Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

Module Handbook Department of Informatics 2024 English

Draft – English translation – not legally binding

Program

Master of Science Intelligent Adaptive Systems

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Contents

General information

Content of a module description

<table>
<tr><td>Module title</td><td colspan="5">The title of the module</td></tr>
<tr><td>Module number/code</td><td colspan="5">The number/code for the module (e.g., InfB, InfM, or ITMC-XXX)</td></tr>
<tr><td>Module applicability, type and curricular area</td><td colspan="5">Examples:
Master of Science in Informatics: Required Elective
Master of Science in Data Science and Artificial Intelligence: Required</td></tr>
<tr><td rowspan="2">Prerequisites</td><td colspan="5">Mandatory: other modules that must be completed before commencement, i.e., passing the respective examinations. “None” means that there are not any mandatory prerequisites.</td></tr>
<tr><td colspan="5">Recommended: prerequisites for which proof of completion does not necessarily need to be submitted before starting the module. “None” means that there are not any recommended prerequisites.</td></tr>
<tr><td>Module coordinator(s)</td><td colspan="5">Generally a professor</td></tr>
<tr><td>Teaching staff</td><td colspan="5">Generally the module coordinator, plus further teaching staff where relevant.</td></tr>
<tr><td>Language</td><td colspan="5">Examples:
German with teaching materials in German and English; English with teaching materials in English.
Master’s modules can be taught in German and teaching materials provided in German and/or English. It must be possible to complete a bachelor’s degree programs in German, that is, required modules and sufficient required elective modules must be offered in German for each degree program.</td></tr>
<tr><td>Qualifikationsziele</td><td colspan="5">Guiding question for a skills-based description of the Qualification targets: which Qualification targets will students have achieved upon successful completion of the module?
Examples: Students are able to design and validate systems and are familiar with a modeling method. Through practical work, they have furthered their ability to grasp specific types of problems and select appropriate solutions...</td></tr>
<tr><td>Contents</td><td colspan="5">Guiding question on the content: Which specialist, methodological, practical, and interdisciplinary content will be taught to ensure the module objectives are met?</td></tr>
<tr><td rowspan="2">Course components and teaching format(s)</td><td colspan="5">Example: Lecture Course 1 (2 credit hours per week)</td></tr>
<tr><td colspan="5">Example: Exercises Course 2 (2 credit hours per week)</td></tr>
<tr><td rowspan="5">Workload
(course components and overall)</td><td></td><td>Credits</td><td>P (hrs)</td><td>S (hrs)</td><td>EP (hrs)</td></tr>
<tr><td>Lecture Course 1</td><td>3</td><td>28</td><td>42</td><td>20</td></tr>
<tr><td>Exercises Course 2</td><td>3</td><td>28</td><td>42</td><td>20</td></tr>
<tr><td>Summe</td><td>6</td><td>56</td><td>84</td><td>40</td></tr>
<tr><td colspan="5">Breakdown of the workload in hours (30 hours per ECTS credit) into attendance hours (P), independent study (S) and examination preparation (EP). As a rule, the number of attendance hours is equal to the number of credit hours per week multiplied by 14 weeks.</td></tr>
<tr><td rowspan="3">Academic requirements and examinations</td><td colspan="5">Examples:
Academic requirements: Regular and successful participation in the seminar / practical course. Participation in the seminar is deemed to have been successful if the topic has been understood, appropriately addressed in a presentation, and explored in writing. Participation in the practical course is deemed to have been successful if all assignments have been completed and at least 50 % have been solved correctly. Any changes to these criteria must be announced prior to module registration.</td></tr>
<tr><td colspan="5">Examples:
Examinations: Joint examination for all module courses; generally an oral examination in the teaching language. Alternatively, a written examination is possible. The examination type(s) will be announced prior to module registration.</td></tr>
<tr><td colspan="5">Grades will be awarded for the examinations in this module.</td></tr>
<tr><td>Module duration</td><td colspan="5">One semester</td></tr>
<tr><td>Semester(s) offered</td><td colspan="5">Semester(s) in which the course is offered.</td></tr>
<tr><td>Literature</td><td colspan="5"></td></tr>
</table>

Key

Credits = ECTS credits
P (hrs) = attendance (hours)
S (hrs) = independent study (hours)
EP (hrs) = examination preparation (hours)

MIN-PO = Prüfungsordnung B.Sc. bzw. M.Sc. der MIN-Fakultät der Universität Hamburg

FSBs = subject-specific provisions for the degree program

1 Modules of Teaching Unit Informatics

Module title	**Bio-Inspired Artificia Intelligence**				
Module number/code	**InfM-BAI**				
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules / Focus Data Science: Selection M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics M.Sc. Bioinformatics: Required elective area – informatics und Required elective area – life sciences, informatics, and bioinformatics M.Sc. Intelligent Adaptive Systems: Required modules				
Prerequisites	Mandatory: none				
	Recommended: none				
Module coordinator(s)	Wermter				
Teaching staff	Wermter, N.N.				
Language	English with teaching materials in English				
Qualification targets	Students are familiar with the scientific investigation and use of intelligent behavior in nature: They are acquainted with the principles of biological intelligent strategies. Students are able to critically analyze relevant characteristics and can implement these characteristics in computer models for intelligent systems and robots.				
Contents	Students are introduced to interdisciplinary research through an exploration of the methods of artificial intelligence based on biological or human capabilities. In the seminar, models from the latest research are evaluated and linked to the material covered in the lecture. The changing topics explored during the seminar are determined before the start of the academic year to take into account changing demands and current research directions. The content focuses on advanced methods for bio-inspired AI systems: • cellular systems and spiking neural systems • bio-inspired image and language processing • evolutionary systems and bio-inspired robots • communication-based cooperation and human-robot interaction				
Course components and teaching format(s)	Lecture Bio-Inspired Artificial Intelligence (2 credit hours per week)				
	Seminar Bio-Inspired Artificial Intelligence (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Bio-Inspired Artificial Intelligence	3	28	42	20
	Seminar Bio-Inspired Artificial Intelligence	3	28	42	20
	Total workload	6	56	84	40
Academic requirements and examinations	Coursework: Regular and successful participation in the seminar. Participation in a seminar is essentially deemed to have been successful if the respective topic areas have been understood, adequately presented and, if applicable, also adequately explored in a written paper. Any changes to the criteria must be announced prior to module registration.				
	Exam(s): Joint examination for all module courses; generally, an oral examination in the teaching language. Alternatively, a written examination is possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Winter semester, every year				
Literature	Floreano, D., Mattiussi, C., Bio-inspired Artificial Intelligence: Theories, Methods, and Technologies. MIT Press, 2008. Eberhart, R.C., Shi, Y., Computational Intelligence: Concepts to Implementations. Elsevier/Morgan Kaufmann, 2007.				

Module title	**Computer Vision I**				
Module number/code	**InfM-CV 1**				
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules / Focus Human-Computer Interaction: Selection M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics M.Sc. Bioinformatics: Required elective area – informatics und Required elective area – life sciences, informatics, and bioinformatics M.Sc. Intelligent Adaptive Systems: Required elective area				
Prerequisites	Mandatory: none				
	Recommended: none				
Module coordinator(s)	Frintrop				
Teaching staff	Frintrop, N.N.				
Language	English with teaching materials in English				
Qualification targets	Students know the basics of digital image processing and computer vision, reinforced through exercises.				
Contents	Focus areas: fundamentals of image processing (digital filters, smoothing, and edge detection), feature extraction (DOG, SIFT, and HOG) and object recognition with features, image segmentation, and superpixel methods, and object classification using machine learning and especially deep learning.				
Course components and teaching format(s)	Lecture Computer Vision I (2 credit hours per week)				
	Exercises Computer Vision I (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Computer Vision I	3	28	42	20
	Exercises Computer Vision I	3	28	42	20
	Total workload	6	56	84	40
Academic requirements and examinations	Coursework: Regular and successful participation in the seminar/exercises. Participation in the seminar is deemed to have been successful if the topic has been understood, appropriately addressed in a presentation, and explored in writing. Participation in the exercises is deemed to have been successful if all assignments have been completed and at least 50 % have been solved correctly. Any changes to these criteria must be announced prior to module registration.				
	Exam(s): Joint examination for all module courses; generally, a written examination in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Winter semester, every year				
Literature					

Module title	**Computer Vision II**				
Module number/code	**InfM-CV 2**				
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics M.Sc. Intelligent Adaptive Systems: Required elective area				
Prerequisites	Mandatory: none				
	Recommended: InfM-CV 1				
Module coordinator(s)	Frintrop				
Teaching staff	Frintrop, N.N.				
Language	English with teaching materials in English				
Qualification targets	Students possess in-depth knowledge of current research topics regarding image processing and are able to independently apply this knowledge to their individual research in this area.				
Contents	Specific current research topics in image processing are selected for detailed discussion. Topics may include the following: visual attention, saliency detection, object discovery, active vision, and convolutional neural networks.				
Course components and teaching format(s)	Lecture Computer Vision II (2 credit hours per week)				
	Exercises/Seminar Computer Vision II (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Computer Vision II	3	28	42	20
	Exercises/Seminar Computer Vision II	3	28	42	20
	Total workload	6	56	84	40
Academic requirements and examinations	Coursework: Regular and successful participation in the seminar/exercises. Participation in the seminar is deemed to have been successful if the topic has been understood, appropriately addressed in a presentation, and explored in writing. Participation in the exercises is deemed to have been successful if all assignments have been completed and at least 50 % have been solved correctly. Any changes to these criteria must be announced prior to module registration.				
	Exam(s): Joint examination for all module courses; generally, an oral examination in the teaching language. Alternatively, a written examination is possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Summer semester, at least every other year				
Literature					

Module title	**Databases and Information Systems**				
Module number/code	**InfM-DIS**				
Module applicability, type and curricular area	M.Sc. Informatics: Required elective area – general / Focus Data Science: At least two out of InfM-DIS, InfM-ML, InfM-STSP M.Sc. Data Science and Artificial Intelligence: Required elective area – Fundamentals of Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics M.Sc. IT Management and Consulting: Required elective area – IT development M.Sc. Information Systems: Required elective area – Informatics und Specialization – Development and Management of Information Systems M.Sc. Bioinformatics: Required elective area – informatics und Required elective area – life sciences, informatics, and bioinformatics M.Sc. Intelligent Adaptive Systems: Required elective area				
Prerequisites	Mandatory: none				
	Recommended: In-depth knowledge of the relational database model (ER modeling, normalization, relational algebra, SQL); basic knowledge of semi-structured data management (XML, XML schema, XML query languages); basic knowledge of formal logic (Horn clause logic, predicate calculus)				
Module coordinator(s)	Professur Data Engineering				
Teaching staff	Professur Data Engineering, N.N.				
Language	English with teaching materials in English				
Qualification targets	Students have in-depth knowledge of the basic principles, concepts, and methods of data management, data preparation, and data analysis. They are able to handle data and knowledge assets and to conceptualize and implement database and information systems and adapt database systems to specific application circumstances. They are moreover aware of the possibilities for integrating database solutions into complex software systems (data warehouses or web-based distributed information systems).				
Contents	Students explore current approaches to the design and implementation of centralized, distributed, and Internet-based information systems. Focus areas: current database technology; object-relational database systems and extensibility of database systems; architecture and components of database management systems, especially transaction management; distributed data management and web access; data warehousing; data, web, and text mining; and the Semantic Web.				
Course components and teaching format(s)	Lecture Databases and Information Systems (4 credit hours per week)				
	Exercises/Seminar Databases and Information Systems (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Databases and Information Systems	6	56	56	40
	Exercises/Seminar Databases and Information Systems	3	28	70	20
	Total workload	9	84	126	60
Academic requirements and examinations	Coursework: Regular and successful participation in the exercises/seminar. Participation in the exercises is deemed to have been successful if all of the assignments have been completed and at least 50 % have been solved correctly. Participation in the seminar is deemed to have been successful if the respective topic area has been understood, appropriately presented, and, if applicable, explored appropriately in writing. Any changes to the criteria must be announced prior to module registration.				
	Exam(s): Joint examination for all module courses, generally a written examination in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Summer semester, every year				
Literature					

Module title	**Distributed Systems and Middleware**				
Module number/code	**InfM-DSM**				
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules M.Sc. Intelligent Adaptive Systems: Elective Area				
Prerequisites	Mandatory: none				
	Recommended: Kenntnisse zu Rechnernetzen, verteilten Systemen, Systemsicherheit und Programmierkenntnisse				
Module coordinator(s)	Edinger				
Teaching staff	Edinger, N.N.				
Language	English with teaching materials in English				
Qualification targets	Students understand the advanced challenges of distributed systems. They are able to explain the different models of distributed systems. Students can explain and implement basic algorithms for error detection, leader election, broadcast and multicast, consensus protocols and group communication. They know the purpose of middleware in distributed systems. Students can design and implement entities and communication in distributed systems for selected scenarios.				
Contents	The lecture deals with advanced research questions in the field of distributed systems and middleware. Building on basic knowledge of computer networks and distributed systems, the course will focus in particular on algorithms used in complex distributed systems. Furthermore, knowledge about the functionality and use of middlewares is imparted and discussed using current examples from research. The following topics are generally covered: • Error detection in distributed systems • Leader Election • Reliable broadcast and epidemic algorithms • Consensus protocols • Group communication and synchronization • Distributed state detection • Exclusion in distributed systems • Logical clocks • Replication • Distributed computation (including MapReduce) • Middleware (distributed objects, name services, remote method calls) In the accompanying exercise, students design and develop a distributed system with a special focus on the algorithms covered in the lecture. Each semester, the focus will be on a different topic. The design and implementation are presented and discussed within the group as part of the exercises.				
Course components and teaching format(s)	Lecture Distributed Systems and Middleware (2 credit hours per week)				
	Exercises Distributed Systems and Middleware (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Distributed Systems and Middleware	3	28	42	20
	Exercises Distributed Systems and Middleware	3	28	42	20
	Total workload	6	56	84	40
Academic requirements and examinations	Coursework: Regular and successful participation in the exercises. Participation in the exercises is deemed successful when a suitable distributed system was developed and presented as part of the exercises. Any changes to the criteria must be announced prior to module registration.				
	Exam(s): Joint examination for all module courses; generally, a written examination in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Winter semester, every year				
Literature	Distributed Systems: Concepts and Design; George Coulouris, Jean Dollimore, Tim Kindberg, Gordon Blair; 5. Ausgabe, Pearson Verlag				

Module title	**Intelligent Robotics**				
Module number/code	**InfM-IR**				
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules / Focus Human-Computer Interaction: Selection M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics M.Sc. IT Management and Consulting: Required elective area – IT development M.Sc. Intelligent Adaptive Systems: Required modules				
Prerequisites	Mandatory: none				
	Recommended: Basic knowledge of knowledge processing				
Module coordinator(s)	Zhang				
Teaching staff	Zhang, N.N.				
Language	English with teaching materials in English				
Qualification targets	Students are familiar with the physical forms of perception in terms of their applications in robotics. They can apply sensor-based techniques in robotics and other technical systems. They master basic techniques of intelligent systems and understand their possible applications in technical systems. They will have an overview of application areas and implementation approaches for machine learning methods.				
Contents	General sensor characteristics and classification, integrated sensor data processing, sensors for various measurement modalities (e.g. haptic, visual), perception-action cycles, robot behavior control architectures, multisensor fusion and filtering, applications of machine learning approaches in robotics.				
Course components and teaching format(s)	Lecture Intelligent Robotics (2 credit hours per week)				
	Seminar Intelligent Robotics (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Intelligent Robotics	3	28	42	20
	Seminar Intelligent Robotics	3	28	42	20
	Total workload	6	56	84	40
Academic requirements and examinations	Coursework: Regular and successful participation in the seminar (seminar work and a presentation in the teaching language).				
	Exam(s): Generally, an oral examination in the teaching language (on all of the content covered during the lecture and seminar). Alternatively, a written examination is possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Winter semester, every year				
Literature					

Module title	**Independent Study**				
Module number/code	**InfM-IS/IAS**				
Module applicability, type and curricular area	M.Sc. Intelligent Adaptive Systems: Required elective area				
Prerequisites	Mandatory: none				
	Recommended: none				
Module coordinator(s)	Wermter				
Teaching staff	Wermter, N.N.				
Language	English with teaching materials in English				
Qualification targets	Students are able to independently expand and deepen their knowledge and skills in the field of intelligent adaptive systems. They can independently analyze problems and develop proposals for solutions using informatics concepts, while placing special emphasis on intelligent adaptive systems. They are able to present their findings in writing and during a presentation.				
Contents	Students learn to use scientific tools to analyze a practical problem and develop a solution. They prepare a written paper and present their findings in a colloquium. With this module, they pick up an issue in informatics and examine it using concepts from informatics. Students consult with their supervisor regularly during the study; this can take place during a seminar.				
Course components and teaching format(s)	Betreute Projektstudie (no scheduled course, therefore no credit hours per week)				
	Student may choose between a workload of 3 ECTS or 6 ECTS. May be conducted multiple times, up to a total of 6 ECTS in required electives and 12 ECTS overall (including free electives).				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Betreute Projektstudie	3/6	0	75/150	15/30
	Total workload	3/6	0	75/150	15/30
Academic requirements and examinations	Coursework: none				
	Exam(s): Generally, a presentation and a term paper, both in English. An overall final grade will be awarded for the presentation and term paper.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Every semester, every year				
Literature					

Module title	**Language Technology**
Module number/code	**InfM-LT**
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules / Focus Data Science: Selection M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics M.Sc. Intelligent Adaptive Systems: Required elective area
Prerequisites	Mandatory: none
	Recommended: Basic knowledge of automatic language processing; basic knowledge of machine learning
Module coordinator(s)	Biemann
Teaching staff	Biemann, N.N.
Language	English with teaching materials in English
Qualification targets	Students gain in-depth knowledge in selected areas of the machine processing of natural language. They are able to assess the viability and transferability of methods of natural language processing and are familiar with and understand the latest research findings.
Contents	Students learn the algorithmic and methodological foundations of natural language machine processing. How does language technology work? How does the computer recognize word forms? How can synonyms be used for the search? Students examine the use of algorithms in speech technology applications. In addition to machine learning and data structures for storing and manipulating text, applications such as machine translation and semantic searches are explored. The practical use of language processing software is considered and the theory consolidated in the accompanying practical course. A selection of the topics covered: • computer morphology • sequence classification • topic modeling • distributional semantics • statistical machine translation • neural methods of language comprehension • distributional semantics • word meaning and disambiguation • large language models
Course components and teaching format(s)	Lecture Language Technology (2 credit hours per week)
	Exercises Language Technology (2 credit hours per week)

Workload (course components and overall)	Credits	P (hrs)	S (hrs)	EP (hrs)
Lecture Language Technology	3	28	42	20
Exercises Language Technology	3	28	42	20
Total workload	6	56	84	40

Academic requirements and examinations	Coursework: Regular and successful participation in the exercises. Participation in the exercises is deemed successful when all of the exercises have been completed and at least 50 % have been solved correctly. Any changes to the criteria must be announced prior to module registration.
	Exam(s): Joint examination for all module courses, generally a written examination in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.
	Grades will be awarded for the module examination(s).
Module duration	1 semester
Semester(s) offered	Summer semester, every year
Literature	Jurafsky, D. and Martin, J. H. (2009): Speech and Language Processing. An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition. Second Edition. Pearson: New Jersey Manning, C. D. and Schütze, H. (1999): Foundations of Statistical Natural Language Processing. MIT Press: Cambridge, Massachusetts Carstensen, K. U., Ebert, Ch., Endriss, C., Jekat, S., Klabunde, R. and Langer, H. (Editors) (2004): Computerlinguistik und Sprachtechnologie. Eine Einführung. 2nd edition. Spektrum: Heidelberg Further topic-specific literature

Module title	**Final Module M.Sc. Intelligent Adaptive Systems**				
Module number/code	**InfM-MA/IAS**				
Module applicability, type and curricular area	M.Sc. Intelligent Adaptive Systems: Required modules				
Prerequisites	Mandatory: Vgl. §14 der MIN-PO sowie die FSB zu §14				
	Recommended: none				
Module coordinator(s)	Studiengangsverantwortliche(r)				
Teaching staff	Gemäß Beschluss des Prüfungsausschusses				
Language	English with teaching materials in English				
Qualification targets	• Students possess the ability to work independently on a complex, scientific problem from the field of informatics using scientific methods • They possess advanced problem-solving skills and the ability to transfer the theoretical and methodological knowledge of informatics to new areas of application • They are able to scientifically evaluate and classify their own work against the background of current research work regarding the chosen topic • They are able to document problem analyses, approaches to solutions, and empirical findings in accordance with scientific standards • They are able to present, scientifically evaluate, and discuss the approaches to solutions both verbally and in writing.				
Contents	Das Thema der Arbeit sollte die Entwicklung, Verfeinerung, Implementierung und/oder Validierung einer informatischen Methode umfassen. Die Bearbeitung erfolgt in der Regel in folgenden Phasen: • Einarbeitung in die Thematik und in den aktuellen Stand der Forschung • Erarbeitung/Auswahl der Methoden und Techniken zur Problemlösung • Entwicklung eines Lösungskonzeptes • Implementierung/Realisierung des eigenen Konzeptes/Ansatzes • Validierung und Bewertung der Ergebnisse • Wissenschaftliche Darstellung der Ergebnisse in schriftlicher Form und als Referat mit anschließender Diskussion				
Course components and teaching format(s)	Masterarbeit und Präsentation in einem Kolloquium (no scheduled course, therefore no credit hours per week)				
	Zur Dauer siehe § 14 der Prüfungsordnung der Fakultät für Mathematik, Informatik und Naturwissenschaften für Studiengänge mit dem Abschluss Master of Science sowie die Fachspezifischen Bestimmungen zu § 14 (Masterarbeit).				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Masterarbeit und Präsentation in einem Kolloquium	30	-	-	-
	Total workload	30	-	-	-
Academic requirements and examinations	Coursework: none				
	Exam(s): Masterarbeit (90 %) und Kolloquium (10 %). Näheres zur Modulprüfung regelt § 14 der Prüfungsordnung der Fakultät für Mathematik, Informatik und Naturwissenschaften für Studiengänge mit dem Abschluss “Master of Science” sowie die Fachspezifischen Bestimmungen zu § 14 (Masterarbeit).				
	Grades will be awarded for the module examination(s).				
Module duration	see details				
Semester(s) offered	Every semester				
Literature					

Module title	**Machine Learning**				
Module number/code	**InfM-ML**				
Module applicability, type and curricular area	M.Sc. Informatics: Required elective area – general und Required elective area – theory / Focus Data Science: At least two out of InfM-DIS, InfM-ML, InfM-STSP M.Sc. Data Science and Artificial Intelligence: Required elective area – Fundamentals of Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics M.Sc. Bioinformatics: Required elective area – informatics und Required elective area – life sciences, informatics, and bioinformatics M.Sc. Intelligent Adaptive Systems: Required modules				
Prerequisites	Mandatory: none				
	Recommended: Basic knowledge of linear algebra, stochastics, data mining, Python				
Module coordinator(s)	Laue				
Teaching staff	Laue, N.N.				
Language	English with teaching materials in English				
Qualification targets	Students have in-depth knowledge of the various approaches to learning from data, including their limitations. They are able to compare learning methods in terms of specific application conditions. They are able to systematically classify new procedures. They can design, implement, and evaluate a learning system for a given task. They can present empirical findings from the field of machine learning.				
Contents	Theoretical foundations of machine learning; Bias-variance trade-off; Regularization; Model selection and model evaluation; Supervised learning methods for regression and classification (linear methods, non-linear methods, kernel methods, decision trees); Methods of unsupervised learning (dimension reduction, clustering, matrix completion); Reinforcement learning.				
Course components and teaching format(s)	Lecture Machine Learning (4 credit hours per week)				
	Exercises/Seminar Machine Learning (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Machine Learning	6	56	56	40
	Exercises/Seminar Machine Learning	3	28	70	20
	Total workload	9	84	126	60
Academic requirements and examinations	Coursework: Regular and successful participation in the exercises/seminar. Participation in the exercises is deemed to have been successful if all of the assignments have been completed and at least 50 % have been solved correctly. Participation in the seminar is deemed to have been successful if the respective topic area has been understood, appropriately presented, and, if applicable, explored appropriately in writing. Any changes to the criteria must be announced prior to module registration.				
	Exam(s): Joint examination for all module courses, generally a written examination in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Summer semester, every year				
Literature					

Module title	**Network Security**				
Module number/code	**InfM-NetSec**				
Module applicability, type and curricular area	M.Sc. Informatics: Required elective area – general / Focus IT-Security: At least one of InfM-NetSec, InfM-SbD M.Sc. IT Management and Consulting: Elective Area M.Sc. Information Systems: Elective Area M.Sc. Bioinformatics: Elective Area M.Sc. Intelligent Adaptive Systems: Elective Area				
Prerequisites	Mandatory: none				
	Recommended: Kenntnisse im Bereich Algorithmik, Mathematik, Rechnernetze, verteilte Systeme, IT-Sicherheit				
Module coordinator(s)	Fischer				
Teaching staff	Fischer, N.N.				
Language	German with teaching materials in English or English with teaching materials in English				
Qualification targets	Students have a basic understanding of threats and attacks to networks as well as network security mechanisms and security protocols. They are able to apply their knowledge in practice to secure communication via networks as well as the networks themselves. They can also perform forensic analyses (e.g., using network data) and are proficient in using the corresponding tools. Students are able to work in smaller groups to develop solutions to problems.				
Contents	Topics: • attacks on networks and networked systems • cryptographic protocols in network security • network security protocols at various levels of the Internet model • protection of critical Internet services • network monitoring and forensics The lecture is complemented with a practical course during which students explore the material covered during the lecture in greater depth, mainly by working on practical tasks in small groups.				
Course components and teaching format(s)	Lecture Network Security (4 credit hours per week)				
	Exercises Network Security (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Network Security	6	56	84	40
	Exercises Network Security	3	28	42	20
	Total workload	9	84	126	60
Academic requirements and examinations	Coursework: Regular and successful participation in the exercises. Participation in the exercises is deemed to have been successful if the respective topic has been understood, appropriately presented, and, if applicable, explored appropriately in writing. Any changes will be announced prior to module registration.				
	Exam(s): Joint examination for all module courses; generally, an oral examination in the teaching language. Alternatively, a written examination is possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Summer semester, every year				
Literature	G. Schäfer, M. Rossberg. Netzsicherheit. dpunkt.verlag, 676 pages, Hardcover, 2014. W. Stallings. Cryptography and Network Security: Principles and Practice. Hardcover, 752 pages, Pearson, 8th edition, 2020. C. Eckert. IT-Sicherheit: Konzepte, Verfahren, Protokolle. zehnte Auflage, Oldenbourg Verlag, 932 pages, 2018.				

Module title	**Neural Networks**				
Module number/code	**InfM-NN**				
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules M.Sc. Data Science and Artificial Intelligence: Required elective area – Fundamentals of Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics M.Sc. Bioinformatics: Required elective area – informatics und Required elective area – life sciences, informatics, and bioinformatics M.Sc. Intelligent Adaptive Systems: Required modules				
Prerequisites	Mandatory: none				
	Recommended: Knowledge in bio-inspired artificial intelligence				
Module coordinator(s)	Wermter				
Teaching staff	Wermter, N.N.				
Language	English with teaching materials in English				
Qualification targets	Students have an in-depth understanding of artificial neural networks and their integration into informatics architectures. They can analyze and understand complex problems and develop adequate solutions for them.				
Contents	Students are introduced to current research in knowledge processing with neural networks, enabling them to participate in research under guidance. The lecture provides a comprehensive overview of artificial neural networks and their use and integration into hybrid neural/symbolic systems. In the seminar, models from the latest research are evaluated and linked to the material covered in the lecture. The changing topics explored during the seminar are determined before the start of the academic year to take into account changing demands and current research directions. Lecture topics: • neural networks: from basic models to advanced networks • unsupervised and reinforcement learning with neural networks • hybrid symbolic and neural architectures • neural clustering and classification • neural models for cognitive processing • neuroscience-inspired architectures for cognitive robots				
Course components and teaching format(s)	Lecture Neural Networks (2 credit hours per week)				
	Seminar Neural Networks (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Neural Networks	3	28	42	20
	Seminar Neural Networks	3	28	42	20
	Total workload	6	56	84	40
Academic requirements and examinations	Coursework: Regular and successful participation in the seminar. Participation in the seminar is deemed to have been successful if the respective topic has been understood, appropriately presented, and, if applicable, explored appropriately in writing. Any changes to the criteria must be announced prior to module registration.				
	Exam(s): Joint examination for all module courses; generally, an oral examination in the teaching language. Alternatively, a written examination is possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Summer semester, every year				
Literature	Haykin S.: Neural networks and learning machines. Prentice Hall, 2008 Wermter S., Sun R.: Hybrid Neural Systems. Springer Verlag, Heidelberg, 2000				

Module title	**Optimization for Machine Learning**
Module number/code	**InfM-OML**
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics M.Sc. Bioinformatics: Required elective area – informatics und Required elective area – life sciences, informatics, and bioinformatics M.Sc. Intelligent Adaptive Systems: Elective Area
Prerequisites	Mandatory: none
	Recommended: InfM-ML, basic knowledge of linear algebra, analysis, Python
Module coordinator(s)	Laue
Teaching staff	Laue, N.N.
Language	English with teaching materials in English
Qualification targets	Many problems in the field of machine learning and artificial intelligence require the solution of an optimization problem. This applies to both classical machine learning and modern deep learning methods. The theoretical foundations of optimization algorithms and their practical implementation in Python are covered with a special focus on machine learning problems. Students know and understand the theoretical guarantees/runtimes and limits of various optimization algorithms. They know which algorithm to choose for a specific machine learning problem and how to efficiently implement optimization algorithms for machine learning. They are aware of numerical robustness and rounding errors in optimization algorithms.
Contents	The theoretical foundations of optimization algorithms as well as their practical implementation and application to machine learning are covered. This means that different algorithms are introduced and their running times are analyzed, lower bounds for different function classes are proven and these algorithms are implemented in Python and applied to different machine learning problems. Therefore, prior knowledge of linear algebra, analysis and probability theory as well as knowledge of writing Python code is essential. In particular, the following topics are covered in more detail: • Fundamentals of optimization, where optimization is used in machine learning • General algorithms for solving unconstrained optimization problems including their runtime analysis • Specialized algorithms that are often used in machine learning, e.g. Frank-Wolfe methods, conditional gradient descent, coordinate descent, proximal methods • Optimization problems with general constraints and algorithms to solve them, duality theory • Optimization algorithms used for large problems and deep learning, e.g. various stochastic gradient descent methods such as SGD, Adam, AdaGrad, RMSProp • Efficient calculation of matrix and tensor derivatives, algorithmic differentiation (AD)
Course components and teaching format(s)	Lecture Optimization for Machine Learning (2 credit hours per week)
	Exercises Optimization for Machine Learning (2 credit hours per week)

Workload (course components and overall)

	Credits	P (hrs)	S (hrs)	EP (hrs)
Lecture Optimization for Machine Learning	3	28	42	20
Exercises Optimization for Machine Learning	3	28	42	20
Total workload	6	56	84	40

Academic requirements and examinations	Coursework: Regular and successful participation in the exercises. Participation is deemed to have been successful if a solution has been presented at least once during the exercises and a solution successfully presented for the exercises accompanying the entire lecture phase. Any changes to the criteria must be announced prior to module registration.
	Exam(s): Joint examination for all module courses, generally a written examination (90 minutes) in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.
	Grades will be awarded for the module examination(s).
Module duration	1 semester
Semester(s) offered	Winter semester, every year
Literature	

Module title	**Project**				
Module number/code	**InfM-Proj**				
Module applicability, type and curricular area	M.Sc. Informatics: Required area M.Sc. Intelligent Adaptive Systems: Required modules				
Prerequisites	Mandatory: none				
	Recommended: Individuelle Projekte können spezifische inhaltliche Voraussetzungen empfehlen.				
Module coordinator(s)	Studiengangsverantwortliche(r)				
Teaching staff	Lehrende des Fachbereichs Informatik, N.N				
Language	German with teaching materials in German and possibly in English or English with teaching materials in English				
Qualification targets	Die Studierenden haben die Fähigkeit zur Einarbeitung in neue Aufgabenstellungen und zum Lösen anspruchsvoller Informatik-Aufgaben mit wissenschaftlichen Methoden (unter Anleitung) im Team erlangt. Sie besitzen vertiefte Fähigkeit zur selbstständigen Erarbeitung fachlicher Inhalte aus der Originalliteratur und zur Präsentation fremder und eigener Problemstellungen und -lösungen in Referat und schriftlicher Form.				
Contents	Die typischen Phasen eines Entwicklungsprojektes werden unter der beruflichen Praxis weitestgehend entsprechenden Rahmenbedingungen im Team durchlaufen, um berufsbefähigende Kompetenzen zu vermitteln. Wissenschaftliches Arbeiten wird gefördert, da aktuelle Forschungsinhalte aufgegriffen und verarbeitet werden sollen, um die Problemlösungskompetenz zu erweitern. Des Weiteren wird die Transferkompetenz besonders gestärkt, da der Theorie- und Methodenschatz der Informatik auf komplexe, neuartige Probleme anzuwenden ist. Neben der Bearbeitung größerer theoretischer, konstruktiver und/oder experimenteller Aufgaben (in der Regel Systementwicklung nach Softwaretechnik-Methoden) in einem Informatik-Fachgebiet ist die Recherche aktueller, wissenschaftlicher Publikationen zum übergeordneten Projektthema und gegenseitige Vermittlung der inhaltlichen Grundlagen der Ergebnisse im integrierten Seminar integraler Bestandteil des Projekts.				
Course components and teaching format(s)	Project (6 credit hours per week)				
	Integrated Seminar (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Project	9	84	126	60
	Integrated Seminar	3	28	42	20
	Total workload	12	112	168	80
Academic requirements and examinations	Coursework: Die Zulassung zur Modulprüfung setzt die aktive Teilnahme an dem Projekt und dem integrierten Seminar, eine kontinuierliche Beteiligung sowie eine erfolgreiche Projektmitarbeit und die Vorstellung der Ergebnisse/Lösungsansätze in Referat und schriftlicher Ausarbeitung voraus.				
	Exam(s): Projektabschluss in Form eines Abschlussberichts in der Unterrichtssprache für Projekt und integriertes Seminar				
	Grades will be awarded for the module examination(s).				
Module duration	1-2 semesters				
Semester(s) offered	Every semester				
Literature					

Module title	**Quantitative Analysis of Software Architectures**				
Module number/code	**InfM-QASA**				
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules / Focus Software Engineering: Selection M.Sc. Intelligent Adaptive Systems: Elective Area				
Prerequisites	Mandatory: none				
	Recommended: InfM-SWA; Grundkenntnisse und Interesse in Software-Engineering und Software-Qualität				
Module coordinator(s)	Professur Softwarearchitektur				
Teaching staff	Professur Softwarearchitektur, N.N.				
Language	English with teaching materials in English				
Qualification targets	Students are able to document, analyze, and interpret quantitative requirements and properties of software architectures using descriptive and prescriptive modeling formalisms as well as model- and measurement-based evaluation methods, techniques, and tools.				
Contents	Software quality is key to the success of software systems. Students are introduced to relevant principles of quantitative software quality attributes and modeling formalisms during the lecture, whereby the focus is on software runtime quality attributes. Building on this, quantitative assessment approaches are presented using design and analysis models and measurement-based approaches such as load and resilience testing, monitoring, and benchmarking as well as advanced approaches and the latest research findings. The concepts covered during the lecture are discussed, applied, and explored in greater depth during the practical course using examples and tools. Topics covered: • metrics and objective values of software runtime quality with a focus on performance, availability, scalability, elasticity, and resilience, including statistical foundations • descriptions of software architecture (UML2 profiles and DSLs) with quantitative properties • probabilistic analysis modeling formalisms and solution techniques, e.g., Markov chains, queuing models (variants), Petri nets (variants), and fault trees • transformations between design and analysis models and their findings • measurement-based techniques, e.g., load and resilience testing/benchmarks and monitoring • advanced topics, e.g., scenario-based architecture assessment, trade-off analysis, multi-objective optimization, model extraction/calibration, and hybrid assessment approaches, that is, the combination of models and measurements				
Course components and teaching format(s)	Lecture Quantitative Analysis of Software Architectures (2 credit hours per week)				
	Exercises Quantitative Analysis of Software Architectures (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Quantitative Analysis of Software Architectures	3	28	42	20
	Exercises Quantitative Analysis of Software Architectures	3	28	42	20
	Total workload	6	56	84	40
Academic requirements and examinations	Coursework: Regular and successful participation in the exercises. Participation in the exercises is deemed successful when all of the exercises have been completed, at least 50 % have been solved correctly, and at least one solution has been presented. Any changes to the criteria must be announced prior to module registration.				
	Exam(s): Joint examination for all module courses; generally, an oral examination in the teaching language. Alternatively, a written examination (lasting 90 minutes) is possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Summer semester, offered occasionally				
Literature	L. Bass, P. Clemens, R. Kazman: Software Architecture in Practice, Fourth Edition. Addison Wesley, 2021 V. Cortellessa, A. Di Marco, P. Inverardi: Model-Based Software Performance Analysis. Springer, 2014. K. S. Trivedi, A. Bobbio: Reliability and Availability Engineering: Modeling, Analysis, and Applications. Cambridge University Press, 2017. S. Kounev, K.-D. Lange, J. von Kistowski: Systems Benchmarking: For Scientists and Engineers, Springer, 2021.				

Module title	**Research Methods**				
Module number/code	**InfM-RM**				
Module applicability, type and curricular area	M.Sc. Intelligent Adaptive Systems: Required modules				
Prerequisites	Mandatory: none				
	Recommended: none				
Module coordinator(s)	Wermter				
Teaching staff	Wermter, N.N.				
Language	English with teaching materials in English				
Qualification targets	Students have an in-depth understanding of scientific methods and their applications in the fields of informatics and artificial intelligence: • They are familiar with the basic principles of scientific research. • They can define and conduct experiments. • They are able to test hypotheses and perform statistical evaluations on these.				
Contents	Students are introduced to scientific processes – from design of the experiment through its execution to data analysis and publication. Methods and tools used particularly in the fields of informatics and artificial intelligence are discussed. The topics covered include various types of empirical studies and their range of uses, statistical methods for data analysis, and scholarly publication and discourse. The interactive lecture is complemented by a mix of a seminar and a practical course during which students can gain practical experience in the concepts taught. Students conduct their own experiments and analyze and discuss the data collected to reinforce what they have learned.				
Course components and teaching format(s)	Lecture Research Methods (2 credit hours per week)				
	Exercises/Seminar Research Methods (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Research Methods	3	28	42	20
	Exercises/Seminar Research Methods	3	28	42	20
	Total workload	6	56	84	40
Academic requirements and examinations	Coursework: Regular and successful participation in the seminar (seminar work and a presentation in the teaching language).				
	Exam(s): Generally, an oral examination in the teaching language (on all of the content covered during the lecture and seminar). Alternatively, a written examination is possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Winter semester, every year				
Literature	Paul R. Cohen. Empirical methods for artificial intelligence, MIT Press, Cambridge, Mass. 1995 M. Law and W.D. Kelton, editors. Simulation Modelling and Analysis. McGraw–Hill Education, 2000. S. M. Ross. Introduction to Probability Models. Harcourt, 7th edition, 2000.				

Module title	**Robot Technology**				
Module number/code	**InfM-RT**				
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules / Focus Human-Computer Interaction: Selection M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics M.Sc. Intelligent Adaptive Systems: Required elective area				
Prerequisites	Mandatory: none				
	Recommended: Basic knowledge of knowledge processing				
Module coordinator(s)	Zhang				
Teaching staff	Zhang, N.N.				
Language	German or English with teaching materials in German or English				
Qualification targets	Students master the mathematical tools for describing robotic systems. They are able to apply and develop components for real robots.				
Contents	Practice-oriented mathematical tools for the description of robotic systems are explained. Methods for generating trajectories/paths for different types of robots such as robot arms, mobile and humanoid robots are taught. The basics of control theory are also introduced. The theoretical knowledge is reinforced with practical exercises.				
Course components and teaching format(s)	Lecture Robot Technology (2 credit hours per week)				
	Exercises Robot Technology (1 credit hour per week)				
	Practical Course Robot Practical Course (1 credit hour per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Robot Technology	3	28	42	20
	Exercises Robot Technology	2	14	36	10
	Practical Course Robot Practical Course	1	14	14	2
	Total workload	6	56	92	32
Academic requirements and examinations	Coursework: Regular and successful participation in the exercises and practical course. Participation in the exercises is deemed successful if all tasks have been completed and at least 50 % have been solved correctly. Successful participation in the practical course requires regular attendance, continuous participation, and successful collaboration. Any changes will be announced prior to module registration.				
	Exam(s): Generally, an oral examination in the teaching language (on all of the content covered during the lecture, exercises, and practical course). Alternatively, a written examination is possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Summer semester, every year				
Literature					

Module title	**Speech Signal Processing**				
Module number/code	**InfM-SSV**				
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules / Focus Human-Computer Interaction: Selection M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics M.Sc. IT Management and Consulting: Required elective area – IT development M.Sc. Intelligent Adaptive Systems: Required elective area				
Prerequisites	Mandatory: none				
	Recommended: Basic knowledge in signal processing				
Module coordinator(s)	Gerkmann				
Teaching staff	Gerkmann, N.N.				
Language	German or English with teaching materials in English				
Qualification targets	Students can explain the basics of speech production, perception, and analysis; understand the mathematical and information theoretic foundations of speech signal processing; and apply the methods learned and explain the functions of practical speech signal processing systems.				
Contents	Language is probably the most natural and important method of interpersonal communication. However, voice commands are also becoming increasingly important in human-machine interaction. Speech communication devices such as smartphones, hearing aids, and voice-controlled assistants enable or simplify communication by means of modern signal processing concepts. In this lecture, students learn about basic speech signal processing concepts used in smartphones, assistive listening devices, and voice-controlled assistants. In particular, the module looks at the following: • signal-related fundamentals of speech generation • speech perception • speech analysis • speech enhancement • speech coding (speech compression)				
Course components and teaching format(s)	Lecture Speech Signal Processing (2 credit hours per week)				
	Exercises Speech Signal Processing (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Speech Signal Processing	3	28	42	20
	Exercises Speech Signal Processing	3	28	42	20
	Total workload	6	56	84	40
Academic requirements and examinations	Coursework: Regular and successful participation in the exercises. Any changes to the criteria must be announced prior to module registration.				
	Exam(s): Joint examination for all module courses; generally, an oral examination in the teaching language. Alternatively, a written examination is possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Summer semester, every year				
Literature	P. Vary, R. Martin: Digital Speech Transmission, Wiley 2006. V. Pulkki, M. Karjalainen, Communication Acoustics, Wiley 2015. J. Benesty, M.M. Sondhi, Y. Huang (Eds.): Handbook of Speech Processing, Springer, 2008. R.C. Hendriks, T. Gerkmann, J. Jensen, "DFT-Domain Based Single-Microphone Noise Reduction for Speech Enhancement – A Survey of the State of the Art", Synthesis Lectures on Speech and Audio Processing, Morgan & Claypool Publishers, pp. 1-80, Jan 2013.				

Module title	**Software Architecture**
Module number/code	**InfM-SWA**
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules / Focus Software Engineering: Selection M.Sc. Data Science and Artificial Intelligence: Required elective area – Fundamentals of Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics M.Sc. IT Management and Consulting: Required elective area – IT development M.Sc. Information Systems: Required elective area – Informatics und Specialization – Development and Management of Information Systems M.Sc. Intelligent Adaptive Systems: Required modules
Prerequisites	Mandatory: none
	Recommended: Programming skills in an object-oriented programming language
Module coordinator(s)	Professur Softwaretechnik
Teaching staff	Professur Softwaretechnik, van Hoorn, N.N.
Language	English with teaching materials in English or German with teaching materials in German and possibly in English
Qualification targets	Students have a sound understanding of the requirements for software architecture as a component in the development of complex systems. They possess fundamental knowledge of the methods, principles, techniques, and procedures involved in the development of software architectures.
Contents	Students take a closer look at software design in the large, whereby the following topics are covered in greater depth and relevant literature and practical experience are also taken into account: • Introduction to software architecture (relevance, basic terminology and concepts) • Brief introduction into requirements engineering and its relationship to software architecture • The role of the person responsible for software architecture • Methods and procedures for architecture design • Specification, modeling and documentation of software architectures • Architecture guidelines and principles • Architecture patterns and styles • Variability and product line architectures • Architecture evaluation, quality assurance, architecture optimization • Cloud-native architectural styles such as microservices and serverless • Tool support
Course components and teaching format(s)	Lecture Software Architecture (2 credit hours per week)
	Seminar Architecture-centric Software Development (2 credit hours per week)

Workload (course components and overall)

	Credits	P (hrs)	S (hrs)	EP (hrs)
Lecture Software Architecture	3	28	22	40
Seminar Architecture-centric Software Development	3	28	30	32
Total workload	6	56	52	72

Academic requirements and examinations	Coursework: Regular and successful participation in the seminar (seminar work and presentation in the teaching language). Any changes to the criteria must be announced prior to module registration.
	Exam(s): Joint examination for all module courses, generally a written examination (duration 90 minutes) in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.
	Grades will be awarded for the module examination(s).
Module duration	1 semester
Semester(s) offered	Winter semester, every year
Literature	L. Bass, P. Clemens, R. Kazman: Software Architecture in Practice, 4th edition. Addison Wesley, 2021. R. Taylor, N. Medvidovic, E. Dashofy. Software Architecture: Foundations, Theory, and Practice. 2009. R. Reussner, W. Hasselbring. Handbuch der Software-Architektur. 2nd edition, dpunkt, 2008. Further topic-specific literature will be mentioned in the course.

Module title	**User Interface Software and Technology**				
Module number/code	**InfM-UIST**				
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules / Focus Human-Computer Interaction: Required for focus M.Sc. IT Management and Consulting: Required elective area – IT development M.Sc. Intelligent Adaptive Systems: Required elective area				
Prerequisites	Mandatory: none				
	Recommended: Kenntnisse im Bereich Mensch-Computer-Interaktion und Interaktionsdesign				
Module coordinator(s)	Steinicke				
Teaching staff	Steinicke, N.N.				
Language	English with teaching materials in English or German with teaching materials in English and/or German				
Qualification targets	Students understand how various software and hardware components of interactive user interfaces work and learn about their potential and limitations. They are able to further their theoretical knowledge through practical application on small prototypes and examine new interaction concepts in the process. Students are moreover able to evaluate these systems.				
Contents	Students are familiarized with various software and hardware components of user interfaces (UIs), for example, from the fields of traditional graphical UIs (GUIs), web UIs, tangible UIs, and virtual and augmented reality 3D UIs as well as multimedia, new input and output devices, and computer-supported cooperative work. In the lectures, components of interactive user interfaces will be introduced, and their potential and limitations will be discussed. Smaller prototypes are developed during the exercises based on the software and hardware components. These prototypes are used to develop novel interaction concepts, which are then examined and evaluated during smaller pilot studies.				
Course components and teaching format(s)	Lecture User Interface Software and Technology (2 credit hours per week)				
	Exercises User Interface Software and Technology (2 credit hours per week)				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture User Interface Software and Technology	3	28	42	20
	Exercises User Interface Software and Technology	3	28	42	20
	Total workload	6	56	84	40
Academic requirements and examinations	Coursework: Regular and successful participation in the exercises. Any changes to the criteria must be announced prior to module registration.				
	Exam(s): Generally, a written examination (60 minutes) in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Winter semester, every year				
Literature	Proceedings of the Annual Symposium on User Interface Software and Technology, ACM J.D. Foley, A. van Dam, S.K. Feiner: Computer Graphics – Priciples and Practice, Addison Wesley				

Module title	**Knowledge Processing**				
Module number/code	**InfM-WV**				
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics M.Sc. Information Systems: Required elective area – Informatics M.Sc. Bioinformatics: Required elective area – informatics und Required elective area – life sciences, informatics, and bioinformatics M.Sc. Intelligent Adaptive Systems: Required elective area				
Prerequisites	Mandatory: none				
	Recommended: Basic knowledge of knowledge processing and logic				
Module coordinator(s)	Wermter				
Teaching staff	Wermter, N.N.				
Language	German with teaching materials in German and possibly in English or English with teaching materials in English				
Qualification targets	Student have an in-depth understanding of how to handle data, information, and knowledge for complex domains. They are able to analyze requirements and to select suitable, i.e. adequate and efficient, knowledge processing concepts. Moreover, they can comprehend complex problems and develop adequate solutions in the field of intelligent systems.				
Contents	Students focus on advanced methods and concepts for knowledge presentation and processing: description logics, ontologies, non-deductive reasoning, Bayesian networks, machine planning, hybrid knowledge processing, knowledge-based agents, and knowledge processing in multi-agent systems.				
Course components and teaching format(s)	Lecture Knowledge Processing (2 credit hours per week)				
	Seminar Knowledge Processing (2 credit hours per week)				
	Alternatively, teaching format may be lecture with 3 credit hours per week and seminar with 1 credit hour per week.				
Workload (course components and overall)		Credits	P (hrs)	S (hrs)	EP (hrs)
	Lecture Knowledge Processing	3	28	42	20
	Seminar Knowledge Processing	3	28	42	20
	Total workload	6	56	84	40
Academic requirements and examinations	Coursework: Regular and successful participation in the seminar (seminar work and a presentation in the teaching language).				
	Exam(s): Generally, an oral examination in the teaching language (on all of the content covered during the lecture and seminar). Alternatively, a written examination is possible. The examination type(s) will be announced prior to module registration.				
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Winter semester, every year				
Literature					