczka: Evolutionary Algorithms for Single and Multicriteria Design Optimization, Studies in Fuzzyness and Soft Computing, Physica-Verlag, A Springer-Verlag Company, Heidelberg</li> </ul>				

<b>Module</b> MA-INF 4203	<b>Autonomous Mobile Systems</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Sven Behnke				
<b>Lecturer(s)</b>	Dr. Dirk Schulz, Prof. Dr. Sven Behnke				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Profound knowledge of development and test regarding structure and function of learning, autonomous, mobile systems; Knowledge of the computational, mathematical, and technical requirements for the design of autonomous systems for specific applications and for specific functional environments				
<b>Soft skills</b>	The students will be capable to assess applications for autonomous mobile systems. They will be capable to identify what part of the applications might be improved by using state of the art developments. The student will learn how to plan and implement a software project in small working groups.				
<b>Contents</b>	Requirements for the implementation of autonomous mobile systems, e.g. for: map making, dead reckoning, localisation, SLAM-methods, various principles of robot path planning; methods for action planning. Comparison of different learning paradigms for specific applications.				
<b>Prerequisites</b>	<b>Recommended:</b> all of the following: MA-INF 4101 – Theory of Sensorimotor Systems MA-INF 4113 – Cognitive Robotics				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• J. Buchli: Mobile Robots: Moving Intelligence, Published by Advanced Robotic Systems and Pro Literatur Verlag</li> <li>• Sebastian Thrun, Wolfram Burgard, Dieter Fox: Probabilistic Robotics, MIT Press, 2005</li> <li>• Howie Choset et al.: Principles of Robot Motion, MIT-Press, 2005</li> </ul>				

<b>Module</b> MA-INF 4204	<b>Technical Neural Nets</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Joachim K. Anlauf				
<b>Lecturer(s)</b>	Prof. Dr. Joachim K. Anlauf, Dr. Nils Goerke				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1., 2. or 3.		
<b>Technical skills</b>	Detailed knowledge of the most important neural network approaches and learning algorithms and its fields of application. Knowledge and understanding of technical neural networks as Non-Von Neumann computer architectures similar to concepts of brain functions at different stages of development				
<b>Soft skills</b>	The students will be capable to propose several paradigms from neural networks that are capable to solve a given task. They can discuss the pro and cons with respect to efficiency and risk. They will be capable to plan and implement a small project with state of the art neural network solutions.				
<b>Contents</b>	Multi-layer perceptron, radial-basis function nets, Hopfield nets, self organizing maps (Kohonen), adaptive resonance theory, learning vector quantization, recurrent networks, back-propagation of error, reinforcement learning, Q-learning, support vector machines, pulse processing neural networks. Exemplary applications of neural nets: function approximation, prediction, quality control, image processing, speech processing, action planning, control of technical processes and robots. Implementation of neural networks in hardware and software: tools, simulators, analog and digital neural hardware.				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Christopher M. Bishop: Neural Networks for Pattern Recognition, Oxford University Press, ISBN-10: 0198538642, ISBN-13: 978-0198538646</li> <li>• Ian T. Nabney: NETLAB. Algorithms for Pattern Recognition, Springer, ISBN-10: 1852334401, ISBN-13: 978-1852334406</li> </ul>				

<b>Module</b> MA-INF 4206	<b>Selected Topics in Sensor Data Interpretation</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	PD Dr. Volker Steinhage				
<b>Lecturer(s)</b>	PD Dr. Volker Steinhage				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science		<b>Mode</b> Optional	<b>Semester</b> 2.	
<b>Technical skills</b>	Understanding of important paradigms and methods of sensor data interpretation and ability to implement systems for interpreting sensor data				
<b>Soft skills</b>	<ul style="list-style-type: none"> <li>• Ability to cooperate in small groups on solving given tasks</li> <li>• Ability to put a conceptual solution and its implementation down on paper</li> <li>• Ability to present and discuss a conceptual solution and its implementation in an oral presentation</li> </ul>				
<b>Contents</b>	Approaches to feature extraction and classification of sensor data with applications in scene analysis, object detection and object tracking				
<b>Prerequisites</b>	<p><b>Required:</b> all of the following:  MA-INF 2201 – Computer Vision  BA-INF 131 – Intelligente Sehsysteme</p> <p>Module MA-INF 4206 "Selected Topics in Sensor Data Interpretation" requires knowledge and skills in the foundations of computer vision like given in the Bachelor module BA-INF 131 "Intelligente Sehsysteme" or in Master module MA-INF 2201 "Computer Vision"</p>				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Simon J.D. Prince: Computer Vision: Models, Learning, and Inference. Cambridge University Press, 2012.</li> <li>• Richard Szeliski: Computer Vision: Algorithms and Applications. Springer, 2010.</li> <li>• Selected up-to-date publications.</li> </ul>				



<b>Module</b> MA-INF 4207	<b>Dynamically Reconfigurable Systems</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every 2 years		
<b>Module coordinator</b>	Prof. Dr. Joachim K. Anlauf				
<b>Lecturer(s)</b>	Prof. Dr. Joachim K. Anlauf				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Knowledge of the most important FPGA architectures, ability to select appropriate FPGAs for a given application, overview of programming tools				
<b>Soft skills</b>	Communicative skills (oral and written presentation of solutions), social skills (ability to solve problems in small teams, discussions of solution concepts) self competences (ability to accept and formulate criticism, ability to analyze problems)				
<b>Contents</b>	Architecture of FPGAs, Configurable Logic Blocks, Wiring Ressources, Special Blocks, Hardware Description Languages, Synthesis, Technology Mapping, Place and Route, FPGA Computing, Partial Reconfigurability				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	Current research papers and technical documentation				

<b>Module</b> MA-INF 4208	<b>Seminar Vision Systems</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Sven Behnke				
<b>Lecturer(s)</b>	Prof. Dr. Sven Behnke, Prof. Dr. Joachim K. Anlauf, Dr. Nils Goerke				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	<p>Knowledge in advanced topics in the area of technical vision systems, such as image segmentation, feature extraction, and object recognition.</p> <p>Ability to understand new research results presented in original scientific papers and to present them in a research talk as well as in a seminar report.</p>				
<b>Soft skills</b>	<p>Self-competences (time management, literature search, self-study),</p> <p>communication skills (preparation and clear didactic presentation of research talk, scientific discussion, structured writing of seminar report),</p> <p>social skills (ability to formulate and accept criticism, critical examination of research results).</p>				
<b>Contents</b>	Current research papers from conferences and journals in the field of vision systems covering fundamental techniques and applications.				
<b>Prerequisites</b>	<p><b>Recommended:</b> At least 1 of the following:  MA-INF 4111 – Intelligent Learning and Analysis Systems: Machine Learning  MA-INF 4204 – Technical Neural Nets</p>				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• R. Szeliski: Computer Vision: Algorithms and Applications, Springer 2010.</li> <li>• C. M. Bishop: Pattern Recognition and Machine Learning, Springer 2006.</li> <li>• D. A. Forsyth and J. Ponce: Computer Vision: A Modern Approach, Prentice Hall, 2003.</li> </ul>				

<b>Module</b> MA-INF 4209	<b>Seminar Principles of Data Mining and Learning Algorithms</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Stefan Wrobel				
<b>Lecturer(s)</b>	Prof. Dr. Stefan Wrobel				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Enhanced and in-depth knowledge in specialized topics in the area of machine learning and data mining, acquiring the competence to independently study scientific literature, present it to others and discuss it with a knowledgeable scientific auditorium. Learn how to scientifically present prior work by others, in writing and in presentations.				
<b>Soft skills</b>	Communicative skills (preparing and presenting talks, written presentation of contents in a longer document), self competences (time management with long-ranging deadlines, ability to accept and formulate criticism, ability to analyse, creativity).				
<b>Contents</b>	Theoretical, statistical and algorithmical principles of data mining and learning algorithms. Search and optimization algorithms. Specialized learning algorithms from the frontier of research. Fundamental results from neighbouring areas.				
<b>Prerequisites</b>	<b>Recommended:</b> At least 1 of the following: MA-INF 4111 – Intelligent Learning and Analysis Systems: Machine Learning MA-INF 4112 – Intelligent Learning and Analysis Systems: Data Mining and Knowledge Discovery				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>	Scientific papers and websites, interactive presentations.				
<b>Literature</b>	The relevant literature will be announced towards the end of the previous semester.				

<b>Module</b> MA-INF 4210	<b>Seminar Advanced Topics in Technical Informatics</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every 2 years		
<b>Module coordinator</b>	Prof. Dr. Joachim K. Anlauf				
<b>Lecturer(s)</b>	Prof. Dr. Joachim K. Anlauf				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Current Topics in Technical Informatics				
<b>Soft skills</b>	Communicative skills (preparing and presenting talks, preparing a structured written document), social skills (ability to accept and formulate criticism, discussions of current content) self competences (time management with long-ranging deadlines, understanding of research topics from original literature)				
<b>Contents</b>	Current topics such as: new architectures of computers or FPGAs (field programmable gate arrays) or new applications of dynamically reconfigurable systems				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	none				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	Current research papers				

<b>Module</b> MA-INF 4211	<b>Seminar Cognitive Robotics</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Sven Behnke				
<b>Lecturer(s)</b>	Prof. Dr. Sven Behnke, Dr. Nils Goerke				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Knowledge in advanced topics in the area of cognitive robotics, such as robot perception, action planning, and robot learning. Ability to understand new research results presented in original scientific papers and to present them in a research talk as well as in a seminar report.				
<b>Soft skills</b>	Self-competences (time management, literature search, self-study), communication skills (preparation and clear didactic presentation of research talk, scientific discussion, structured writing of seminar report), social skills (ability to formulate and accept criticism, critical examination of research results).				
<b>Contents</b>	Current research papers from conferences and journals in the field of cognitive robotics covering fundamental techniques and applications.				
<b>Prerequisites</b>	<b>Recommended:</b> At least 1 of the following: MA-INF 4113 – Cognitive Robotics MA-INF 4114 – Robot Learning				
<b>Format</b>	<b>Teaching format</b> Seminar	<b>Group size</b> 10	<b>h/week</b> 2	<b>Workload[h]</b> 30 T / 90 S	<b>CP</b> 4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics. MIT Press, 2005.</li> <li>• B. Siciliano, O. Khatib (Eds.): Springer Handbook of Robotics, 2008.</li> <li>• Selected papers.</li> </ul>				

<b>Module</b> MA-INF 4212	<b>Data Science and Big Data</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Stefan Wrobel				
<b>Lecturer(s)</b>	Dr. Tamas Horvath, PD Dr. Michael Mock				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3. or 4.		
<b>Technical skills</b>	Participants acquire in-depth knowledge of different aspects of big data analytics and systems, including distributed processing systems and big data databases, as well as algorithmic techniques for analyzing structured and unstructured data that cannot be stored in a single computer because it has enormous size and/or continuously arrives with such a high rate that requires immediate processing.				
<b>Soft skills</b>	Communicative skills (oral and written presentation of solutions, discussions in teams), self-competences (ability to accept and formulate criticism, ability to analyse, creativity in the context of an "open end" task), social skills (effective team work and project planning).				
<b>Contents</b>	The module is offered every year, each time concentrating on one or more specific issues, such as <ul style="list-style-type: none"> <li>- architectures and procols for big data systems,</li> <li>- distributed batch and stream processing systems,</li> <li>- non-standard databases for big data,</li> <li>- databases for structured data,</li> <li>- similarity search,</li> <li>- synopses for massive data,</li> <li>- classical data mining tasks for massive data and/or data streams,</li> <li>- mining massive graphs,</li> <li>- applications.</li> </ul>				
<b>Prerequisites</b>	<b>Recommended:</b> all of the following: MA-INF 4111 – Intelligent Learning and Analysis Systems: Machine Learning MA-INF 4112 – Intelligent Learning and Analysis Systems: Data Mining and Knowledge Discovery				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>	lectures, exercises, software systems				
<b>Literature</b>	<ul style="list-style-type: none"> <li>- N. Marz and J. Warren: Big Data. Principles and best practices of scalable realtime data systems. Manning Pubn, 2014.</li> <li>- T. White: Hadoop The Definitive Guide. O'REILLY, 2012.</li> <li>- A. Rajaraman and J.D. Ullman.: Mining of Massive Datasets. Cambridge University Press, 2011.</li> <li>- G. Cormode, M. Garofalakis, P.J. Haas, and C. Jermaine: Synopses for Massive Data: Samples, Histograms, Wavelets, Sketches. Foundations and Trends in Databases 4(1-3): 1-294 (2012).</li> </ul>				

<b>Module</b> MA-INF 4213	<b>Seminar Humanoid Robots</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Maren Bennewitz				
<b>Lecturer(s)</b>	Prof. Dr. Maren Bennewitz				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Knowledge in advanced topics in the area of humanoid robotics, such as environment perception, state estimation, navigation, or motion planning. Ability to understand new research results of scientific papers and to present them in a talk as well as in a self-written summary.				
<b>Soft skills</b>	Self-competences (time management, literature search, self-study), communication skills (preparation of the talk, clear didactic presentation of techniques and experimental results, scientific discussion, structured writing of summary), social skills (ability to formulate and accept criticism, critical examination of algorithms and experimental results).				
<b>Contents</b>	Current research papers from conferences and journals in the field of humanoid robotics covering fundamental techniques and applications.				
<b>Prerequisites</b>	<b>Recommended:</b> At least 1 of the following: MA-INF 4215 – Humanoid Robotics MA-INF 4113 – Cognitive Robotics				
<b>Format</b>	<b>Teaching format</b> Seminar	<b>Group size</b> 10	<b>h/week</b> 2	<b>Workload[h]</b> 30 T / 90 S	<b>CP</b> 4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>- S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics. MIT Press</li> <li>- B. Siciliano, O. Khatib (Eds.): Springer Handbook of Robotics</li> <li>- K. Harada, E. Yoshida, K. Yokoi (Eds.), Motion Planning for Humanoid Robots, Springer</li> <li>- Selected papers.</li> </ul>				

<b>Module</b> MA-INF 4214	<b>Lab Humanoid Robots</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Maren Bennewitz				
<b>Lecturer(s)</b>	Prof. Dr. Maren Bennewitz				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Practical experience and in-depth knowledge in the design and implementation of perception, state estimation, environment representation, navigation, and motion planning techniques for humanoid robots. In small groups, the participants analyze a problem, realize a solution, and perform an experimental evaluation.				
<b>Soft skills</b>	Self-competences (time management, goal-oriented work, ability to analyze problems theoretically and to find practical solutions), communication skills (collaboration in small teams, oral and written presentation of solutions, critical examination of implementations).				
<b>Contents</b>	Robot middleware (ROS), perception, state estimation, environment representations, navigation, and motion planning for humanoid robots.				
<b>Prerequisites</b>	<b>Recommended:</b> At least 1 of the following: MA-INF 4215 – Humanoid Robotics MA-INF 4113 – Cognitive Robotics				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>- S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics. MIT Press</li> <li>- B. Siciliano, O. Khatib (Eds.): Springer Handbook of Robotics</li> <li>- K. Harada, E. Yoshida, K. Yokoi (Eds.), Motion Planning for Humanoid Robots, Springer</li> <li>- Selected papers.</li> </ul>				



<b>Module</b> MA-INF 4215	<b>Humanoid Robotics</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Maren Bennewitz				
<b>Lecturer(s)</b>	Prof. Dr. Maren Bennewitz				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	This lecture covers techniques for humanoid robots such as perception, navigation, motion planning, grasping, and human motion analysis.				
<b>Soft skills</b>	Communicative skills (oral and written presentation of solutions, discussions in small teams), ability to analyze problems.				
<b>Contents</b>	Self-calibration with least squares, 3D environment representation, self-localization with particle filters and improved proposals, footstep planning, whole-body motion planning with rapidly exploring random trees, grasping, active perception, human motion analysis, activity recognition, statistical testing, paper writing.				
<b>Prerequisites</b>	<b>Recommended:</b> MA-INF 4113 – Cognitive Robotics				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics. MIT Press, 2005.</li> <li>• B. Siciliano, O. Khatib (Eds.): Springer Handbook of Robotics</li> <li>• K. Harada, E. Yoshida, K. Yokoi (Eds.), Motion Planning for Humanoid Robots, Springer</li> <li>• Selected research papers.</li> </ul>				

<b>Module</b> MA-INF 4216	<b>Data Mining and Machine Learning Methods in Bioinformatics</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Dr. Holger Fröhlich				
<b>Lecturer(s)</b>	Dr. Holger Fröhlich				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	<ul style="list-style-type: none"> <li>- understanding and knowledge of fundamental data mining and machine learning methods</li> <li>- understanding of their application in bioinformatics</li> </ul>				
<b>Soft skills</b>	<ul style="list-style-type: none"> <li>- communication: oral and written presentation of solutions to exercises</li> <li>- self-competences: ability to analyze application problems and to formulate possible solutions</li> <li>- practical skills: ability to practically implement solutions</li> <li>- social skills: working in a small team with other students</li> </ul>				
<b>Contents</b>	<ul style="list-style-type: none"> <li>- Introduction: Data Mining and Machine Learning in Bioinformatics</li> <li>- Introduction to Statistics: hypothesis tests, (generalized) linear models, Bayesian inference</li> <li>- Clustering algorithms</li> <li>- Hidden Markov Models</li> <li>- Support Vector Machines</li> </ul> <p>For all algorithms the specific context in bioinformatics is discussed (e.g. -omics data and sequence analysis)</p>				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<p>T. Hastie, R. Tibshirani, J. Friedman, The Elements of Statistical Learning, Springer, 2008</p> <p>S. Boslaugh, P. Watters, Statistics in a Nutshell, O'Reilly, 2008</p> <p>N. Jones, P. Pevzner, An Introduction to Bioinformatics Algorithms, MIT Press, 2004</p>				

<b>Module</b> MA-INF 4217	<b>Seminar Machine Learning Methods in Systems Biology</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Dr. Holger Fröhlich				
<b>Lecturer(s)</b>	Dr. Holger Fröhlich				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	<ul style="list-style-type: none"> <li>- understanding and knowledge of current concepts in systems biology</li> <li>- understanding and knowledge of involved computational methods, specifically from the field of Machine Learning</li> </ul>				
<b>Soft skills</b>	<ul style="list-style-type: none"> <li>- communication: oral scientific presentation of a defined topic</li> <li>- self-competences: ability to read, understand and analyze scientific publications</li> <li>- social skills: ability to discuss a scientific topic with other students and the staff</li> </ul>				
<b>Contents</b>	<p>Conference and journal papers covering the areas:</p> <ul style="list-style-type: none"> <li>- Introduction to Systems Biology</li> <li>- Overview about different modeling concepts and philosophies</li> <li>- Machine Learning based approaches: Gaussian Graphical Models, Dynamic Bayesian Networks, methods for heterogenous data integration</li> </ul>				
<b>Prerequisites</b>	<b>Recommended:</b> MA-INF 4216 – Data Mining and Machine Learning Methods in Bioinformatics				
<b>Format</b>	<b>Teaching format</b> Seminar	<b>Group size</b> 10	<b>h/week</b> 2	<b>Workload[h]</b> 30 T / 90 S	<b>CP</b> 4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>	powerpoint				
<b>Literature</b>	selected journal and conference papers				

<b>Module</b> MA-INF 4218	<b>Lab Modeling and Simulation</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Andreas Weber				
<b>Lecturer(s)</b>	Prof. Dr. Andreas Weber, Prof. Dr. Holger Fröhlich				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	<ul style="list-style-type: none"> <li>- ability to describe a system via a model</li> <li>- ability to conduct a simulation study, visualize and interpret its results</li> <li>- ability to implement self-written program modules in MATLAB, R or via usage of some other software</li> </ul>				
<b>Soft skills</b>	<ul style="list-style-type: none"> <li>- ability to communicate effectively in order to implement learned methods together with a team of other students</li> <li>- ability to present and explain results and to defend design decisions</li> </ul>				
<b>Contents</b>	Simulation and analysis of complex systems that arise, for example, in systems biology. Covered modelling approaches are: <ul style="list-style-type: none"> <li>- Boolean Networks</li> <li>- ODEs</li> </ul>				
<b>Prerequisites</b>	<b>Recommended:</b> MA-INF 4217 – Seminar Machine Learning Methods in Systems Biology				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>	powerpoint				
<b>Literature</b>	<ul style="list-style-type: none"> <li>- U. Alon, An Introduction to Systems Biology, CRC Press, 2007</li> <li>- E.S. Allman &amp; J.A. Rhodes “Mathematical Models in Biology” Cambr.Univ.Press 2004</li> </ul>				

<b>Module</b> MA-INF 4302	<b>Advanced Learning Systems</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Stefan Wrobel				
<b>Lecturer(s)</b>	Prof. Dr. Stefan Wrobel, Dr. Thomas Gärtner				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Participants specialize and require in-depth knowledge of one particular class of learning algorithms, they acquire the necessary knowledge to improve existing algorithms and construct their own within the given class, all the way up to the research frontier on the topic.				
<b>Soft skills</b>	In group work, students acquire the necessary social and communication skills for effective team work and project planning, and learn how to present software projects to others.				
<b>Contents</b>	The module is offered every year, each time concentrating on one or more specific algorithm classes, e.g. <ul style="list-style-type: none"> <li>• kernel machines</li> <li>• neural networks</li> <li>• probabilistic and statistical learning approaches</li> <li>• logic-based learning approaches</li> <li>• reinforcement learning</li> </ul>				
<b>Prerequisites</b>	<b>Recommended:</b> all of the following: MA-INF 4111 – Intelligent Learning and Analysis Systems: Machine Learning MA-INF 4112 – Intelligent Learning and Analysis Systems: Data Mining and Knowledge Discovery				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>	lectures, exercises, software systems				
<b>Literature</b>	<ul style="list-style-type: none"> <li>• B. Schoelkopf, A.J. Smola, Learning with Kernels, The MIT Press, 2002, Cambridge, MA</li> <li>• John Shawe-Taylor, Nello Christianini, Kernel Methods for Pattern Analysis, CUP, 2004</li> <li>• Christopher Bishop, Pattern Recognition and Machine Learning, The University of Edinburgh, 2006</li> <li>• David MacKay, Information Theory, Inference, and Learning Algorithms, 2003</li> <li>• Richard Duda, Peter Hart, David Stork, Pattern Classification, John Wiley and Sons, 2001</li> </ul>				

<b>Module</b> MA-INF 4303	<b>Learning from Non-Standard Data</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Stefan Wrobel				
<b>Lecturer(s)</b>	Prof. Dr. Stefan Wrobel, Dr. Tamas Horvath				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Participants deepen their knowledge of learning systems with respect to one particular non-standard data type, i.e., non-tabular data, as they are becoming increasingly important in many applications. Each type of data not only requires specialized algorithms but also knowledge of the surrounding pre- and postprocessing operations which is acquired by the participants in the module. In group work, students acquire the necessary social and communication skills for effective team work and project planning, and learn how to present software projects to others.				
<b>Soft skills</b>	Communicative skills (oral and written presentation of solutions, discussions in teams), self-competences (ability to accept and formulate criticism, ability to analyse, creativity in the context of an "open end" task)				
<b>Contents</b>	The module will offered every year, concentrating on one particular non-standard data type each time, including: Text Mining, Multimedia Mining, Graph Mining. Learning from structured data, Spatial Data Mining				
<b>Prerequisites</b>	<b>Recommended:</b> all of the following: MA-INF 4111 – Intelligent Learning and Analysis Systems: Machine Learning MA-INF 4112 – Intelligent Learning and Analysis Systems: Data Mining and Knowledge Discovery				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>	lectures, exercises, software systems.				
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Gennady Andrienko, Natalia Andrienko, Exploratory Analysis of Spatial and Temporal Data, Springer, 2006</li> <li>• Diane J. Cook, Lawrence B. Holder, Mining Graph Data, Wiley &amp; Sons, 2006</li> <li>• Saso Dzeroski, Nada Lavrac, Relational Data Mining, Springer, 2001</li> <li>• Sholom M. Weiss, Nitin Indurkha, Tong Zhang, Fred J. Damerau, Text Mining. Predictive Methods for Analyzing Unstructured Information, Springer, 2004</li> </ul>				

<b>Module</b> MA-INF 4304	<b>Lab Cognitive Robotics</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Sven Behnke				
<b>Lecturer(s)</b>	Prof. Dr. Sven Behnke				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	<p>Participants acquire practical experience and in-depth knowledge in the design and implementation of perception and control algorithms for complex robotic systems.</p> <p>In a small group, they analyze a problem, realize a state-of-the-art solution, and evaluate its performance.</p>				
<b>Soft skills</b>	<p>Self-competences (time management, goal-oriented work, ability to analyze problems and to find practical solutions), communication skills (Work together in small teams, oral and written presentation of solutions, critical examination of implementations)</p>				
<b>Contents</b>	<p>Robot middleware (ROS), simultaneous localization and mapping (SLAM), 3D representations of objects and environments, object detection and recognition, person detection and tracking, action recognition, action planning and control, mobile manipulation, human-robot interaction.</p>				
<b>Prerequisites</b>	<p><b>Recommended:</b> At least 1 of the following:  MA-INF 4113 – Cognitive Robotics  MA-INF 4114 – Robot Learning</p>				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	none				(not graded)
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics. MIT Press, 2005.</li> <li>• B. Siciliano, O. Khatib (Eds.): Springer Handbook of Robotics, 2008.</li> <li>• Selected research papers.</li> </ul>				

<b>Module</b> MA-INF 4306	<b>Lab Development and Application of Data Mining and Learning Systems</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Stefan Wrobel				
<b>Lecturer(s)</b>	Prof. Dr. Stefan Wrobel				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	Students will acquire in-depth knowledge in the construction and development of intelligent learning systems for machine learning and data mining. They learn how to work with existing state-of-the-art systems and apply them to application problems, usually extending them for the requirements of their particular task.				
<b>Soft skills</b>	Communicative skills (appropriate oral presentation and written documentation of project results), social skills (ability to work in teams), self-competences (time management, aiming at long-range goals under limited resources, ability to work under pressure, ability to accept/formulate criticism)				
<b>Contents</b>	Data storage and process models of data analysis. Common open source frameworks for the construction of data analysis systems, specialized statistical packages. Pre-processing tools. Mathematical libraries for numerical computation. Search and optimization methods. User interfaces and visualization for analysis systems. Data analysis algorithms for embedded and distributed systems. Ubiquitous discovery systems.				
<b>Prerequisites</b>	<b>Recommended:</b> At least 1 of the following: MA-INF 4111 – Intelligent Learning and Analysis Systems: Machine Learning MA-INF 4112 – Intelligent Learning and Analysis Systems: Data Mining and Knowledge Discovery				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	none				(not graded)
<b>Forms of media</b>	Computer Software, Documentation, Research Papers.				
<b>Literature</b>	The relevant literature will be announced towards the end of the previous semester.				



<b>Module</b> MA-INF 4307	<b>Lab Field Programmable Gate Arrays</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every 2 years		
<b>Module coordinator</b>	Prof. Dr. Joachim K. Anlauf				
<b>Lecturer(s)</b>	Prof. Dr. Joachim K. Anlauf				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Development and simulation of digital circuits in VHDL and SystemC, experience with synthesizable subsets, knowledge of the design path from the idea to a realized circuit implemented in an FPGA (field programmable gate array)				
<b>Soft skills</b>	Communicative skills (oral and written presentation of results), social skills (ability to cooperate in small teams, discussions of solution concepts) self competences (ability to accept and formulate criticism, ability to analyze and find practical solutions to problems)				
<b>Contents</b>	VHDL for Hardware Description, Simulation, and Synthesis, SystemC for Hardware Description, Simulation, and Synthesis, Synthesizable Subsets, Test of Implementations on FPGA Evaluation Boards				
<b>Prerequisites</b>	<b>Recommended:</b> MA-INF 4207 – Dynamically Reconfigurable Systems				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	Technical documentation				

<b>Module</b> MA-INF 4308	<b>Lab Vision Systems</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>	Prof. Dr. Sven Behnke				
<b>Lecturer(s)</b>	Dr. Nils Goerke				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 3.		
<b>Technical skills</b>	Students will acquire knowledge of the design and implementation of parallel algorithms on GPUs. They will apply these techniques to accelerate standard machine learning algorithms for data-intensive computer vision tasks.				
<b>Soft skills</b>	Self-competences (time management, goal-oriented work, ability to analyze problems and to find practical solutions), communication skills (Work together in small teams, oral and written presentation of solutions, critical examination of implementations)				
<b>Contents</b>	Basic matrix and vector computations with GPUs (CUDA). Classification algorithms, such as multi-layer perceptrons, support-vector machines, k-nearest neighbors, linear-discriminant analysis. Image preprocessing and data handling. Quantitative performance evaluation of learning algorithms for segmentation and categorization.				
<b>Prerequisites</b>	<b>Recommended:</b> At least 1 of the following: MA-INF 4111 – Intelligent Learning and Analysis Systems: Machine Learning MA-INF 4204 – Technical Neural Nets				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	<ul style="list-style-type: none"> <li>• R. Szeliski: Computer Vision: Algorithms and Applications, Springer 2010.</li> <li>• C. M. Bishop: Pattern Recognition and Machine Learning, Springer 2006.</li> <li>• NVidia CUDA Programming Guide, Version 4.0, 2011.</li> </ul>				

<b>Module</b> MA-INF 4309	<b>Lab Sensor Data Interpretation</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every 2 years		
<b>Module coordinator</b>	PD. Dr. Volker Steinhage				
<b>Lecturer(s)</b>	PD. Dr. Volker Steinhage				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Competence to implement algorithms for sensor data interpretation, efficient handling and testing, documentation.				
<b>Soft skills</b>	Efficient implementation of complex algorithms, abstract thinking, documentation of source code.				
<b>Contents</b>	Varying selected up-to-date topics on sensor data interpretation				
<b>Prerequisites</b>	<b>Required:</b> all of the following: MA-INF 2201 – Computer Vision MA-INF 4206 – Selected Topics in Sensor Data Interpretation				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	Relevant literature will be announced at start of the lab.				

<b>Module</b> MA-INF 4310	<b>Lab Mobile Robots</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> at least every year		
<b>Module coordinator</b>	Prof. Dr. Sven Behnke				
<b>Lecturer(s)</b>	Prof. Dr. Sven Behnke, Dr. Nils Goerke				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2. or 3.		
<b>Technical skills</b>	Participants acquire basic knowledge and practical experience in the design and implementation of control algorithms for simple structured robotic systems using real mobile robots. Fundamental paradigms for mobile robots will be identified and implemented in 2 person groups.				
<b>Soft skills</b>	Self-competences (time management, goal-oriented work, ability to analyze problems and to find practical solutions), communication skills (Work together in small teams, oral and written presentation of solutions, critical examination of implementations)				
<b>Contents</b>	Robot middleware (e.g. ROS), robot simulation tools, basic capabilities for mobile robots: reactive control, SMPA architecture, navigation, path planning, localisation, simultaneous localization and mapping (SLAM), visual based object detection, learning robot control.				
<b>Prerequisites</b>	<b>Recommended:</b> At least 1 of the following: BA-INF 132 – Grundlagen der Robotik BA-INF 131 – Intelligente Sehsysteme MA-INF 1314 – Online Motion Planning MA-INF 2201 – Computer Vision MA-INF 4113 – Cognitive Robotics MA-INF 4114 – Robot Learning MA-INF 4203 – Autonomous Mobile Systems				
<b>Format</b>	<b>Teaching format</b> Lab	<b>Group size</b> 8	<b>h/week</b> 4	<b>Workload[h]</b> 60 T / 210 S	<b>CP</b> 9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>	Robots simulation environments, robot control middleware, computer vision libraries, programming, demonstration of robot capabilities (real robotic systems), presentation and written report of approach and results.				
<b>Literature</b>	<ul style="list-style-type: none"> <li>• S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics. MIT Press, 2005.</li> <li>• J. Buchli: Mobile Robots: Moving Intelligence, Published by Advanced Robotic Systems and Pro Literatur Verlag</li> <li>• B. Siciliano, O. Khatib (Eds.): Springer Handbook of Robotics, 2008.</li> <li>• Additional State-of-the-art publications.</li> </ul>				

<b>Module</b> MA-INF 4311	<b>Seminar Advanced Topics in Data Analysis</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Sören Auer				
<b>Lecturer(s)</b>					
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss these results in the framework of the corresponding area.				
<b>Contents</b>	Current conference and journal papers				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Seminar	10	2	30 T / 90 S	4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 4312	<b>Semantic Data Web Technologies</b>				
<b>Workload</b> 180 h	<b>Credit points</b> 6 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Sören Auer				
<b>Lecturer(s)</b>	Prof. Dr. Sören Auer, Dr. Christoph Lange				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1.		
<b>Technical skills</b>	The goal of this lecture is to impart knowledge on the fundamentals, technologies and applications of the Semantic Web and information retrieval. As part of the lecture the basic concepts and standards for semantic technologies are explained.				
<b>Soft skills</b>					
<b>Contents</b>	<p>As part of the W3C Semantic Web initiative standards and technologies have been developed for machine-readable exchange of data, information and knowledge on the Web. These standards and technologies are increasingly being used in applications and have already led to a number of exciting projects (e.g. DBpedia, semantic wiki or commercial applications such as schema.org, OpenCalais, or Google's Freebase). The module provides a theoretically grounded and practically oriented introduction to this area. The topics discussed within the lecture include:</p> <ul style="list-style-type: none"> <li>• RDF syntax and data model</li> <li>• RDF Schema and formal semantics of RDF (S)</li> <li>• ontologies in OWL and formal semantics of OWL</li> <li>• RDF databases, triple and knowledge stores, query languages</li> <li>• Linked Data Web and Semantic Web applications</li> <li>• Semantic text analysis and information retrieval systems</li> </ul>				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	2	30 T / 45 S	2.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam				(graded)
<b>Study achievements</b>	Successful exercise participation				(not graded)
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 4313	<b>Seminar Semantic Data Web Technologies</b>				
<b>Workload</b> 120 h	<b>Credit points</b> 4 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Sören Auer				
<b>Lecturer(s)</b>	Prof. Dr. Christoph Lange				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	Through the seminar, students will learn to work with tools and technologies of the Semantic Web as well as assess their capabilities for given problems. They will gain the ability to understand new research results presented in original scientific papers.				
<b>Soft skills</b>	Ability to present and to critically discuss technologies and research results in the framework of Semantic Web technologies.				
<b>Contents</b>	<ul style="list-style-type: none"> <li>• technologies such as triple stores, link discovery frameworks, NLP pipelines.</li> <li>• recent conference and journal papers</li> </ul>				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b> Seminar	<b>Group size</b> 10	<b>h/week</b> 2	<b>Workload[h]</b> 30 T / 90 S	<b>CP</b> 4
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

<b>Module</b> MA-INF 4314	<b>Lab Semantic Data Web Technologies</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Prof. Dr. Sören Auer				
<b>Lecturer(s)</b>	Prof. Dr. Sören Auer, Dr. Christoph Lange				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 2.		
<b>Technical skills</b>	The students will carry out a practical task (project) in the context of Semantic Web technologies, including test and documentation of the implemented software/system.				
<b>Soft skills</b>	Ability to properly present and defend design decisions, to prepare readable documentation of software; skills in constructively collaborating with others in small teams over a longer period of time; ability to classify own results with regard to the state-of-the-art				
<b>Contents</b>					
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lab	8	4	60 T / 210 S	9
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation, written report				(graded)
<b>Study achievements</b>	none				(not graded)
<b>Forms of media</b>					
<b>Literature</b>					



<b>Module</b> MA-INF 4315	<b>Probabilistic Graphical Models</b>				
<b>Workload</b> 270 h	<b>Credit points</b> 9 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every year		
<b>Module coordinator</b>	Jun.-Prof. Dr. Angela Yao				
<b>Lecturer(s)</b>					
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Optional	<b>Semester</b> 1., 2., 3. or 4.		
<b>Technical skills</b>	Students will be introduced to the theory of probabilistic graphical models and study various applications of such models in image processing, computer vision and other topics in AI.				
<b>Soft skills</b>	Productive work in small teams, development and realization of individual approaches and solutions, critical reflection of competing methods, discussion in groups.				
<b>Contents</b>	This course introduces probabilistic graphical models and their use in solving problems in computer vision and machine learning. Graphical models offer a probabilistic framework for modelling and making decisions in complex scenarios with limited and noisy data. We will cover topics such as Markov and Bayesian networks, parameter learning, and inference techniques. The theory will be demonstrated in computer vision applications such as human pose estimation, object tracking, image de-noising and semantic segmentation.				
<b>Prerequisites</b>	<b>Recommended:</b> No prior knowledge of statistics is required to follow the course. Exercises will be both theory and programming (Matlab / Python) based.				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Lecture	60	4	60 T / 105 S	5.5
	Exercises	30	2	30 T / 75 S	3.5
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Written exam (graded)				
<b>Study achievements</b>	Successful exercise participation (not graded)				
<b>Forms of media</b>					
<b>Literature</b>					

## 5 Master Thesis

MA-INF 0401	30 CP	Master Thesis .....	139
MA-INF 0402	Sem2 2 CP	Master Seminar .....	140

<b>Module</b> MA-INF 0401	<b>Master Thesis</b>				
<b>Workload</b> 900 h	<b>Credit points</b> 30 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>					
<b>Lecturer(s)</b>	All lecturers of computer science				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Compulsory	<b>Semester</b> 4.		
<b>Technical skills</b>	Ability to solve a well-defined, significant research problem under supervision, but in principle independently				
<b>Soft skills</b>	Ability to write a scientific documentation of considerable length according to established scientific principles of form and style, in particular reflecting solid knowledge about the state-of-the-art in the field				
<b>Contents</b>	Topics of the thesis may be chosen from any of the areas of computer science represented in the curriculum				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b>	<b>Group size</b>	<b>h/week</b>	<b>Workload[h]</b>	<b>CP</b>
	Independent preparation of a scientific thesis with individual coaching			900 S	30
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Master Thesis (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	Individual bibliographic research required for identifying relevant literature (depending on the topic of the thesis)				

<b>Module</b> MA-INF 0402	<b>Master Seminar</b>				
<b>Workload</b> 60 h	<b>Credit points</b> 2 CP	<b>Duration</b> 1 semester	<b>Frequency</b> every semester		
<b>Module coordinator</b>					
<b>Lecturer(s)</b>	All lecturers of computer science				
<b>Classification</b>	<b>Programme</b> M. Sc. Computer Science	<b>Mode</b> Compulsory	<b>Semester</b> 4.		
<b>Technical skills</b>	Ability to document and defend the results of the thesis work in a scientifically appropriate style, taking into consideration the state-of-the-art in research in the resp. area				
<b>Soft skills</b>					
<b>Contents</b>	Topic, scientific context, and results of the master thesis				
<b>Prerequisites</b>	none				
<b>Format</b>	<b>Teaching format</b> Seminar	<b>Group size</b>	<b>h/week</b> 2	<b>Workload[h]</b> 30 T / 30 S	<b>CP</b> 2
	T = face-to-face teaching; S = independent study				
<b>Exam achievements</b>	Oral presentation of final results (graded)				
<b>Study achievements</b>	none (not graded)				
<b>Forms of media</b>					
<b>Literature</b>	Individual bibliographic research required for identifying relevant literature (depending on the topic of the thesis)				