University Hildesheim

Faculty 4
Mathematics, Natural Sciences, Economics and Computer Science

Software Engineering International Master

Course Catalogue

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Compulsory Modules

Module	Type/HPW	CPs	P.
Software Engineering	2 HPW lecture, 2 HPW tutorial	6	5
Model-based Software Engineering	2 HPW lecture, 2 HPW tutorial	6	7
Requirements Engineering for Quality	2 HPW lecture, 2 HPW tutorial	6	8
Software Architectures	2 HPW lecture, 2 HPW tutorial	6	9
Programming Languages Lab	2 HPW lab course	3	11
SE Tools Lab	4 HPW lab course	6	12
Advanced Web Development	2 HPW lecture, 2 HPW lab course	6	13
Research Methods	2 HPW lecture with exercises	3	14
Integrated Research Project	2 HPW project	8	15
Seminar Software Engineering	2 HPW seminar	4	16
Group Development Project	4 HPW lab course	6	17

Methodological Specialization (Elective Modules)

Module	Type/HPW	CPs	P.
Processes and Management of Software Engineering	2 HPW lecture, 2 HPW tutorial	6	18
Software Product Line Engineering	2 HPW lecture, 2 HPW tutorial	6	20
Software Testing	2 HPW lecture (with integrated tutorial)	3	22
Analysis of Software Systems	2 HPW Lecture with Tutorium	3	23
Software Verification	2 HPW lecture and tutorial	3	24

Application Areas (Elective Modules)

Machine Learning Specialization

Module	Type/HPW	CPs	P.
Machine Learning	2 HPW lecture, 2 HPW tutorial	6	25
Advanced Machine Learning	2 HPW lecture, 2 HPW tutorial	6	27
Big Data Analytics	2 HPW lecture, 2 HPW tutorial	6	29
Modern Optimization Techniques	2 HPW lecture, 2 HPW tutorial	6	30
Deep Learning	2 HPW lecture, 2 HPW tutorial	6	32
Large Language Models	2 HPW lecture, 2 HPW tutorial	6	33
Planning and Optimal Control	2 HPW lecture, 2 HPW tutorial	6	34
Data and Privacy Protection	2 HPW lecture	3	36
Business Analytics	2 HPW lecture, 2 HPW tutorial	6	37
Advanced Case-Based Reasoning	2 HPW lecture, 2 HPW tutorial	6	39
Bayesian Networks	2 HPW lecture, 2 HPW tutorial	6	40
Computer Vision	2 HPW lecture, 2 HPW tutorial	6	42
Natural Language Processing	2 HPW lecture, 2 HPW tutorial	6	43
Machine Learning for IT Security	2 HPW lecture, 2 HPW tutorial	6	45
Advanced Computer Vision	2 HPW lecture, 2 HPW tutorial	6	47
Time Series Analysis	2 HPW lecture, 2 HPW tutorial	6	48
Business Intelligence and Data Warehousing	2 HPW lecture, 2 HPW tutorial	6	49
Data Warehousing in Practice	2 HPW lecture, 2 HPW tutorial	6	50
Seminar Data Analytics I	2 HPW seminar	4	52
Seminar Data Analytics II	2 HPW seminar	4	53
Seminar Data Analytics III	2 HPW seminar	4	54
Lab Course Programming Machine Learning	4 HPW lab course	6	55
Lab Course Distributed Data Analytics	4 HPW lab course	6	56
Lab Course Deep Learning	4 HPW lab course	6	57
Deep Learning Masterclass	4 HPW lecture, 4 HPW tutorial	6	58

Business Administration and Information Systems

Module	Type/HPW	CPs	P.
Advanced Marketing / Marketing 2	4 HPW lecture	6	59
Project Scheduling	2 HPW lecture, 2 HPW tutorial	6	60
Seminar Business Studies	2 HPW seminar	4	62
Business Intelligence and Data Warehousing	2 HPW lecture, 2 HPW tutorial	6	49
Data Warehousing in Practice			50

Information Retrieval and Information Sciences

Module	Type/HPW	CPs	P.
Introduction Information Retrieval (IR)	2 HPW lecture	4	63
Introduction Natural Language Processing	3 HPW lecture	4	64
Multilingual Information Systems	2 HPW lecture	4	65
Seminar Multilingiual Information Retrieval	2 HPW seminar	4	66
Project Multilingual Information Systems	4 HPW project	6	67
Lab Course Information Retrieval (IR)	2 HPW lab course	4	68

Natural Language Processing

Module	Type/HPW	CPs	P.
Language Modelling	2 HPW lecture 2 HPW project	6	69
Natural Language Processing 2	2 HPW lecture	4	71
Seminar Computer Linguistic Resources	2 HPW seminar	4	73
Seminar Computer Linguistic Processes	2 HPW seminar	4	74
Project Computer Linguistic Resources	4 HPW project	6	75
Project Computer Linguistic Processes	4 HPW project	6	76
Lab Course Natural Language Processing	2 HPW lab course	4	77

Environmental Sciences

Module	Type/HPW	CPs	P.
Geographic Information Systems	2 HPW lecture, 4 HPW tutorial	6	80

Psychology

Module	Type/HPW	CPs	P.
Cognitive Psychology	2 HPW lecture, 2 HPW tutorial	6	81
Brain and Neural Science	2 HPW lecture, 2 HPW tutorial	6	82

Soft Skills

Module	Type/HPW	CPs	P.
English 1	2 HPW lecture	3	85
English 2	2 HPW lecture	3	86
German 1	2 HPW lecture	3	87
German 2	2 HPW lecture	3	88

Master Thesis

Module	Type/HPW	CPs	P.
Master Thesis	Master Thesis	30	89

Compulsory Modules

Module: Software Engineering

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Prof. Dr. Klaus Schmid and members of the study group
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	The aim of this module is to provide a basic understanding of the problems, challenges and solution approaches of software engineering. The focus is on teaching essential techniques, as well as the methodological approaches of systematic software development. Students will acquire competencies for problem analysis, as well as competencies in the area of design and implementation of IT systems. In particular, students understand the fundamentals of software engineering workflows and software engineering modelling techniques.
Content	The fundamentals of software development are taught on a large scale. This includes in particular: 1. Process, product and quality reference models 2. Process models and life cycle models such as the waterfall model, spiral model 3. Requirements engineering (among other things, use cases, business process modeling) 4. Software architecture (among other things, architecture styles, design patterns) 5. Implementation techniques 6. Testing techniques (black-box, white-box) 7. Verification techniques (formal verification, inspection techniques) In the tutorial, the contents taught in the lecture are deepened by means of exercises. In the course of the exercise, tasks are worked on together as well as homework is distributed and corrected. The focus is on teaching the students the competence of independently applying the discussed techniques.
Literature	• Ian Sommerville, Software Engineering, 10th Edition. Pearson, 2015. • Current scientific publications. Announced in class. • Additional Material, made available in class.

Requirements	general knowledge of computer science
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	BSc 4 or MSc 1
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Compulsory Modules
Language	English

Module: Model-based Software Engineering

Responsible	Dr. Holger Eichelberger
Responsible Instructors	Dr. Holger Eichelberger; Prof. Dr. Klaus Schmid and members of the study group
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	Students are able to name the essential differences between various types of models in software development, to describe transformations between models and to reflect on these in the context of given use cases. They know the current state of science in this area and are able to relate different approaches to each other, or to distinguish them from each other. They know the current state of science in this area and are able to classify current work. They are able to continuously develop their knowledge.
Content	The creation, processing, and analysis of models will be presented. Current approaches in these areas will be discussed. Main topics of the lecture are: 1. Formal basics of models 2. Meta-modeling 3. Model semantics 4. Textual and graphical models 5. Model-to-model transformations 6. Model-to-text transformations In the exercise, the contents taught in the lecture Model-Based Development are deepened by means of exercises. Tasks will be worked on together in the exercise and questions concerning the analysis of the methods will be discussed. The focus is on teaching the competence for independent analysis and further development by the students.
Literature	• Current scientific publications. Announced in class. • Additional Material, made available in class.
Requirements	Knowledge of Software Engineering as thought, for example, in the course Software Engineering.
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1-3
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Compulsory Modules
Language	English

Module: Requirements Engineering for Quality

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Prof. Dr. Michael Hißmann; Prof. Dr. Klaus Schmid and members of the study group
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	Students acquire the essential methodological and theoretical basics in requirements engineering. They can use different methods within the context of specific development situations and they are able to reflect the limits and possibilities of different approaches. Students can indepently adapt these approaches to specific contexts.
Content	This lecture introduces methodological and theoretical basics of requirements engineering. The components of requirements engineering and state-of-the-art techniques and their application are discussed In particular: 1. elicitation techniques 2. requirements analysis and modelling 3. creating contracts and requirements specifications 4. quality requirements (reliability, security, usability) During the tutorium students deepen their knowledge of the material taught in the lectures. They solve tasks together and do homeworks. The tutorium focusses on communication, problem-solving-competence and transfer-competence.
Literature	• C. Rupp: *Requirements Engineering und Management.* Hanser, 2020. • K. Pohl: *Requirements Engineering: Fundamentals, Principles, and Techniques.* Springer, 2016. • Current scientific publications. Announced in class. • Additional Material, made available in class.
Requirements	Knowledge of Software Engineering as thought, for example, in the course Software Engineering.
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1-3
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Compulsory Modules
Language	English

Module: Software Architectures

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Prof. Dr. Klaus Schmid and members of the study group
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	Students learn the foundations of creating, evaluating and realizing software architectures. They understand the foundations of good architectures and they acquire the competence to define software architectures for specific systems. They also achieve the capability to evaluate and criticize existing architectures. The students understand the importance of software architectures in the software development lifecycle and how software architectures relate to business models on the one hand and technical aspects on the other hand.
Content	The course will cover both in a theoretically advanced and a practically concrete way the following areas: • Principles of good architectures • Modeling architectures • Architectural styles, patterns, tactics • Design approaches • Architecture evaluation • Modern architecture paradigms like service-orientation • Architectures for Big Data Systems
Submodules	*SM 1: Software Architectures, Lecture* Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Klaus Schmid *SM 2: Software Architectures, Tutorium* Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Klaus Schmid and members of the study group
Literature	• K. Bass, P. Clements, R. Kazman: *Software architecture in practice*. Addison-Wesley, 2012. • R.Kazman, H. Cervantes: *Designing Software Architectures*. Addison-Wesley, 2016. • Current scientific publications. Announced in class. • Additional Material, made available in class.
Requirements	• Knowledge of Software Engineering as thought, for example, in the course Software Engineering. • Good Programming Skills, preferably in Java, but other languages are also possible
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1-3
Turn	every winter term
Duration	1 Semester

Use	• International Master Software Engineering – Compulsory Modules
Language	English

Module: Programming Languages Lab

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Prof. Dr. Klaus Schmid and members of the study group
Type	2 HPW lab course
Credit Points	3 CPs
Workload	presence: 21 hours; self-study: 54 hours
Learning goals/ Competencies	The students learn the fundamentals of multiple relevant programming languages as a standardised basis for other courses in the area of software engineering. They understand the basic principles of the languages regarding syntax, semantics and mental models. They are able to apply them to solve problems.
Content	The course covers basic language principles, especially Java and Python as basic languages for other Software Engineering courses. The students are trained by a combination of teaching hours, reading assignments, and pedagogic tasks to explore certain language features.
Literature	Material will be made available in class.
Requirements	This course targets students that did not have previous experience in either Java or Python.
Exam	Multiple programming tasks
Recommended Term	MSc 1-3
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Compulsory Modules
Language	English

Module: SE Tools Lab

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Prof. Dr. Klaus Schmid and members of the study group
Type	4 HPW lab course
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	Students learn about different classes of software development tools that cover the essential phases of software development. Subsequently, the students have the necessary competences for the independent selection and application of tools.
Content	In this lab course, students learn the use of various software development tools and techniques. This includes tools for requirements engineering, modeling of software systems, version management and continuous integration. The lab course complements the contents of the Software Engineering course.
Literature	material handed out in class.
Requirements	Knowledge of Software Engineering as thought, for example, in the course Software Engineering.
Exam	multiple tasks with oral examination
Recommended Term	MSc 1-3
Turn	every summer term
Duration	1 Semester
Use	• International Master Software Engineering – Compulsory Modules
Language	English

Module: Advanced Web Development

Responsible	Dr. Holger Eichelberger
Responsible Instructors	Dr. Holger Eichelberger and members of the study group
Type	2 HPW lecture, 2 HPW lab course
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	Students acquire analytical and methodological competencies in the area of modern web technologies and architectures. They recognize and understand the practical constraints relevant to the implementation of modern web applications. They are able to reflect on possibilities and application areas of web technologies as well as associated development environments and to assess them in context. They acquire the technical competences for the realisation of an exemplary web application, especially by working in a team. Through teamwork and exchange with the lecturers, they acquire social skills such as conflict resolution strategies, communication skills, technology and effectiveness assessment.
Content	In this course, students learn software development for current web technologies. For this purpose, the technical basics of website creation, current web technologies and frameworks, associated development environments and techniques are explained and practiced in the form of an accompanying development project. The development work is done in a team and includes realization and testing of an (in the final stage) platform-dependent web application. Students learn the necessary activities and practice the underlying techniques and tools. The tasks typically relate to practicing the techniques and technologies explained.
Literature	provided in class
Requirements	• Proven programming skills in at least one programming language • Knowledge of Software Engineering as thought, for example, in the course Software Engineering.
Exam	Final presentation, prototype and written elaboration/documentation.
Recommended Term	MSc 1-3
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Compulsory Modules
Language	English

Module: Research Methods

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Prof. Dr. Klaus Schmid and members of the study group
Type	2 HPW lecture with exercises
Credit Points	3 CPs
Workload	presence: 21 hours; self-study: 54 hours
Learning goals/ Competencies	Students can apply advanced research methods of computer science. They can formulate research questions and research designs. They get an overview of different research methods. This includes both primary methods of empirical and formal research as well as secondary research approaches such as literature studies. They can discuss the relationships between research questions and research designs by means of examples and with professional competence. They know some of the most important research methods of computer science and can apply selected approaches.
Content	• Basic aspects of research like repeatability and traceability of studies • Statistical aspects and forms of bias • Empirical research approaches such as experimentation, case study, grounded theory • Analytical procedures of a technical nature, e.g., technical experiment, benchmarking • Formal Approaches such as proofs • Secondary research approaches (Survey, Mapping Study) • Interaction between research questions and research design
Literature	• Kitchenham, Budgen Bereton: Evidence-Based Software Engineering und Systematic Reviews, CRC Press, 2016 • Claes Wohlin, Per Runeson, Martin Höst, Magnus C. Ohlsson, Björn Regnell, Anders Wesslén Experimentation in Software Engineering, Springer, 2012 • Current scientific publications. Announced in class. • Additional Material, made available in class.
Requirements	none
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1-3
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Compulsory Modules
Language	English

Module: Integrated Research Project

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Prof. Dr. Klaus Schmid and members of the study group
Type	2 HPW project
Credit Points	8 CPs
Workload	presence: 21 hours; self-study: 179 hours
Learning goals/ Competencies	Students learn how to systematically approach current research problems as well as the application of the relevant research methods. They develop their research methodological skills by independently formulating research questions, conceiving research designs, reflecting them critically and organizing the implementation of research and implementation processes. They can familiarize themselves independently with a topic that is new to them and can apply methods to the problem in a targeted manner and, if necessary, adapt the methods. They will be able to scientifically document and communicate a project in detail.
Content	Students work individually or in a team to find a solution to significant problem. Regardless of the specific task, the following content is addressed: 1. Iterative formulation, review and revision of research questions 2. Iterative drafting and critical reflection of research designs 3. Selection and use of basic and advanced research methods 4. Methods of project management 5. Concurrent project documentation 6. Scientific communication of results Further content depends on the content of the IT study project
Literature	depending on the topic
Requirements	• Knowledge of Software Engineering as thought, for example, in the course Software Engineering. • Course on Research Methods
Exam	Project
Recommended Term	MSc 3
Turn	every semester
Duration	1 Semester
Use	• International Master Software Engineering – Compulsory Modules
Language	English

Module: Seminar Software Engineering

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Prof. Dr. Klaus Schmid and members of the study group
Type	2 HPW seminar
Credit Points	4 CPs
Workload	presence: 21 hours; self-study: 79 hours
Learning goals/ Competencies	The students deepen their analytic and methodological skills for understanding current research areas. Writing a report and giving a presentation as well as discussing scientific issues with their peers help the students to put the knowledge acquired during their studies into context and gives them an opportunity to add new knowledge to their corpus. Furthermore, skills are developed which will allow the students to adapt their knowledge to changing technical and societal conditions in the future.
Content	Students analyse a specific research topic within Software Engineering. They independently search for literature and are able to analyse it. They prepare a written summary and take an informed opinion on the research topic. In addition they present their results and discuss them.
Literature	Depends on the topic; announced in class
Requirements	Knowledge of Software Engineering as thought, for example, in the course Software Engineering.
Exam	Colloquium and written summary
Recommended Term	MSc 3
Turn	every semester
Duration	1 Semester
Use	• International Master Software Engineering – Compulsory Modules
Language	English

Module: Group Development Project

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Prof. Dr. Klaus Schmid and members of the study group
Type	4 HPW lab course
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals / Competencies	The students deepen their analytical, technical, and methodological competencies in the context of a concrete development project. They understand the practical framework and its constraints relevant to the implementation of the project. They are able to reflect on possibilities and limitations of existing development approaches and assess them in context. They learn the necessity of cooperation and role allocation by working in a team. Through teamwork and their exchange with the lecturers in the role of the client, they acquire social skills such as conflict resolution strategies, communication skills, team management, effectiveness assessment, and negotiation skills.
Content	In this project, students learn software development on a large scale using a combination of role-based process models with agile approaches. For this purpose, an challenging development project is given as the basis of the work, which will usually also require the acquisition of new technological skills The students learn how to adapt to different roles and how to execute the relevant activities required for this. They practice the underlying techniques and tools. The tasks are typically related to current research questions.
Submodules	none
Literature	Relevant Material will be made available in class.
Requirements	• Knowledge of Software Engineering as thought, for example, in the course Software Engineering. • Good programming skills
Exam	Final presentation, prototype, and written paper/documentation. In addition, active participation during the attendance phase is expected. The exam can also take place in a suitable online format.
Recommended Term	MSc 3
Turn	every summer term
Duration	1 Semester
Use	• International Master Software Engineering – Compulsory Modules
Language	English

Methodological Specialization (Elective Modules)

Module: Processes and Management of Software Engineering

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Prof. Dr. Michael Hißmann; Prof. Dr. Klaus Schmid and members of the study group
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	This module teaches methodological and analytical competencies that are necessary for a scientific study of processes and management activities in the field of software engineering. In particular, competencies for empirical research in the field of software engineering are taught. This provides students with the necessary expertise to analyze the suitability of software development processes and quality management methods and to develop improvements. The students understand current research questions and approaches.
Content	In this module, the fundamentals of the process models and management activities of software engineering are taught. Special emphasis is placed on the empirical scientific methods of software engineering. In particular, the following topics are addressed: 1. Process modeling and process description languages. 2. Basics of project management (cost estimation, project control) 3. Maturity models and assessments (CMMI, ISO 9000, ...) 4. Measurement and evaluation (e.g., Goal-Question-Metric) 5. Organizational improvement approaches (QIP, TQM) 6. Configuration management 7. Quality Management In the exercise, the contents taught in the lecture: Processes and Management of Software Engineering are deepened by means of exercises. Tasks are worked on together in the exercise and questions concerning the analysis of the methods are discussed. The focus is on imparting the competence for independent analysis and further development by the students.
Literature	Announced in class
Requirements	Knowledge of Software Engineering as thought, for example, in the course Software Engineering.
Exam	written exam (120 min) or an oral exam (30 min)

Recommended Term	MSc 1-3
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Methodological Specialization (Elective Modules)
Language	English

Module: Software Product Line Engineering

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Prof. Dr. Klaus Schmid and members of the study group
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	Students understand the essential differences between single system and product line development, to describe the necessary methodological differences of a product line development and to reflect these in the context of given use cases. They know the current state of science in this field and are able to relate different approaches to each other or to distinguish them from each other. They know the current state of science in this field and are able to classify recent work. They are able to continuously develop their level of knowledge.
Content	The entire software life cycle from the perspective of product line engineering (PLE) is presented. Current approaches from these areas are discussed. Since all sub-activities of software development are affected by PLE, all activities are also examined with respect to changes in a product line approach. Major focal points of the lecture are: 1. Product portfolio planning from a technical perspective and from a market perspective 2. Modeling of variability (decision modeling, feature modeling) 3. Architecture patterns for representing variability 4. Implementation mechanisms for the realization of variability 5. Test strategies 6. Maturity and adaptation models for product line development Within the scope of the exercise, the contents taught in the lecture: Software Product Line Development are deepened on the basis of exercises. Tasks are worked on together in the exercise and questions concerning the analysis of the methods are discussed. The focus is on imparting the competence for independent analysis and further development by the students.
Submodules	*SM 1: Software Product Line Engineering, Lecture* Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Klaus Schmid *SM 2: Software Product Line Engineering, Tutorium* Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Klaus Schmid and members of the study group

Literature	• Frank van der Linden, Klaus Schmid, Eelco Rommes. Product Lines in Action. Springer, 2007. • Linda Northrop, Paul Clements. Software Product Lines: Practices and Patterns. Addison-Wesley, 2001. • Sven Apel, Don Batory, Christian Kästner, Gunter Saake. Feature-Oriented Software Product Lines: Concepts and Implementation. Springer, 2013. • Current scientific publications. Announced in class. • Additional Material, made available in class.
Requirements	Knowledge of Software Engineering as thought, for example, in the course Software Engineering.
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1-3
Turn	every summer term
Duration	1 Semester
Use	• International Master Software Engineering – Methodological Specialization (Elective Modules)
Language	English

Module: Software Testing

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Dirk Herrmann
Type	2 HPW lecture (with integrated tutorial)
Credit Points	3 CPs
Workload	presence: 21 hours; self-study: 54 hours
Learning goals/ Competencies	In this module, students acquire detailed knowledge of the field of software testing. They learn the basic procedures of software testing and acquire the necessary practical knowledge to perform this manually and automatically. They will also learn advanced testing methodologies that lead to the optimization of the defect detection rate. They are able to apply these techniques systematically and in a goal-oriented manner.
Content	This course broadly covers the fundamentals of software testing. This includes in particular: • Basics of testing (incl. test levels) • Black-box/white-box testing • Derivation procedures for test cases (boundary cases) • Standards • Test metrics • GUI testing
Literature	Announced in class
Requirements	• Knowledge of Software Engineering as thought, for example, in the course Software Engineering. • Good programming knowledge, ideally Java.
Exam	written exam (60 - 90 min) or oral exam (20 min)
Recommended Term	MSc 1-3
Turn	every summer term
Duration	1 Semester
Use	• International Master Software Engineering – Methodological Specialization (Elective Modules)
Language	English

Module: Analysis of Software Systems

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Prof. Dr. Klaus Schmid and members of the study group
Type	2 HPW Lecture with Tutorium
Credit Points	3 CPs
Workload	presence: 21 hours; self-study: 54 hours
Learning goals/ Competencies	The students understand the range of different software analysis techniques, their advantages and limitations. In particular, they know the relevant algorithms and their underlying principles. They are able to apply those in the context of specific problems and implement some major ones. They also understand the major difficulties that are relevant to these tasks.
Content	• Data-flow analysis • Control-flow analysis • Type analysis • Interprocedural analysis
Literature	Anders Moller and Michael I. Schwartzbach. Static Program Analysis. Lecture Notes Aarhus University.
Requirements	• Knowledge of Software Engineering as thought, for example, in the course Software Engineering. • Good programming skills
Exam	written exam (60 - 90 min) or oral exam (20 min)
Recommended Term	MSc 3
Turn	every summer term
Duration	1 Semester
Use	• International Master Software Engineering – Methodological Specialization (Elective Modules)
Language	English

Module: Software Verification

Responsible	Prof. Dr. Klaus Schmid
Responsible Instructors	Prof. Dr. Klaus Schmid and members of the study group
Type	2 HPW lecture and tutorial
Credit Points	3 CPs
Workload	presence: 21 hours; self-study: 54 hours
Learning goals/ Competencies	The students understand the range of different software verification techniques, their advantages and limitations. In particular, they know the relevant verification technologies and their underlying principles. They are able to apply those in the context of specific verification problems and use them for specialised situations. They also understand the range of applicability that can be expected per technique.
Content	Various verification technqiques and the underlying solver technologies. • Hoare-Style verification • Symbolic Execution • SAT-based Analysis • Satisfiability Modulo Theories (SMT) • Model Checking
Literature	• Current scientific publications. Announced in class. • Additional Material, made available in class.
Requirements	• Knowledge of Software Engineering as thought, for example, in the course Software Engineering. • Good programming skills
Exam	written exam (60 - 90 min) or oral exam (20 min)
Recommended Term	MSc 1-3
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Methodological Specialization (Elective Modules)
Language	English

Application Areas (Elective Modules)

Machine Learning Specialization

Module: Machine Learning

Responsible	Prof. Dr. Niels Landwehr, Prof. Dr. Dr. Lars Schmidt-Thieme
Lecturer	none
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	After the completion of this module, the students should be able to map practical tasks to their respective theoretical problem. They should have developed a deeper understanding in the field of machine learning. They should be able to recognize the different types of machine learning problems as well as understand, implement and apply different machine learning techniques. The students should be capable of adapting those techniques to specific applications. In addition, they should be in a position to understand and elaborate further procedures based on the literature.
Content	The lecture gives an overview of machine learning. It focuses on: 1. *fundamental machine learning problems:* different machine learning problems are described and shown in examples. 2. *classification:* basic models for decision and classification tasks are treated (logistic regression, nearest neighbor, decision trees, neuronal networks, support-vector machine, simple bayesian networks). 3. *cluster-analysis and dimensionality reduction:* models for non-supervised classification are treated (hierarchical clustering, k-means, graph partitioning). 4. *application of machine learning models for problems in informatics*
Submodules	*SM 1: Advanced Machine Learning, Lecture* Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme *SM 2: Advanced Machine Learning, Tutorium* Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group

Literature	• Kevin Murphy: *Machine Learning: a Probabilistic Perspective*. MIT Press, 2012. • Richard O. Duda, Peter E. Hart, David G. Stork: *Pattern Classification*. Springer, 2001. • Trevor Hastie, Robert Tibshirani, Jerome Friedman: *The Elements of Statistical Learning*. Springer, 2001. • Tom Mitchell: *Machine Learning*. McGraw-Hill, 1997.
Requirements	The module Machine Learning is compulsory for all students but those having an equivalent module already in their Bachelor's.
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Advanced Machine Learning

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Lecturer	none
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	After the completion of this module, the students should be able to map practical tasks to their respective theoretical problem. They should have developed a deeper understanding in the field of machine learning. They should be able to recognize the different types of machine learning problems as well as understand, implement and apply different machine learning techniques. The students should be capable of adapting those techniques to specific applications. In addition, they should be in a position to understand and elaborate further procedures based on the literature.
Content	The lecture gives an overview of machine learning. It focusses on: 1. *fundamental machine learning problems:* different machine learning problems are described and shown in examples. 2. *classification:* basic models for decsion and classification tasks are treated (logistic regression, nearest neighbor, decision trees, neuronal networks, support-vector machine, simple bayesian networks). 3. *cluster-analysis and dimensionality reduction:* models for non-supervised classification are treated (hierarchical clustering, k-means, graph partitioning). 4. *methods for learning hyperparameters* 5. *structured prediction*
Submodules	*SM 1: Advanced Machine Learning, Lecture* Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme *SM 2: Advanced Machine Learning, Tutorium* Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group
Literature	• Kevin Murphy: *Machine Learning: a Probabilistic Perspective.* MIT Press, 2012. • Richard O. Duda, Peter E. Hart, David G. Stork: *Pattern Classification.* Springer, 2001. • Trevor Hastie, Robert Tibshirani, Jerome Friedman: *The Elements of Statistical Learning.* Springer, 2001. • Tom Mitchell: *Machine Learning.* McGraw-Hill, 1997.
Requirements	The lecture 'Machine Learning' is recommended.
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1
Turn	every summer term
Duration	1 Semester

Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Big Data Analytics

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	The Students should have developed an extended understanding in the field of Big Data Analytics and be able to map practical tasks to their respective theoretical problem. They should be able to use the learned methods for more complex problems and be able to recognize differences in the problems. In addition, they should be in a position to understand and elaborate further procedures based on the literature.
Content	The course will cover the following topic areas: 1. *Large Scale Distributed File Systems and Data Storage frameworks* 2. *Computational models for large scale data*: (e.g. MapReduce and GraphLab) 3. *Data Stream Analysis* 4. *Statistical learning techniques for Large Scale Data*: For example Large Scale Recommender Systems and Link Analysis
Submodules	*SM 1: Big Data Analytics, lecture* Type: 2 HPW lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme *SM 2: Big Data Analytics, tutorial* Type: 2 HPW tutorial (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group
Literature	• Anand Rajaraman, Jure Leskovec, and Jeffrey Ullman: *Mining of massive datasets* • Yucheng Low, Joseph Gonzalez, Aapo Kyrola, Danny Bickson, Carlos Guestrinand Joseph M. Hellerstein: *Distributed GraphLab: A Framework for Machine Learning and Data Mining in the Cloud* PVLDB. 2012
Requirements	none
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 2
Turn	every 4th Semester but not regularly.
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Modern Optimization Techniques

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	The students should have developed a deeper understanding in the field of Optimization. They learn to implement and apply different optimization techniques and should be able to adapt these techniques to specific applications. They should be able to map practical tasks to their respective theoretical problem. Students are able to recognize different types of optimization problems and should be able to understand and elaborate further procedure based on the literature.
Content	The Lecture will discuss Optimization techniques on which modern Data Analytics approaches are based. The topics discussed will be: 1. *Optimization Problems:* the different types of Optimization problems will be described both formally and with examples 2. *Unconstrained and Equality Constrained Convex Optimization:* The main convex optimization methods (Stochastic Gradient Descent, Newton Methods, and Coordinate Descent) 3. *Interior Point Methods:* Methods for solving inequality constrained problems by solving a sequence of unconstrained, or equality constrained, problems. 4. *Modern Optimization methods*: Extensions and improvements of classical optimization methods: Quasi-Newton, Conjugate Gradient, Bundle methods and Cutting-plane algorithms
Submodules	*SM 1: Modern Optimization Techniques, lecture* Type: 2 HPW lecture (3 ECTS) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme *SM 2: Modern Optimization Techniques, tutorial* Type: 2 HPW tutorial (3 ECTS) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group
Literature	• Stephen Boyd and Lieven Vandenberghe. *Convex Optimization*. Cambridge Univ Press, 2004. • Suvrit Sra, Sebastian Nowozin and Stephen J. Wright. *Optimization for Machine Learning*. MIT Press, 2011. • Igor Griva. *Linear and nonlinear optimization*. Society for Industrial and Applied Mathematics, 2009.
Requirements	none
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1
Turn	every winter term
Duration	1 Semester

Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Deep Learning

Responsible	Prof. Dr. Niels Landwehr, Prof. Dr. Dr. Lars Schmidt-Thieme
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	Deep learning has recently been associated with revolutionary Artificial Intelligence achievements, ranging from "close-to-human" speech and image recognition performances, up to "super-human" game playing results. Throughout this course, students will have the opportunity to understand the building blocks of neural networks
Content	The curriculum starts by introducing supervised learning concepts and incrementally dives into the peculiarities of learning the parameters of neural networks through back-propagation. Specific architectures, such as the Convolutional Neural Networks will be covered, as well as different types of network regularization strategies. Furthermore implementation techniques involving GPU-based optimization will be explained. The students are expected to master the necessary knowledge that will empower them to apply Deep Learning in real-life problems.
Submodules	*SM 1: Deep Learning, lecture* Type: 2 HPW lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme *SM 2: Deep Learning, tutorial* Type: 2 HPW tutorial (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group
Literature	will be announced in the lecture
Requirements	none
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 2
Turn	every 4th Semester but not regularly.
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Large Language Models

Responsible	Dr. Maximilian Stubbemann
Responsible Instructors	Dr. Maximilian Stubbemann, Prof. Dr. Dr. Lars Schmidt-Thieme
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	Conversation bots based on Large Language Models (LLMs) have caused a massive public interest into the developments in the field of artificial intelligence. In this course, the students will learn how these models work and on which fundamental concepts they are based on. More specifically, the students will gain an understanding of the architectures and training procedures that are the building blocks of recent LLMs.
Content	The course will contain the major concepts behind LLMs, including: • The Attention Mechanism and Transformer Architecture • Generative and Masked Pre-Training • Reinforcement Learning from Human Feedback • Scaling Laws for LLMs
Submodules	*SM 1: Large Language Models, lecture* Type: 2 HPW lecture (3 CPs) Lecturer: Dr. Maximilian Stubbemann, Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group *SM 2: Large Language Models, tutorial* Type: 2 HPW tutorial (3 CPs) Lecturer: Dr. Maximilian Stubbemann, Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group
Literature	will be announced in the lecture
Requirements	none
Exam	Written exam with duration of 120 minutes or oral examn with duration of 30 minutes. The lecture will be completely in English.
Recommended Term	MSc 2
Turn	every 4th Semester but not regularly.
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Planning and Optimal Control

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	After the completion of this module, the students should be able to map practical tasks to their respective theoretical problem. They should have developed a deeper understanding in the field of Planning and Optimal Control. They should be able to recognize the different types of planning and control problems as well as understand, implement and apply different techniques. The students should be capable of adapting those techniques to specific applications. In addition, they should be in a position to understand and elaborate further procedures based on the literature.
Content	The lecture will discuss main topics from Planning and optimal control theory. The topics discussed will be: 1. *Discrete and Heuristic Search* 2. *Motion Planning* 3. *Dealing with dynamics and Stochastic Optimal Control* 4. *Reinforcement Learning*
Submodules	*SM 1: Planning and Optimal Control, lecture* Type: 2 HPW lecture (3 ECTS) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme *SM 2: Planning and Optimal Control, tutorial* Type: 2 HPW tutorial (3 ECTS) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group
Literature	• H. Geffner, B. Bonet: *A Concise Introduction to Models and Methods for Automated Planning*, Morgan and Claypool, 2013. • D. Nau, M. Ghallab, P. Traverso: *Automated Planning: Theory and Practice*, Morgan Kaufmann, 2004. • H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki and S. Thrun. *Principles of Robot Motion: Theory, Algorithms, and Implementations*; MIT Press, Boston, 2005. • Steve LaValle. *Planning Algorithms*; Cambridge University Press, 2006 (Available Online). • Dimitri P. Bertsekas. *Dynamic Programming and Optimal Control*, Athena Scientific, 3rd ed. Vols. I and II, 2007. • Richard S. Sutton and Andrew G. Barto. *Reinforcement Learning: An Introduction*. MIT Press, Cambridge, MA, 1998.
Requirements	none
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 3

Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Data and Privacy Protection

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Type	2 HPW lecture
Credit Points	3 CPs
Workload	presence: 21 hours; self-study: 54 hours
Learning goals/ Competencies	Students have an overview of specific requirements of data and privacy protection in different application areas such as e-commerce and medicine. Students know basic laws about data and privacy protection in Germany, the EU and the US and can apply them to specific situations. Students have a broad overview of technological tools to protect data and privacy.
Content	The lecture provides an overview of methods for data and privacy protection, esp. 1. Requirements of data and privacy protection a) General requirements b) Requirements in e-commerce c) Requirements in medicine 2. Laws about data and privacy protection a) German Laws b) EU Laws c) US Laws 3. Data and privacy protection policies & technologies a) IT security b) Data encryption c) Authorization and Rights Management
Submodules	none
Literature	• David G. Hill: *Data Protection: Governance, Risk Management, and Compliance*, Crc Pr Inc, 2009. • Helen Nissenbaum: *Privacy in Context: Technology, Policy, and the Integrity of Social Life*, Stanford Univ Pr, 2009.
Requirements	none
Exam	written exam (60 - 90 min) or oral exam (20 min)
Recommended Term	MSc 2
Turn	every summer term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Business Analytics

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Lecturer	none
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	• Understanding the classical forecasting methodologies and their application to business domains • Exploring the state-of-the-art in terms of Recommender Systems and the Internet economy • Empowering the analytical ability to abstract the necessary data-driven methodologies for complex business problems
Content	Business Analytics aims at introducing students to the fundamental data science know-how, which provides a start-level proficiency for tackling data-driven business problems. Initially the course explains prediction models for Regression and Classification tasks, as well as typical Clustering approaches. Frequent Pattern Mining that discovers association rules from transactional data will be covered as well. Dimensionality Reduction techniques are taught with regards to both visualisation and feature extraction aspects. In addition, personalized strategies in the realm of Recommender Systems will be exploited. On the other hand, the course covers Time-Series Forecasting methods, as well as Process Mining from industrial data logs. Last, but not least, the course aims at providing an introduction on current strategies needed to scale data analytics methods to handle big data.
Submodules	*SM 1: Business Analytics, Lecture* Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme *SM 2: Business Analytics, Tutorium* Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group
Literature	• Hyndman et al., Forecasting: Principles and Practice, 2012 • Aggarwal et al., Frequent Pattern Mining, 2014 • Aggarwal, Recommender Systems, 2016 • Tie-Yan Liu, Learning to Rank for Information Retrieval, 2011
Requirements	none
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1
Turn	every winter term
Duration	1 Semester

Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Advanced Case-Based Reasoning

Responsible	Dr. Pascal Reuss
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	Students have an extended understanding of case-based reasoning. They master advanced and detailed procedures to develop, operate and maintain case-based reasoning and be able to use them for more complex scenarios. Students are able to assign complex scenarios and case studies to special task classes and to state-of-the-art and state-of-the-practice.
Content	Development, operation and maintainance of case-based reasoning and its application. Some characteristics of case-based reasoning like case-based classification, diagnosis and decision making, configuration and design and case-based planning are presented for special task categories. The application potential is shown in case studies and in state-of-the-art/practice-systems.
Submodules	*SM 1: Advanced Case-Based Reasoning, Lecture* Type: 2 HPW Lecture (3 CPs) Lecturer: Dr. Pascal Reuss *SM 2: Advanced Case-Based Reasoning, Tutorium* Type: 1 HPW Tutorium (2 CPs) Lecturer: Prof. Dr. Klaus-Dieter Althoff and members of the study group
Literature	• M.M. Richter, R.O. Weber: *Case-Based Reasoning*, Springer, Berlin 2013 • R. Bergmann: *Experience Management- Foundations, Development Methodology, and Internet-Based Applications.* Springer, Berlin 2002. • R. Bergmann, K.-D. Althoff, S. Breen, M. Göker, M. Manago, R. Traphöner, S. Wess: *Developing Industrial Case-Based Reasoning Applications - The INRECA Methodology.* Springer, Berlin 2003. • M. Lenz, B. Bartsch-Spörl, H.-D. Burkhard, S. Wess (Hrsg.): *Case-Based Reasoning Technology: From Foundations to Applications.* Springer, Berlin 1998.
Requirements	none
Exam	written exam (90 minutes)
Recommended Term	MSc 1-3
Turn	irregular turn, for additional information on next lecture turn please contact Dr. Pascal Reuss
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Bayesian Networks

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	Students have detailed knowledge about Bayesian Networks. They are able to model problems using Bayesian Networks. They understand exact and approximative inference methods and are able to choose suitable methods depending on the problem. Students know learning methods for parameter and structure and can estimate the results of learning processes. They get used to work with new books in Bayesian Networks.
Content	The lecture introduces bayesian networks. Based on modelling influences and conditional probabilities, algorithms for exact and approximative inference, analysis of bayesian networks, learning parameters and learning structure are treated. Algorithms for inference and learning bayesian networks go back to graph-algorithms as well as methods like topological sorting and connectivity-property and specific methods like counting cliques and so on. Every necessary algorithm will be introduced in the lecture.
Submodules	*SM 1: Bayesian Networks, Lecture* Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme *SM 2: Bayesian Networks, Tutorium* Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group
Literature	• Marco Scutari: *Bayesian Networks: With Examples in R*, Chapman and Hall/CRC, 2014. • D. Koller, N. Friedmann: *Probabilistic Graphical Models: Principles and Techniques*, The MIT Press, 2009. • Finn V. Jensen: *Bayesian networks and decision graphs*. Springer, 2001. • Richard E. Neapolitan: *Learning Bayesian Networks*. Prentice Hall, 2003. • Enrique Castillo, Jose Manuel Gutierrez, Ali S. Hadi: *Expert Systems and Probabilistic Network Models*. Springer, 1997. • Christian Borgelt, Rudolf Kruse: *Graphical Models*. Wiley, 2002.
Requirements	none
Exam	written exam (60 - 90 min) or oral exam (20 min)
Recommended Term	MSc 1-3
Turn	not regularly, normally every 4th semester
Duration	1 Semester

Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Computer Vision

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	After the completion of this module, the students should be able to solve relevant tasks and research questions from the Computer Vision. They should have developed a deeper understanding in the field of Computer Vision. They should be able to understand, implement and apply different Computer Vision techniques. The students should be capable of adapting those techniques to specific applications. In addition, they should be in a position to understand and elaborate further procedures based on the literature.
Content	The course will cover statistical data-driven approaches for automatic processing, analyzing and understanding of images. The lecture will cover topics from the pre-processing of images, like image filtering and feature detection to object recognition and object tracking as well as image classification.
Submodules	*SM 1: Computer Vision, Lecture* Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme *SM 2: Computer Vision, Tutorium* Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group
Literature	• Richard Szeliski: *Computer Vision: Algorithms and Applications*. Microsoft Research, 2010. • Milan Sonka, Vaclav Hlavac, Roger Boyle: *Image Processing, Analysis, and Machine Vision*. Thomson, 2008. • John C. Russ, J. Christian Russ: *Introduction to Image Processing and Analysis*. CRC Press, 2008. • R. C. Gonzalez, R. E Woods: *Digital Image Processing*. Pearson, 2008. • G. Aubert, P. Kornprobst: *Mathematical Problems in Image Processing. Partial Differential Equations and the Calculus of Variations*. Springer, 2006. • J. R. Parker: *Algorithms for Image Processing and Computer Vision*. Wiley, 1997.
Requirements	none
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1-3
Turn	not regularly, normally every 4th semester
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Natural Language Processing

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Lecturer	Prof. Dr. Christian Wartena and members of the study group
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	The students have an understanding of structures in natural languages and the traditional symbolic and statistical approaches to model structures in phonology, morphology, syntax and lexical semantics. They have an overview of state-of-the-art Natural Language Processing (NLP) methods. Students are able to build applications using or extending standard NLP methods. They are able to familiarize quickly with other topics in NLP and are able to read original research literature.
Content	Student will learn the most important phenomena in natural languages on different levels of granularity, starting with the combination of sounds to the meaning of words, sentences and texts. You will get an introduction to main symbolic and statistical approaches to model these phenomena. All theoretical topics will be accompanied by exercises dealing with these phenomena and demonstrating their use in practical applications, like spelling correction, auto completion, keyword extraction, topic detection, named entity recognition, relation extraction, synonym detection, etc. Students will apply the basic natural language processing methods in the implementation of a small application or in the analysis of a data set. For this part they will study one specific phenomenon into depth and will be free to explore various machine learning and natural language processing techniques to find their own solution.
Submodules	*SM 1: Natural Language Processing 2, Lecture* Type: 2 HPW Lecture (2 CPs) Lecturer: Prof. Dr. Christian Wartena *SM 2: Natural Language Processing 2, Tutorium* Type: 2 HPW Tutorium (2 CPs) Lecturer: Prof. Dr. Christian Wartena and members of the study group
Literature	• Bird, Steven, Ewan Klein, and Edward Loper. Natural language processing with Python: analyzing text with the natural language toolkit. *O'Reilly Media, Inc.* (2009) • Daniel Jurafsky and James H. Martin: Speech and Language Processing. Prentice Hall; 2nd edition (2008) • Christopher D. Manning and Hinrich Schütze: Foundations of Statistical Natural Language Processing. The MIT Press (1999) • Additional literature will be announced in the lecture
Requirements	Basic knowledge of theoretical Computer Science (Automata theory, complexity, rewriting systems, Markov models).

Exam	Several tests during the semester and/or written exam (60 - 90 min) or oral exam (20 min) or seminar paper
Recommended Term	MSc 2-3
Turn	irregular
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization • International Master Software Engineering – Application Areas (Elective Modules)
Language	English

Module: Machine Learning for IT Security

Responsible	Prof. Dr. Niels Landwehr
Responsible Instructors	See submodules
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	After completion of the module, students have a detailed understanding of how machine learning can be used in IT security to detect and counter threats and attacks. They are able to map IT security problems to appropriate problem settings in machine learning and choose effective data representations for a given problem. They also understand the limitations of using data-driven methods such as machine learning in a security context. They are finally able to read and follow the current literature on machine learning in IT security to further enhance their knowledge about the topic.
Content	The lecture studies different threats and tasks in IT security (such as filtering malicious email messages, detecting malicious executable files, discovering security vulnerabilities in source code, or detecting fraudulent activity). We discuss how such tasks can be cast as machine learning problems, the process of data collection and data representation, and appropriate machine learning techniques for solving these tasks.
Submodules	*SM 1: Machine Learning for IT Security, lecture* Type: 2 HPW lecture (3 CPs) Lecturer: Prof. Dr. Niels Landwehr *SM 2: Machine Learning for IT Security, tutorial* Type: 2 HPW tutorial (3 CPs) Lecturer: Prof. Dr. Niels Landwehr and members of the study group
Literature	• Salomon, David. Elements of computer security. Springer Science & Business Media, 2010. • Tom Mitchell: Machine Learning. McGraw-Hill, 1997. • Thomas, Tony, Athira P. Vijayaraghavan and Sabu Emmanuel. Machine Learning Approaches in Cyber Security Analytics. Springer, 2020. Further literature will be announced in the lecture
Requirements	Some prior knowledge in the area of machine learning is recommended
Exam	written exam (90 minutes) or oral exam (30 min)
Recommended Term	BSc 5, MSc 1-3
Turn	summer semester
Duration	1 semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization

Language	English

Module: Advanced Computer Vision

Responsible	Prof. Dr. Niels Landwehr
Responsible Instructors	See submodules
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	After completion of the module, students are familiar with different problem settings and tasks studied in modern computer vision. They understand how machine learning techniques and specifically deep neural networks can be used to solve these tasks. They are able to build upon established techniques and adapt them to novel problem settings, enabling them to solve practical computer vision problems.
Content	The lecture starts with an overview of deep neural networks. It then discusses design principles of deep neural network architectures for computer vision problems. Specific computer vision problems such as image classification, segmentation, object detection and localization, or metric learning are discussed. The lecture also presents examples for practical applications of computer vision techniques in different domains.
Submodules	*SM 1: Advanced Computer Vision, lecture* Type: 2 HPW lecture (3 CPs) Lecturer: Prof. Dr. Niels Landwehr *SM 2: Advanced Computer Vision, tutorial* Type: 2 HPW tutorial (3 CPs) Lecturer: Prof. Dr. Niels Landwehr and members of the study group
Literature	• Goodfellow, Ian, Bengio, Yoshua, Courville, Aaron. (2016). Deep learning. Cambridge: MIT press. • Szeliski, Richard. Computer vision: algorithms and applications. Springer Science & Business Media, 2010.
Requirements	Completion of the module "Machine Learning" or a simultaneous enrollment in the module "Machine Learning" is recommended.
Exam	written exam (90 minutes) or oral exam (30 min)
Recommended Term	MSc 1-3
Turn	winter semester
Duration	1 semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Time Series Analysis

Responsible	Prof. Dr. Sebastian Mentemeier
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	After completion of this module, students are able to describe and analyse time series data with methods from probability theory and statistics, to make predictions about future development of the observed time series and to make decisions based on observations of time series data. The students have a deeper understanding of mathematical models for time series and their fields of applications. They have good command of a statistical programming language, e.g. R.
Content	This lecture gives an overview of time series analysis from the viewpoint of mathematical statistics. It focusses on: • Decomposition: Identification of trends and seasonal components • Models for discrete time series: Autoregressive Models, Moving Average Models and ARMA models, parameter estimation for these models • Models for heteroskedasticity: ARCH and GARCH models and parameter estimation • Aspects of extreme value theory for time series • Models for continuous time series: Brownian motion and related stochastic processes - if time permits.
Submodules	*SM 1: Time Series Analysis, Lecture* Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Sebastian Mentemeier *SM 2: Time Series Analysis, Tutorium* Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Sebastian Mentemeier and members of the study group
Literature	• P. Cowpertwait, A. Metcalfe: Introductory Time Series with R, Springer 2009 • P. Brockwell, R. Davis: Introduction to Time Series and Forecasting, Springer 1996
Requirements	none
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1-3
Turn	Usually every summer semester.
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Business Intelligence and Data Warehousing

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Responsible Instructors	Prof. Dr. Dr. Lars Schmidt-Thieme
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	Business Intelligence seeks to extract and present insights from operational data that are relevant to future decisions. In larger companies, it is common practice to provide the operating data for this in one place data warehouse adjusted and systematized
Content	This lecture deals with the basics of the task, the construction and realization of data warehouses and the embedding of data warehousing in the overall context of Business Intelligence.
Literature	• J. Celko: *Joe Celko's Data Warehouse and Analytic Queries in SQL*, (2006) ISBN-13: 978-0123695123 • Graziano, Linstedt: *Super Charge Your Data Warehouse*, (2011) ISBN-13: 978-1463778682 • W.H. Inmon: *Building the Data Warehouse*, (2005) ISBN-13: 978-0764599446 • J.E.Olson: Data Quality: *The Accuracy Dimension*, (2002) ISBN-13: 978-1558608917
Requirements	none
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1-3
Turn	every second term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization • International Master Software Engineering – Application Areas (Elective Modules) – Business Administration and Information Systems
Language	English

Module: Data Warehousing in Practice

Modulverantwortlicher	Prof. Dr. Dr. Lars Schmidt-Thieme
Lehrende	Christoph Seck
Lehrform/SWS	2 SWS Vorlesung, 2 SWS Übung
Leistungspunkte	6 LP
Lernziele/Kompetenzen	Die Studierenden erlangen Kompetenzen zum Data Warehousing. Business Intelligence versucht aus operativen Daten Erkenntnisse zu extrahieren und zu präsentieren, die für zukünftige Entscheidungen relevant sind. In größeren Unternehmen ist es gängige Praxis , die operativen Daten dafür an einer Stelle – dem „Data Warehouse“ – bereinigt und systematisiert bereitzustellen.
Lehrinhalte	Kern der Vorlesung ist die Entwicklung eines Data Warehouses an einem konkreten Beispiel. Den Einstieg bildet dabei ein scheinbar einfaches Problem aus einem produzierenden Betrieb. Noch stärker als in Business Intelligence and Data Warehousing 1, werden Übungen und Praxisarbeit im Zentrum stehen. Zeitlich wird der Fokus daher auch auf den Aspekten des DWH Prozesses liegen die in solchen Projekten den meisten Raum einnehmen: Analyse von Quellsystemen, Umgang mit unzureichenden Anforderungen, Datenqualitätsprobleme, ausgefallene Berichtswünsche etc. Ergänzend wird in der Vorlesung noch auf einige Themen eingegangen, die im letzten Semester gar nicht, oder nur im Vorübergehen behandelt wurden. Her geht es etwa um Master Data Management, Data Vault und die aktuellen Hypethemen Self Service BI und Big Data
Teilmodule / Veranstaltungen	=== TM 1: PAGENAME, Vorlesung === ==== Lehrform ==== 2 SWS Vorlesung (3 LP) ==== Lehrende ==== Seck === TM 2: PAGENAME, Übung=== ==== Lehrform ==== 2 SWS Übung (3 LP) ==== Lehrende ==== Seck

Literatur	• J. Celko: *Joe Celko's Data Warehouse and Analytic Queries in SQL*, (2006) ISBN-13: 978-0123695123 • Graziano, Linstedt: *Super Charge Your Data Warehouse*, (2011) ISBN-13: 978-1463778682 • W.H. Inmon: *Building the Data Warehouse*, (2005) ISBN-13: 978-0764599446 • Kimball, Ross: *The Data Warehouse Toolkit*, (2013) ISBN-13: 978-1118530801 • Kimball, Munday, Thronthwaite: *The Microsoft Data Warehouse Toolkit*, (2011) ISBN-13: 978-0470640388 • J.E.Olson: *Data Quality: The Accuracy Dimension*, (2002) ISBN-13: 978-1558608917 • Russo, Ferrari, Webb: *Expert Cube Development with Microsoft SQL Server 2008 Analysis Services*, (2009) ISBN-13: 978-1847197221 • Russo, Ferrari, Webb: *Microsoft SQL Server 2012 Analysis Services: The BISM Tabular Model*, (2012) ISBN-13: 978-0735658189 • NBI Testing Tool und Dokumentation auf: `http://nbi.codeplex.com/`
Voraussetzungen für die Teilnahme	keine
Prüfungsleistung	Schriftliche Prüfung in Form einer Klausur im Umfang von 120 Minuten oder mündliche Prüfung im Umfang von 30 Minuten.
empfohlenes Semester	MSc 1-3
Turnus	unregelmäßig, i.d.R. jedes 2. Semester
Dauer des Moduls	1 Semester
Verwendung	• Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Betriebswirtschaft und Informationswissenschaft • Wirtschaftsinformatik i.e.S./ MSc., Gebiet Business Intelligence
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization • International Master Software Engineering – Application Areas (Elective Modules) – Business Administration and Information Systems

Module: Seminar Data Analytics I

Responsible	Prof. Dr. Niels Landwehr, Prof. Dr. Dr. Lars Schmidt-Thieme
Type	2 HPW seminar
Credit Points	4 CPs
Workload	presence: 21 hours; self-study: 79 hours
Learning goals/ Competencies	The students deepen their analytic and methodological skills for understanding current research areas. Writing a report and giving a presentation as well as discussing scientific issues with their peers help the students to put the knowledge acquired during their studies into context and gives them an opportunity to add new knowledge to their corpus. Furthermore, skills are developed which will allow the students to adapt their knowledge to changing technical and societal conditions in the future.
Content	Selected topics in the area of data analytics. Covers advanced topics that require an advanced background in data science.
Submodules	*SM 1: Seminar Data Analytics I* Type: Seminar (4 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group
Literature	depending on the topic
Requirements	none
Exam	Presentation and written summary
Recommended Term	MSc 1-3
Turn	every semester
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Seminar Data Analytics II

Responsible	Prof. Dr. Niels Landwehr, Prof. Dr. Dr. Lars Schmidt-Thieme
Type	2 HPW seminar
Credit Points	4 CPs
Workload	presence: 21 hours; self-study: 79 hours
Learning goals/ Competencies	The students deepen their analytic and methodological skills for understanding current research areas. Writing a report and giving a presentation as well as discussing scientific issues with their peers help the students to put the knowledge acquired during their studies into context and gives them an opportunity to add new knowledge to their corpus. Furthermore, skills are developed which will allow the students to adapt their knowledge to changing technical and societal conditions in the future.
Content	Selected topics in the area of data analytics. Covers very advanced topics that require a very advanced background in data science.
Submodules	*SM 1: Seminar Data Analytics II* Type: Seminar (4 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group
Literature	depending on the topic
Requirements	Seminar Data Analytics I
Exam	Presentation and written summary
Recommended Term	MSc 1-3
Turn	every semester
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Seminar Data Analytics III

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Type	2 HPW seminar
Credit Points	4 CPs
Workload	presence: 21 hours; self-study: 79 hours
Learning goals/ Competencies	The students deepen their analytic and methodological skills for understanding current research areas. Writing a report and giving a presentation as well as discussing scientific issues with their peers help the students to put the knowledge acquired during their studies into context and gives them an opportunity to add new knowledge to their corpus. Furthermore, skills are developed which will allow the students to adapt their knowledge to changing technical and societal conditions in the future.
Content	Selected topics in the area of data analytics. Covers very advanced topics that require a very advanced background in data science and possibly a background in a specialized topic.
Submodules	*SM 1: Seminar Data Analytics III* Type: Seminar (4 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group
Literature	depending on the topic
Requirements	Seminar Data Analytics I Seminar Data Analytics II
Exam	Presentation and written summary
Recommended Term	MSc 1-3
Turn	every semester
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Lab Course Programming Machine Learning

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Type	4 HPW lab course
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	The praktikum allows students to gain practical knowledge and capabilities in the area of Machine Learning.
Content	This implementation-oriented course offers hands-on experience with current algorithms and approaches in Machine Learning and Artificial Intelligence, and their application to real-world learning and decision-making tasks. Praktikum will also cover empirical methods for comparing learning algorithms, for understanding and explaining their differences, for analyzing the conditions in which a method is more suitable than others. List of Methods: 1. Linear models of prediction (Linear Regression, Logistic Regression) 2. Generative learning algorithms (Discriminant Analysis, Naïve Bayes) 3. Classification trees (Decision Trees) 4. k - Nearest Neighbor 5. Clustering (k-Means) 6. Dimensionality Reduction (Principal Component Analysis) 7. Support Vector Machines 8. Matrix Factorization for Recommender Systems
Submodules	none
Literature	• Brett Lantz: *Machine Learning with R*, Packt Publishing, 2013. • Drew Conway, John Myles White: *Machine Learning for Hackers*, O'Reilly, 2012.
Requirements	none
Exam	colloquium and written summary
Recommended Term	MSc 1
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Lab Course Distributed Data Analytics

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Type	4 HPW lab course
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	The praktikum allows students to gain practical knowledge and capabilities in the area of Machine Learning. Praktikum will also cover empirical methods for comparing learning algorithms, for understanding and explaining their differences, for analyzing the conditions in which a method is more suitable than others.
Content	Practical knowledge of methods and technologies for distributed computing in data analysis: 1. working with a scheduler in a Computer Cluster (e.g. Sun Grid Engine) 2. working with a distributed data system to manage big data 3. working with NoSQL-data-bases for loose structured data 4. Large Scale distributed file systems and data storage frameworks 5. Computational models for large scale data (e.g. MapReduce and GraphLab) 6. working with message passing frameworks 7. working with GPU/ coprocessor-machine
Submodules	none
Literature	• Anand Rajaraman, Jure Leskovec, and Jeffrey Ullman: *Mining of massive datasets* • Yucheng Low, Joseph Gonzalez, Aapo Kyrola, Danny Bickson, Carlos Guestrinand Joseph M. Hellerstein: *Distributed GraphLab: A Framework for Machine Learning and Data Mining in the Cloud* PVLDB. 2012
Requirements	none
Exam	colloquium and written summary
Recommended Term	MSc 2
Turn	every summer term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Lab Course Deep Learning

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Type	4 HPW lab course
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	The lab allows students to gain practical knowledge and capabilities in the area of Deep Learning. Students will be able to reproduce probabilistic models from state-of-the-art techniques from recent papers.
Content	The lab allows students to gain practical knowledge and capabilities in the area of Deep Learning. This implementation-oriented course offers hands-on experience with current algorithms and approaches in Deep Learning and their application to real-world learning and decision-making tasks. This course will provide capabilities for students to reproduce experiments seen in papers and also how to model their discoveries. This course also aims to guide students in how to use Deep Learning tools and also to adopt healthy implementations practices. The methods being taught will change according to recent publications allowing students to participate in research in current topics. Methods will include: 1. Basic usage of Deep Learning Tools 2. Implementation of basic types of networks: CNN, RNN, and FCN. 3. Data Pre-Processing 4. Image Classification 5. Image Segmentation 6. Time Series Analysis 7. Reccomender Systems
Submodules	none
Literature	will be announced in the lab
Requirements	Deep Learning Lecture
Exam	colloquium and written summary
Recommended Term	MSc 2
Turn	every summer term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Module: Deep Learning Masterclass

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Responsible Instructors	Prof. Dr. Artus Krohn-Grimberghe
Type	4 HPW lecture, 4 HPW tutorial
Credit Points	6 CPs
Workload	presence: 84 hours; self-study: 66 hours
Learning goals/ Competencies	The course allows students to gain practical knowledge and capabilities in the area of Deep Learning. Students will be able to reproduce probabilistic models from state-of-the-art techniques from recent papers.
Content	This 10-day full-time instructor-led deep-dive course for coders consists of three parts. The first part, an overview over deep learning and deep neural networks, which problems they are applicable to, how they work and how they are implemented on a very high level (using pytorch building blocks to be precise) on day 1. The second part teaches how to code deep learning using deep neural networks efficiently for various problem settings such as image classification, multi-class classification, tabular data, audio, image segmentation, superresolution, neural style transfer, GAN and NLP on days 2-6. The third part re-creates large parts of fast.ai and pytorch as an optional module for those who want to dive deep into the inner workings of deep learning during days 7-10. The days of this course are structured such that the mornings consist of recorded lectures presenting the jupyter notebooks with the course contents and the afternoons consist of paper reading and presentation groups (reading several of the original seminal and brand new publication that drive the field), code presentation groups and guided coding and q&a sessions. Participants are encouraged to apply the learned content on their own datasets or rehearse or prepare materials during the evenings.
Submodules	none
Literature	will be announced in the lecture
Requirements	none
Exam	Project and written report
Recommended Term	MSc 2
Turn	Every Semester
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Machine Learning Specialization
Language	English

Business Administration and Information Systems

Module: Advanced Marketing / Marketing 2

Responsible	Prof. Dr. Julia Rieck
Responsible Instructors	Prof. Dr. Julia Rieck and members of the study group
Type	4 HPW lecture
Credit Points	4 or 6 CPs
Workload	presence: 42 hours; self-study: 58 hours
Learning goals/ Competencies	The students know different analysis methods for marketing data and use them specifically. Furthermore they can analyse market research data with the use of appropriate evaluation programs. Students are able to distinguish between alternative methods and to recognize possible limits. Furthermore they are capable to analyse and evaluate data sets and interpret the results. They are able to understand and to implement current developments independently.
Content	Topics covered on the course include market research relevant methods of data collection and analysis (supervised and unsupervised methods) and application in marketing.
Submodules	none
Literature	• Malhotra, N., Nunan, D., Birks, D.: *Marketing Research: An applied approach*, Pearson Education Limited, 5th Edition, 2017 • Kotler, P., Armstrong, G., Harris, L., Piercy, N.: *Principles of Marketing (European Edition)*, Pearson, 7th Edition, 2016 • Sorger, S.: *Marketing Analytics: Strategic Models and Metrics*, CreateSpace Independent Publishing Platform, 2013
Requirements	Machine Learning
Exam	Written exam (60 min) and submission of implementation/homework task(s). For details see LSF.
Term	MSc 1-3
Turn	every summer term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Business Administration and Information Systems
Language	English

Module: Project Scheduling

Responsible	Prof. Dr. Julia Rieck
Responsible Instructors	Prof. Dr. Julia Rieck
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	Upon completion of this course, the students can: • fully understand fundamental scheduling and sequencing problems that arise in resource-constrained project scheduling environments within the manufacturing and service industry, • apply state-of-the-art methodologies for effectively and efficiently planning projects subject to both precedence and resource constraints, • manage and control a project.
Content	Project representation using activity networks, time analysis (estimating the project duration in a deterministic setting), resource management, i.e. resource leveling (leveling the use of the resources over time subject to a project deadline) and resource-constrained-project scheduling (scheduling the activities subject to the various precedence and resource constraints in order to minimize the project duration and other objective functions).
Submodules	none
Literature	• Neumann, K.; Schwindt, C.; Zimmermann, J. (2003): *Project Scheduling with Time Windows and Scarce Resources*, 2nd edition, Springer, Berlin • Schwindt, C.; Zimmermann, J. (2015): *Handbook on Project Management and Scheduling Vol. 1*, Springer, Cham • Schwindt, C.; Zimmermann, J. (2015): *Handbook on Project Management and Scheduling Vol. 2*, Springer, Cham • Vanhoucke, M. (2013): *Project Management with Dynamic Scheduling: Baseline Scheduling, Risk Analysis and Project Control*, 2nd edition, Springer, Berlin
Requirements	none
Exam	Written exam (90 min); for justified exceptions oral exam (30 min). Possibly additional requierements have to be met to be admitted to the final exam - further information is available in the accompanying learnweb-course.
Term	MSc 1-3
Turn	Each winter term
Duration	1 Semester

Use	• International Master Software Engineering – Application Areas (Elective Modules) – Business Administration and Information Systems
Language	English

Module: Seminar Business Studies

Responsible	Prof. Dr. Julia Rieck, Dr. Felix Hahne
Responsible Instructors	Prof. Dr. Julia Rieck, Dr. Felix Hahne and members of the study group
Type	2 HPW seminar
Credit Points	4 CPs
Workload	presence: 21 hours; self-study: 79 hours
Learning goals/ Competencies	The objective of this seminar is the autonomous exploitation and elaboration of a predetermined subject. The participation in course and the scholarly debate about the presentations are to lead to a deeper understanding of previously acquired knowledge. Acquirement of methodological competence: students gain transfer competence allowing them to autonomously adjust their level of knowledge to technical and social development. Depending on the area of specialization, students acquire different economical competences and become acquainted with different instruments. Possible areas of specialization include: marketing, logistics, production, business intelligence systems.
Content	Different advanced topics from the fields of marketing (e.g. marketing research, marketing policy), logistics (e.g. transportation planning, location planning, warehousing), production, and business intelligence systems (e.g. support of business functions, opening of new business areas).
Submodules	none
Literature	depending on the topic
Requirements	The contents of a correspondent master's course in the selected topic are implied (e.g. Advanced Marketing, Advanced Logistics, Advanced Production, Business Intelligence Systems)
Exam	Seminar paper and oral presentation
Recommended Term	MSc 2-3
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Business Administration and Information Systems
Language	English

Information Retrieval and Information Sciences

Module: Introduction Information Retrieval (IR)

Responsible	Prof. Dr. Thomas Mandl
Lecturer	Prof. Dr. Thomas Mandl and members of the study group
Type	2 HPW lecture
Credit Points	4 CPs
Workload	presence: 21 hours; self-study: 79 hours
Learning goals/ Competencies	Students know the technologies for representing Information Retrieval Systems and are familiar with search models. They should be able to describe Information Retrieval Systems and their components as well as assign them to fundamental paradigms. The Students are able to differentiate Information Retrieval systems from the area of Databases. They know how to use user-oriented processes for evaluating Information Processes.
Content	Information Retrieval deals with uncertain representation of unstructured knowledge (especially text) and a vague search of information. The lecture gives an overview of Retrieval-Processes and introduces in detail manual and automatic indexing as well as weighting and treats important search models (partial and exact match, vector space, language model). One main focuss are evaluation approaches. Other contents are user behavior, user interface, web-retrieval and multimedia-retrieval.
Literature	• R. Manning, H. Schütze: *Introduction to Information Retrieval* Cambridge University Press. 2008.
Requirements	none
Exam	written exam (60 - 90 min) or oral exam (20 min)
Recommended Term	MSc 1-3
Turn	every year
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Information Retrieval and Information Sciences
Language	English

Module: Introduction Natural Language Processing

Responsible	Prof. Dr. Ulrich Heid
Lecturer	Prof. Dr. Ulrich Heid and members of the study group
Type	3 HPW lecture
Credit Points	4 CPs
Workload	presence: 32 hours; self-study: 68 hours
Learning goals/ Competencies	The Students know the most important symbolic and statistical language process methods and are able to estimate their performance and limits as well as their application relevance. They are able to understand and give a professional opinion on model and implememntation approaches. The students know evaluation approaches for language processing systems and are able to evaluate on there own. During the tutorium they gain knowledge how to install and use language processing tools and know their functunality, their Input and Output and their resource requirements. They are able to interpret the different outcomes and judge them related to the explicit task. Some example of those tools are Tokenizer, Wordclass-Tagging, morphological and syntactical analysis systems (Parser) and so on.
Content	Tasks, methods, processes and application of language processing. The main focuss are the fundamental rule-based and statistic procedures for automatic processing of written language; especially the ones who are important for information science applications (e.g. Information retrieval, Imformation-Extraction, Multilingual Applications). Evaluation methods and principles. The tutorium startsin the third week of the semester. First an introduction in Linux is given. Since week 3: exercises depending on the topics of the lecture: procedures, methods and application of language processing. The focuss lies on the practical use of language processign tools available from the institute or the internet.
Submodules	*SM 1: Introduction Natural Language Processing, Lecture* Type: 3 HPW Lecture (4 CPs)
Literature	will be announced in the lecture
Requirements	basic knowledge in Information Systems.
Exam	written exam (60 - 90 min) or oral exam (20 min)
Recommended Term	MSc 1-3
Turn	every year
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Information Retrieval and Information Sciences
Language	English

Module: Multilingual Information Systems

Responsible	Prof. Dr. Thomas Mandl
Lecturer	Prof. Dr. Thomas Mandl and members of the study group
Type	2 HPW lecture
Credit Points	4 CPs
Workload	presence: 21 hours; self-study: 79 hours
Learning goals/ Competencies	The students should have developed a deeper understanding in multilingual information systems. They are able to use such systems target-oriented and apply evaluation methods to multilingual information systems.
Content	The multilingual content in Information Systems increases and must be handled. For example Information Retrieval or Text Mining to multiple language, structure and management of multilingual knowledge bases, software-localization as well as databases with multilingual content. Content of this course are methods, systems, evaluation methods and problems with the usage of information systems in multilingual areas. The students deepen their knowledge in multilingual information systems. They are able to use such systems target-oriented and apply evaluation methods to multilingual information systems.
Submodules	*SM 1: Introduction Information Retrieval (IR), Lecture* Type: 2 HPW Lecture (4 CPs)
Literature	will be announced in the lecture
Requirements	Contents of the lecture „Introduction Information Retrieval (IR)“.
Exam	written exam (60 - 90 min) or oral exam (20 min)
Recommended Term	MSc 1-3
Turn	every year
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Information Retrieval and Information Sciences
Language	English

Module: Seminar Multilingiual Information Retrieval

Responsible	Prof. Dr. Thomas Mandl
Responsible Instructors	Prof. Dr. Thomas Mandl and members of the study group
Type	2 HPW seminar
Credit Points	4 CPs
Workload	presence: 21 hours; self-study: 79 hours
Learning goals/ Competencies	The students are familar with Multilingual Inforamtion Retrieval Systems, know the problems, tools and user-oriented evaluation methods. They are able to exploit and elaborate a predetermined problem.
Content	This Seminar deepens the knowledge of Multilingual Information Retrieval, presents state-of-the-art language-dependent and language-independent methods and shows tools for Multilingual Retrieval.
Submodules	none
Literature	depending on the topic
Requirements	The contents of the lecture „Multilingual Information Systems“
Exam	Active participation and written seminar paper.
Recommended Term	MSc 2-3
Turn	every year
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Information Retrieval and Information Sciences
Language	English

Module: Project Multilingual Information Systems

Responsible	Prof. Dr. Thomas Mandl
Responsible Instructors	Prof. Dr. Thomas Mandl and members of the study group
Type	4 HPW project
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	In this project students have the possibility to choose suitable methods and use them target-oriented. Reflected and led by theory students strive for a praxisoriented solution. The students should be able to organize and structure their project in a small team.
Content	In this course students perform a specific small-scale-project based on state-of-the-art researches in Multilingual Information Systems.
Submodules	none
Literature	depending on the topic
Requirements	The contents of the Module „Multilingual Information Systems“
Exam	written summary
Recommended Term	MSc 3
Turn	every year
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Information Retrieval and Information Sciences
Language	English

Module: Lab Course Information Retrieval (IR)

Responsible	Prof. Dr. Thomas Mandl
Lecturer	Prof. Dr. Thomas Mandl and members of the study group
Type	2 HPW lab course
Credit Points	4 CPs
Workload	presence: 21 hours; self-study: 79 hours
Learning goals/ Competencies	Students are able to use tools for every phase in Information Retrieval Processes. They can use systems target- and task-oriented and evalaute them depending on the situation.
Content	The Praktikum focusses on tools for Information Retrieval and their components: • manual indexing based on a classification system • automatic indexing (stemming) and its evaluation • search methods and search tools • relevance-feedback and term extension • relevance-evaluation and evaluation methods
Submodules	none
Literature	• R. Manning, H. Schütze: *Introduction to Information Retrieval* Cambridge University Press. 2008.
Requirements	Contents of the lecture „Introduction Information Retrieval (IR)“.
Exam	Homework and written exam.
Recommended Term	MSc 2-3
Turn	every year
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Information Retrieval and Information Sciences
Language	English

Natural Language Processing

Module: Language Modelling

Responsible	Prof. Dr. Ulrich Heid
Lecturer	Prof. Dr. Ulrich Heid and members of the study group
Type	2 HPW lecture 2 HPW project
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	The students should have developed an understanding of structures in natural languages and the traditional symbolic and statistical approaches to model structures in phonology, morphology, syntax and lexical semantics. The students should understand the relevance of language modelling for information retrieval, information extraction and natural language processing. The students should be able to implement a model for one isolated linguistic phenomenon and be able to identify potentials of machine learning for that phenomenon.
Content	In the lecture the most important symbolic and statistical models for phonology, morphology and syntax, like e.g. optimality theory, two level morphology, Hidden Markov Models, phrase structure grammars and dependency grammars as well as their application to part-of-speech tagging, lemmatization and parsing will be presented. In the project one topic will be studied into depth using original literature. Students will investigate the possibilities to apply machine learning to improve the model or to reduce the implementation costs. The students will make a prototypical implementation.
Submodules	*SM 1: Natural Language Processing 2, Lecture* Type: 2 HPW Lecture, 2 HPW Project (6 CPs)
Literature	1. Daniel Jurafsky and James H. Martin: Speech and Language Processing. Prentice Hall; 2nd edition (2008) 1. Christopher D. Manning and Hinrich Schütze: Foundations of Statistical Natural Language Processing. The MIT Press (1999) 1. Additional literature will be announced in the lecture
Requirements	Basic knowledge of theoretical computer science (Automata theory, complexity, rewriting systems, Markov models).
Exam	written exam (120 min) or seminar paper
Recommended Term	MSc 2-3
Turn	irregular
Duration	1 Semester

Use	• International Master Software Engineering – Application Areas (Elective Modules) – Natural Language Processing
Language	English

Module: Natural Language Processing 2

Responsible	Prof. Dr. Ulrich Heid
Lecturer	Prof. Dr. Ulrich Heid and members of the study group
Type	2 HPW lecture
Credit Points	4 CPs
Workload	presence: 21 hours; self-study: 79 hours
Learning goals/ Competencies	Students gain an overview of state-of-the-art Natural Language Processing methods. They are able to estimate advantages and limits of those methods; they understand and can relate aspects of Natural Language Processing to Information Research and Human-Machine-Interaction. The students can develop a professional opinion on inputs, resources and outputs, and on Natural Language Processing applications.
Content	The lecture treats selected areas of Natural Language Processing and Language Technology in detail with respect to state-of-the-art research, international as well as research at the institute. It focusses on methods and tools based on these methods. Some topics are: 1. Analysis and annotation of textual data (tagging, parsing, annotation methods and representations, standards for interoperable annotated corpora, etc.). 2. Methods and paradigms of Language Processing Evaluation: Evaluation methods, degrees, gold standard, shared tasks, etc. 3. Statistical methods for Language Processing: lexicostatistics, co-occurences analysis, statistical parsing, statistical machine translation, etc. 4. Language Technology as method and tool: digital humanities applications, Language Processing daily life tools (e.g. dialogue systems, correction of orthography, style-checking, etc.). 5. Modern Neural Network Language Models and their applications.
Submodules	*SM 1: Natural Language Processing 2, Lecture* Type: 2 HPW Lecture (4 CPs)
Literature	will be announced in the lecture
Requirements	basic knowledge of Natural Language Processing.
Exam	Several tests during the semester and/or written exam (60 - 90 min) or oral exam (20 min). Homework
Recommended Term	MSc 2-3
Turn	irregular
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Natural Language Processing

Language	English

Module: Seminar Computer Linguistic Resources

Responsible	Prof. Dr. Ulrich Heid
Responsible Instructors	Prof. Dr. Ulrich Heid and members of the study group
Type	2 HPW seminar
Credit Points	4 CPs
Workload	presence: 21 hours; self-study: 79 hours
Learning goals/ Competencies	The students have a detailed knowledge about one selected Computer Linguistic Resource as an application for Natural Language Technologies. They are able to adapt and evaluate appropriate processes and applications to the selected application.
Content	This seminar deepens the knowledge of specific topics in Computational Linguistics and Language Technology. Students are led to their own research topics, ideally corresponding to the institute's research. The main theme concerns Language resources, their establishment, management and usage: e.g. corpora and corpus linguistics, from compiling and annotations to repositories. Data extraction from corpora. Other themes may concern electronic dictionaries, terminology data bases, special lexicons for Language Technology (e.g. Sentiment-Lexicons); standards on Language resources, Language Resources applications, e.g. in the area of Digital Humanities or intelligent Computer Aided Language Learning (CALL).
Submodules	none
Literature	depending on the topic
Requirements	The contents of the lecture „Natural Language Processing 2“
Exam	Colloquium and a written summary.
Recommended Term	MSc 2-3
Turn	irregular
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Natural Language Processing
Language	English

Module: Seminar Computer Linguistic Processes

Responsible	Prof. Dr. Ulrich Heid
Responsible Instructors	Prof. Dr. Ulrich Heid and members of the study group
Type	2 HPW seminar
Credit Points	4 CPs
Workload	presence: 21 hours; self-study: 79 hours
Learning goals/ Competencies	The students have aquired a detailed knowledge about at least one applied Computational Linguistic process. They are able to adapt and evaluate appropriate processes and applications to the selected application.
Content	This seminar deepens the knowledge of specific topics in Computational Linguistics and Language Technology; Students are led to own research topics, ideally corresponding to the institute's research concerning Computational Linguistics Processes, methods and applications: e.g. syntactic-semantic analysis, generation, models of dialogues, machine translation.
Submodules	none
Literature	depending on the topic
Requirements	The contents of the lecture „Natural Language Processing 2“
Exam	Colloquium and written summary.
Recommended Term	MSc 3
Turn	irregular
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Natural Language Processing
Language	English

Module: Project Computer Linguistic Resources

Responsible	Prof. Dr. Ulrich Heid
Responsible Instructors	Prof. Dr. Ulrich Heid and members of the study group
Type	4 HPW project
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	The students are able to analyse and to evaluate Computational Linguistic Resources. The students are able to respectively adapt or optimize Computational Linguistic Resources thereby solving practical questions and challenges independently. They are able to relate their solution to state-of-the-art research. This seminar imparts the foundations for a master thesis.
Content	Specialization and integrated, theoretical, methodological and practical research-based treatment of topics in Computational Linguistic and Language Technology with a focus on NL-Resources. The students independently solve tasks concerning such resources (e.g. participating in shared tasks, resource creation, and resources evaluation, etc). Other themes concern the analyis and the adaption of relevant research-literature with respect to the topic. Possibly, a tutorial is offered; in this case, the workload is calculated as a sum of project and tutorial. Such tutorials can be utilized to mediate, to train and to deepen programming techniques, annotation schemes and -methods, specific statistical procedures, evaluation methods and/or usage of complex systems.
Submodules	none
Literature	depending on the topic
Requirements	The contents of the Module „Seminar Computer Linguistic Resources“
Exam	written summary
Recommended Term	MSc 3
Turn	irregular
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Natural Language Processing
Language	English

Module: Project Computer Linguistic Processes

Responsible	Prof. Dr. Ulrich Heid
Responsible Instructors	Prof. Dr. Ulrich Heid and members of the study group
Type	4 HPW project
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	The students are able to analyse and evaluate Computational Linguistic Processes, in other words Language Technology tools and applications. The students should be able to independently analyse and implement or respectively adapt or optimize questions from the area of Computational Linguistic Processes or Language Technology respectively. They are able to relate their solution to state-of-the-art research. This seminar imparts the foundations for a master thesis.
Content	Specialized and integrated, theoretical, methodological and practical research-based treatment of topics in Computational Linguistics and Language Technology with a focus on processes. The students independently solve tasks concerning such processes (e.g. participating in shared tasks, process development and implementation and/or evaluation, etc). Other themes concern the analysis and the adaption of relevant research-literature with respect to the topic. Possibly, a tutorial is offered; in this case, the workload is calculated as a sum of project and tutorial. Such tutorials can be utilized to mediate, to train and to deepen programming techniques, annotation schemes and -methods, specific statistical procedures, evaluation methods and/or usage of complex systems.
Submodules	none
Literature	depending on the topic
Requirements	The contents of the Module „Seminar Computer Linguistic Processes“
Exam	written summary
Recommended Term	MSc 3
Turn	irregular
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Natural Language Processing
Language	English

Module: Lab Course Natural Language Processing

Responsible	Prof. Dr. Ulrich Heid
Lecturer	Prof. Dr. Ulrich Heid and members of the study group
Type	2 HPW lab course
Credit Points	4 CPs
Workload	presence: 21 hours; self-study: 79 hours
Learning goals/ Competencies	Testing of and independently work with tools, methods and resources in Language Processing. Evaluation of existing implementation approaches; implementation- and test/evaluation-practice. Knowledge of relevant tools and programming languages; skills for their productive usage: ability to estimate the realization of practical tasks in Language Processing.

Content	In the Praktikum students deal with concrete research- and development topics in the sense of case studies with a high percentage of practical content. Obtain knowledge and skills with tools, methods and Language Technology resources. For example: • (a) corpus-linguistic tools: tools for the whole corpus-linguistic process, starting with data acquisition and conversion (crawler, scripts) over annotation (tokenizing, tagging, parsing) till data extraction (search tools andstrategies). Implementation of simple questions of language and information research in corpus-linguistic analysis; interpretation of the results. • (b) script languages for working wih text data: Introduction to one script language (Perl, Python), concepts of programming with script languages, working with big data. Implementation concepts, test and evaluation of scripts. • (c) data bases and Natural Language Processing software projects: principles and praxis of relational data bases; SQL, definition and creation of data bases, linguistic data retrieval; adapt data bases in bigger software projects od Language Processing:; architeture and implementation strategies for the work with big text data. Aspects of other data bases approaches (e.g. XML-data bases, object oriented data bases) • (d) statistic methods for Language Technology: need and task formulation for descriptive statistic methods for working with language data (e.g. corpus-linguistic work); fundamental statistical methods for distribution calculation, assoziations, evaluation matching, etc. Implementation concepts of statistical programming languages like R or Python. In this lab, students deal with concrete research- and development topics in the sense of case studies – with a high percentage of practical content. They obtain knowledge and skills concerning tools, methods and Language Technology resources. For example: • (a) Corpus Linguistic tools: Tools for the whole corpus-linguistic process, starting with data acquisition and conversion (crawler, scripts) over annotation (tokenizing, tagging, parsing) to data extraction (search tools and strategies). Implementation of simple questions of language and information science research in corpus linguistic analysis; interpretation of the results. • (b) Script languages for working wih text data: Introduction to one script language (perl, python). Concepts of programming with script languages, working with big data. Implementation concepts, test and evaluation of scripts. • (c) Databases and Natural Language Processing software projects: Principles and practices of Relational Databases (SQL). Design of Databases for linguistic data retrieval; implementation strategies for the work with "big" data. Aspects of other database approaches (e.g. XML-databases, object oriented databases) • (d) Statistic and or neural methods for Language Technology: needs and tasks formulation for diverse methods for working with language data (e.g. corpus linguistics); fundamental statistical methods for distribution calculation, associations, evaluation matching, etc. Implementation concepts

Submodules	none
Literature	depending on the topic
Requirements	Contents of the lecture „Introduction Natural Language Processing“.
Exam	colloquium and written summary
Recommended Term	MSc 2-3
Turn	irregular
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Natural Language Processing
Language	English

Environmental Sciences

Module: Geographic Information Systems

Responsible	Prof. Dr. Martin Sauerwein
Type	2 HPW lecture, 4 HPW tutorial
Credit Points	6 CPs
Workload	presence: 63 hours; self-study: 87 hours
Learning goals/ Competencies	The students should be able to visualize geographic data and creating professional maps using GIS (SM 1). The second aim is that students gain basic knowledge of geoprocessing tools for the analysis of spatial geographic data in GI-Systems (SM 2).
Content	1. SM 1: The course introduces the fundamental concepts of Geographic Systems (GIS) and includes computer exercises with the software ArcGIS. In the course students acquire practical skills of major work steps as creating and editing spatial data, integrating data from different data sources, georeferencing, spatial queries, and creating and exporting maps. 2. SM 2: The second course focuses on spatial analysis and geoprocessing tools. In different GIS-projects real data sets are used for a spatial analysis with the software ArcGIS. The integration of software knowledge and ecological knowledge will be practiced.
Submodules	*SM 1: Geographic Information Systems I* Type: 2 HPW Lecture (2 CPs) 1 HPW Tutorium (1 CP) Lecturer: Prof. Dr. Martin Sauerwein *SM 2: Geographic Information Systems II* Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Martin Sauerwein
Literature	will be announced in the lecture
Requirements	none
Exam	module exam: submission of a GIS-project and oral presentation of the GIS-project (20 min)
Recommended Term	MSc 1-3
Turn	every year
Duration	2 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Environmental Sciences
Language	English

Psychology

Module: Cognitive Psychology

Responsible	Professor Dr. habil. Christina Bermeitinger
Responsible Instructors	Professor Dr. habil. Christina Bermeitinger and members of the study group
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	After completion of this module, students will have developed a deep understanding of concepts and methods of cognitive psychology.
Content	Introduction to the concepts and methods of cognitive psychology.
Submodules	*SM 1: Cognitive Psychology, Lecture* Type: 2 HPW Lecture (3 CPs) Lecturer: Professor Dr. habil. Christina Bermeitinger *SM 2: Cognitive Psychology, Tutorium* Type: 2 HPW Tutorium (3 CPs) Lecturer: Professor Dr. habil. Christina Bermeitinger and members of the study group
Literature	• Eysenck, Michael W., Keane, Mark T. (2020): Cognitive Psychology: A Student's Handbook, Taylor and Francis Ltd.
Requirements	None
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1-3
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Psychology
Language	English

Module: Brain and Neural Science

Responsible	Professor Dr. rer. nat. Kristian Folta-Schoofs
Responsible Instructors	Professor Dr. rer. nat. Kristian Folta-Schoofs and members of the study group
Type	2 HPW lecture, 2 HPW tutorial
Credit Points	6 CPs
Workload	presence: 42 hours; self-study: 108 hours
Learning goals/ Competencies	After completion of this module, students will have developed a deep understanding of the functional organization and major properties of neural circuits of the brain that give rise to perceptions, thoughts, and planned actions. They will be able to outline basic neural principles essential for understanding human cognition and behavior. Furthermore, they will be able to discuss, how sensations are assembled into inner representations and formulated into plans for immediate behavior or concepts for future actions.

Content	The human brain is a complex network of nerve cells and glial cells interconnected in systems of the central nervous system which construct our perceptions of the external world, fix our attention, and control our actions. Advances in neural science have been matched by advances in our understanding of the biology of higher brain functions which allow humans to perceive, act, think, speak, learn, and remember. Neural science represents a merger of molecular biology, neurophysiology, anatomy, embryology, cell biology, immunology, and biological psychology. Powerful research tools permit to investigate and describe the functional organization and system properties of neural circuits of the brain (in controlled experiments), and to link the molecular dynamics of individual nerve cells to representations of perceptual and motor acts. This module focuses on major neural structures, principles and mechanisms, and their relation to particular modes of cognition and behavior. We attempt to address the following questions: • How does the central nervous system and its organization develop? • What are the molecular mechanisms underlying the developmental processes responsible for assembling functional neural circuits? • How do nerve cells and glial cells communicate and interact with one another? • How do properties of specific nerve cells and different patterns of interconnections give rise to higher brain functions and particular modes of thinking and behavior? • To what extent are mental processes hard-wired into the neural architecture of the brain? • How is communication between neurons influenced by the environment, including the actions of other people? • How does the brain and its functional organization produce the remarkable individuality of human cognition and action? • What contributes to the pathogenesis of diseases that affect the structures and functions of the nervous system?
Submodules	*SM 1: Brain and Neural Science, Lecture* Type: 2 HPW Lecture (3 CPs) Lecturer: Professor Dr. rer. nat. Kristian Folta-Schoofs *SM 2: Brain and Neural Science, Tutorium* Type: 2 HPW Tutorium (3 CPs) Lecturer: Professor Dr. rer. nat. Kristian Folta-Schoofs and members of the study group
Literature	• Eric R. Kandel, John D. Koester, Sarah H. Mack, Steven A Siegelbaum: Principles of Neural Science. Sixth Edition. McGraw Hill, 2021.
Requirements	None
Exam	written exam (120 min) or an oral exam (30 min)
Recommended Term	MSc 1-3

Turn	every summer term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Psychology
Language	English

Soft Skills

Module: English 1

Responsible	external lecturer
Type	2 HPW lecture
Credit Points	3 CPs
Workload	presence: 21 hours; self-study: 54 hours
Learning goals/ Competencies	Students should be able to communicate and negotiate in correct English especially in the area of Data Analytics. They should know the specialist vocabular for written and oral communication.
Content	Writing and speaking English. Learn English grammar.
Submodules	*SM 1: English 1 I* Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer *SM 2: English 1 II* Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer
Literature	Refer to instructor
Requirements	none
Exam	Refer to instructor
Recommended Term	MSc 1-3
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Soft Skills
Language	English

Module: English 2

Responsible	external lecturer
Type	2 HPW lecture
Credit Points	3 CPs
Workload	presence: 21 hours; self-study: 54 hours
Learning goals/ Competencies	Students should be able to run specialist negotiations in correct English, to speak and discuss fluently.They earn a great vocabulary to negotiate in the area of Data Analytics. They know the formal business ommunication and what has to be respected. Students should be able to present their results in English.
Content	Writing and speaking English. Learn English grammar.
Submodules	*SM 1: English 2 I* Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer *SM 2: English 2 II* Type: 2 HPW Lecture (3 CPs)
Lecturer	external lecturer
Literature	Refer to instructor
Requirements	Refer to instructor
Exam	Refer to instructor
Recommended Term	MSc 1-3
Turn	every summer term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Soft Skills
Language	English

Module: German 1

Responsible	external lecturer
Type	2 HPW lecture
Credit Points	3 CPs
Workload	presence: 21 hours; self-study: 54 hours
Learning goals/ Competencies	This course should encourage students to speak German.
Content	This course focuses on different chapters of the German grammar, vocabulary and conversation.
Submodules	*SM 1: German 1 I* Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer *SM 2: German 1 II* Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer
Literature	Given in Class
Requirements	none
Exam	Exam
Recommended Term	MSc 1-3
Turn	every winter term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Soft Skills
Language	English/German

Module: German 2

Responsible	external lecturer
Type	2 HPW lecture
Credit Points	3 CPs
Workload	presence: 21 hours; self-study: 54 hours
Learning goals/ Competencies	This course should encourage students to speak German.
Content	This course focuses on different chapters of the German grammar, vocabulary and conversation.
Submodules	*SM 1: German 2 I* Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer *SM 2: German 2 II* Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer
Literature	Refer to instructor
Requirements	German 1 or equivalent German knowledge
Exam	Refer to instructor
Recommended Term	MSc 1-3
Turn	every summer term
Duration	1 Semester
Use	• International Master Software Engineering – Application Areas (Elective Modules) – Soft Skills
Language	English/German

Master Thesis

Module: Master Thesis

Responsible	Prof. Dr. Dr. Lars Schmidt-Thieme
Lecturer	According to agreement
Type	Master Thesis
Credit Points	30 CPs
Workload	presence: 0 hours; self-study: 750 hours
Learning goals/ Competencies	Student will acquire in-depth knowledge of the area data analytics. Through their master thesis projects students will gain necessary research skills and expertise on a specific issue of their own choosing in the area of data analytics.
Content	Students demonstrate adequate knowledge and understanding that provides a basis for developing original ideas within an academic context. Integrate knowledge and processes complex information that link to the chosen research topic. They prove their ability in reporting, source-finding, critical thinking and analysis, problem formulation and solving, argumentation, and reasoning.
Submodules	*SM 1: Master Thesis, Lecture* Type: written thesis (27 CPs) Lecturer: Professors in the course of study *SM 2: Master Thesis, Tutorium* Type: colloquium (3 CPs) Lecturer: Professors in the course of study
Literature	depends on the topic
Requirements	passed all necessary modules
Exam	written thesis
Recommended Term	MSc 4
Turn	every semester
Duration	1 Semester
Use	• International Master Software Engineering – • International Master Software Engineering – Master Thesis
Language	English