University Hildesheim

Faculty 4
Mathematics, Natural Sciences, Economics and Computer Science

# Data Analytics International Master
## (Study program within IMIT master program)

### Course Catalogue

Version October 24, 2018

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Compulsory Modules

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| Modul | Lehrform/SWS | LP | S. |
|---|---|---|---|
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# Compulsory Modules

## Module: Machine Learning

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Lecturer | none |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| 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: <br><br> 1. *fundamental machine learning problems:* different machine learning problems are described and shown in examples. <br> 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). <br> 3. *cluster-analysis and dimensionality reduction:* models for non-supervised classification are treated (hierarchical clustering, k-means, graph partitioning). <br> 4. *application of machine learning models for problems in informatics* |
| Submodules | SM 1: Advanced Machine Learning, Lecture <br> Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme SM 2: Advanced Machine Learning, Tutorium <br> Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group |

Compulsory Modules – Machine Learning

| | |
|---|---|
| Literature | <ul><li>Kevin Murphy: *Machine Learning: a Probabilistic Perspective.* MIT Press, 2012.</li><li>Richard O. Duda, Peter E. Hart, David G. Stork: *Pattern Classification.* Springer, 2001.</li><li>Trevor Hastie, Robert Tibshirani, Jerome Friedman: *The Elements of Statistical Learning.* Springer, 2001.</li><li>Tom Mitchell: *Machine Learning.* McGraw-Hill, 1997.</li></ul> |
| 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 | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics (DA) / MSc. Compulsory Module - Application - Natural Language Processing</li></ul> |
| Language | English |

Compulsory Modules – Advanced Machine Learning

# Module: Advanced Machine Learning

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Lecturer | none |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| 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: <ol><li>*fundamental machine learning problems:* different machine learning problems are described and shown in examples.</li><li>*classification:* basic models for decsion and classification tasks are treated (logistic regression, nearest neighbor, decision trees, neuronal networks, support-vector machine, simple bayesian networks).</li><li>*cluster-analysis and dimensionality reduction:* models for non-supervised classification are treated (hierarchical clustering, k-means, graph partitioning).</li><li>*methods for learning hyperparameters*</li><li>*structured prediction*</li></ol> |
| Submodules | SM 1: Advanced Machine Learning, Lecture<br>Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme SM 2: Advanced Machine Learning, Tutorium<br>Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group |
| Literature | <ul><li>Kevin Murphy: *Machine Learning: a Probabilistic Perspective.* MIT Press, 2012.</li><li>Richard O. Duda, Peter E. Hart, David G. Stork: *Pattern Classification.* Springer, 2001.</li><li>Trevor Hastie, Robert Tibshirani, Jerome Friedman: *The Elements of Statistical Learning.* Springer, 2001.</li><li>Tom Mitchell: *Machine Learning.* McGraw-Hill, 1997.</li></ul> |
| 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 |

Compulsory Modules – Advanced Machine Learning

| Use | |
|---|---|
| | • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik<br>• Data Analytics (DA) / MSc. Compulsory Module |
| Language | English |

# Module: Modern Optimization Techniques

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| 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: <br><br> 1. *Optimization Problems:* the different types of Optimization problems will be described both formally and with examples <br> 2. *Unconstrained and Equality Constrained Convex Optimization:* The main convex optimization methods (Stochastic Gradient Descent, Newton Methods, and Coordinate Descent) <br> 3. *Interior Point Methods:* Methods for solving inequality constrained problems by solving a sequence of unconstrained, or equality constrained, problems. <br> 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 <br> 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 | <br> • Stephen Boyd and Lieven Vandenberghe. *Convex Optimization.* Cambridge Univ Press, 2004. <br> • Suvrit Sra, Sebastian Nowozin and Stephen J. Wright. *Optimization for Machine Learning.* MIT Press, 2011. <br> • 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 |

Compulsory Modules – Modern Optimization Techniques

| Use | |
|---|---|
| | • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik<br><br>• Data Analytics (DA) / MSc. compulsory module |
| Language | English |

Compulsory Modules – Planning and optimal Control

# Module: Planning and optimal Control

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| 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: <br><br> 1. *Discrete and Heuristic Search* <br> 2. *Motion Planning* <br> 3. *Dealing with dynamics and Stochastic Optimal Control* <br> 4. *Reinforcement Learning* |
| Submodules | SM 1: Planning and optimal Control, lecture <br> Type: 2 HPW lecture (3 ECTS) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme SM 2: Planning and optimal Control, tutorial <br> Type: 2 HPW tutorial (3 ECTS) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group |
| Literature | <ul><li>H. Geffner, B. Bonet: *A Concise Introduction to Models and Methods for Automated Planning*, Morgan and Claypool, 2013.</li><li>D. Nau, M. Ghallab, P. Traverso: *Automated Planning: Theory and Practice*, Morgan Kaufmann, 2004.</li><li>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.</li><li>Steve LaValle. *Planning Algorithms*; Cambridge University Press, 2006 (Available Online).</li><li>Dimitri P. Bertsekas. *Dynamic Programming and Optimal Control*, Athena Scientific, 3rd ed. Vols. I and II, 2007.</li><li>Richard S. Sutton and Andrew G. Barto. *Reinforcement Learning: An Introduction*. MIT Press, Cambridge, MA, 1998.</li></ul> |
| Requirements | none |
| Exam | written exam (120 min) or an oral exam (30 min) |
| Recommended Term | MSc 3 |
| Turn | every winter term |

Compulsory Modules – Planning and optimal Control

| Duration | 1 Semester |
|---|---|
| Use | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics (DA) / MSc. compulsory module</li></ul> |
| Language | English |

Compulsory Modules – Big Data Analytics

## Module: Big Data Analytics

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| 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: <br><br> 1. *Large Scale Distributed File Systems and Data Storage frameworks* <br> 2. *Computational models for large scale data*: (e.g. MapReduce and GraphLab) <br> 3. *Data Stream Analysis* <br> 4. *Statistical learning techniques for Large Scale Data*: For example Large Scale Recommender Systems and Link Analysis |
| Submodules | SM 1: Big Data Analytics, lecture <br> Type: 2 HPW lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme SM 2: Big Data Analytics, tutorial <br> Type: 2 HPW tutorial (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group |
| Literature | <br> • Anand Rajaraman, Jure Leskovec, and Jeffrey Ullman: *Mining of massive datasets* <br> • 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 | <br> • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik <br> • Data Analytics (DA) / MSc. compulsory module |
| Language | English |

# Module: Data and Privacy Protection

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Type | 2 HPW lecture |
| Credit Points | 3 CPs |
| 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.<br><br>1. Requirements of data and privacy protection<br>  a) General requirements<br>  b) Requirements in e-commerce<br>  c) Requirements in medicine<br><br>2. Laws about data and privacy protection<br>  a) German Laws<br>  b) EU Laws<br>  c) US Laws<br><br>3. Data and privacy protection policies & technologies<br>  a) IT security<br>  b) Data encryption<br>  c) Authorization and Rights Management |
| Submodules | none |
| Literature | • David G. Hill: *Data Protection: Governance, Risk Management, and Compliance*, Crc Pr Inc, 2009.<br>• 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 | • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik<br>• Data Analytics (DA) / MSc. Compulsory Module |
| Language | English |

## Module: Project Data Analytics

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Type | 4 HPW project |
| Credit Points | 15 CPs |
| Learning goals/ Competencies | Students independently learn how to plan and manage their projects and thus develop methodological and social skills. Through teamwork they develop social skills such as conflict solving strategies, communicative skills and team management. In this project students improve their experience in research methodology, they independently formulate research topics, create the research design and reflect on them critically and organize the implementation of research processes. They should be in a position to independently work on a new topic and use known methods on new problems. They are able to document their project and present their solution. |
| Content | In teams students work out a contribution for a extensive problem. The following contents are treated, independently from the specific task: <br><br> 1. Iterative formulation, verification and revision of research topics <br> 2. Iterative design and critical reflection of research design <br> 3. Basic and advanced research methods <br> 4. Project management methods <br> 5. Organization, management, leading group sessions <br> 6. Project documentation <br><br> Other contents depends on the project task. |
| Submodules | SM 1: Project Data Analytics, Part I <br> Type: Project (6 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme SM 2: Project Data Analytics, Part II <br> Type: Project (9 Cps) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group |
| Literature | depending on the topic |
| Requirements | none |
| Exam | Project |
| Recommended Term | MSc 2-3 |
| Turn | every semester |
| Duration | 2 Semester |
| Use | <br> • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik <br> • Data Analytics (DA) / MSc. compulsory module <br> |
| Language | English |

## Module: Seminar Data Analytics

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Type | 2 HPW seminar |
| Credit Points | 4 CPs |
| 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. |
| Submodules | SM 1: Seminar Data Analytics <br> 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 | 3 Semester |
| Use | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics (DA) / MSc. compulsory module</li></ul> |
| Language | English |

Compulsory Modules – Lab Course Programming Machine Learning

# Module: Lab Course Programming Machine Learning

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Type | 4 HPW lab course |
| Credit Points | 6 CPs |
| 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: <br><br> 1. Linear models of prediction (Linear Regression, Logistic Regression) <br> 2. Generative learning algorithms (Discriminant Analysis, Naïve Bayes) <br> 3. Classification trees (Decision Trees) <br> 4. k - Nearest Neighbor <br> 5. Clustering (k-Means) <br> 6. Dimensionality Reduction (Principal Component Analysis) <br> 7. Support Vector Machines <br> 8. Matrix Factorization for Recommender Systems |
| Submodules | none |
| Literature | <br> • Brett Lantz: *Machine Learning with R*, Packt Publishing, 2013. <br> • 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 | <br> • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik <br> • Data Analytics (DA) / MSc. compulsory module |
| Language | English |

Compulsory Modules – Lab Course Distributed Data Analytics

## Module: Lab Course Distributed Data Analytics

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Type | 4 HPW lab course |
| Credit Points | 6 CPs |
| 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: <br><br> 1. working with a scheduler in a Computer Cluster (e.g. Sun Grid Engine) <br> 2. working with a distributed data system to manage big data <br> 3. working with NoSQL-data-bases for loose structured data <br> 4. Large Scale distributed file systems and data storage frameworks <br> 5. Computational models for large scale data (e.g. MapReduce and GraphLab) <br> 6. working with message passing frameworks <br> 7. working with GPU/ coprocessor-machine |
| Submodules | none |
| Literature | <br> • Anand Rajaraman, Jure Leskovec, and Jeffrey Ullman: *Mining of massive datasets* <br> • 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 | <br> • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik <br> • Data Analytics (DA) / MSc. compulsory module |
| Language | English |

# Elective Modules

## Methodological Specialization

### Module: Advanced Case-Based Reasoning

| | |
|---|---|
| Responsible | Prof. Dr. Klaus-Dieter Althoff |
| Type | 2 HPW lecture, 1 HPW tutorial |
| Credit Points | 5 CPs |
| Learning goals/ Competencies | Students develop 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<br>Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Klaus-Dieter Althoff SM 2: Advanced Case-Based Reasoning, Tutorium<br>Type: 1 HPW Tutorium (2 CPs) Lecturer: Prof. Dr. Klaus-Dieter Althoff and members of the study group |
| Literature | <ul><li>M.M. Richter, R.O. Weber: *Case-Based Reasoning*, Springer, Berlin 2013</li><li>R. Bergmann: *Experience Management- Foundations, Development Methodology, and Internet-Based Applications.* Springer, Berlin 2002.</li><li>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.</li><li>M. Lenz, B. Bartsch-Spörl, H.-D. Burkhard, S. Wess (Hrsg.): *Case-Based Reasoning Technology: From Foundations to Applications.* Springer, Berlin 1998.</li></ul> |
| Requirements | none |
| Exam | written exam (60 - 90 min) or oral exam (20 min) there are some prerequisite for admission to examination |
| Recommended Term | MSc 1-3 |

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Elective Modules – Methodological Specialization – Advanced Case-Based Reasoning

| Turn | every summer term |
|---|---|
| Duration | 1 Semester |
| Use | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics (DA) / MSc. elective module methodological specialization</li></ul> |
| Language | English |

Elective Modules – Methodological Specialization – Deep Learning

## Module: Deep Learning

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| 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<br>Type: 2 HPW lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme SM 2: Deep Learning, tutorial<br>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 | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics (DA) / MSc. methodological specialization</li></ul> |
| Language | English |

Elective Modules – Methodological Specialization – Bayesian Networks

## Module: Bayesian Networks

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| 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<br>Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme SM 2: Bayesian Networks, Tutorium<br>Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group |
| Literature | <ul><li>Marco Scutari: *Bayesian Networks: With Examples in R*, Chapman and Hall/CRC, 2014.</li><li>D. Koller, N. Friedmann: *Probabilistic Graphical Models: Principles and Techniques*, The MIT Press, 2009.</li><li>Finn V. Jensen: *Bayesian networks and decision graphs.* Springer, 2001.</li><li>Richard E. Neapolitan: *Learning Bayesian Networks.* Prentice Hall, 2003.</li><li>Enrique Castillo, Jose Manuel Gutierrez, Ali S. Hadi: *Expert Systems and Probabilistic Network Models.* Springer, 1997.</li><li>Christian Borgelt, Rudolf Kruse: *Graphical Models.* Wiley, 2002.</li></ul> |
| 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 |

Elective Modules – Methodological Specialization – Bayesian Networks

| Use | |
|---|---|
| | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics (DA) / MSc. elective module Methodological Specialization</li></ul> |
| Language | English |

Elective Modules – Methodological Specialization – Computer Vision

## Module: Computer Vision

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| 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<br>Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme SM 2: Computer Vision, Tutorium<br>Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group |
| Literature | <ul><li>Richard Szeliski: *Computer Vision: Algorithms and Applications.* Microsoft Research, 2010.</li><li>Milan Sonka, Vaclav Hlavac, Roger Boyle: *Image Processing, Analysis, and Machine Vision.* Thomson, 2008.</li><li>John C. Russ, J. Christian Russ: *Introduction to Image Processing and Analysis.* CRC Press, 2008.</li><li>R. C. Gonzalez, R. E Woods: *Digital Image Processing.* Pearson, 2008.</li><li>G. Aubert, P. Kornprobst: *Mathematical Problems in Image Processing. Partial Differential Equations and the Calculus of Variations.* Springer, 2006.</li><li>J. R. Parker: *Algorithms for Image Processing and Computer Vision.* Wiley, 1997.</li></ul> |
| 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 |

Elective Modules – Methodological Specialization – Computer Vision

| Use | |
|---|---|
| | • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik<br>• Data Analytics - Elective modules - Methodological Specialization |
| Language | English |

Elective Modules – Methodological Specialization – Business Analytics

## Module: Business Analytics

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Lecturer | none |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| Learning goals/ Competencies | <ul><li>Understanding the classical forecasting methodologies and their application to business domains</li><li>Exploring the state-of-the-art in terms of Recommender Systems and the Internet economy</li><li>Empowering the analytical ability to abstract the necessary data-driven methodologies for complex business problems</li></ul> |
| 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<br>Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme SM 2: Business Analytics, Tutorium<br>Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Dr. Lars Schmidt-Thieme and members of the study group |
| Literature | <ul><li>Hyndman et al., Forecasting: Principles and Practice, 2012</li><li>Aggarwal et al., Frequent Pattern Mining, 2014</li><li>Aggarwal, Recommender Systems, 2016</li><li>Tie-Yan Liu, Learning to Rank for Information Retrieval, 2011</li></ul> |
| Requirements | none |
| Exam | written exam (120 min) or an oral exam (30 min) |
| Recommended Term | MSc 1 |
| Turn | every winter term |
| Duration | 1 Semester |

Elective Modules – Methodological Specialization – Business Analytics

| Use | |
|---|---|
| | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics (DA) / MSc. Compulsory Module</li></ul> |
| Language | English |

# Application

## Computer Science/Software Engineering

### Module: Software Architectures

| | |
|---|---|
| Responsible | Prof. Dr. Klaus Schmid |
| Responsible Instructors | Prof. Dr. Klaus Schmid and members of the study group |
| Type | 3 HPW lecture, 2 HPW tutorial |
| Credit Points | 8 CPs |
| 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:<br><br>• Principles of good architectures<br>• Modeling architectures<br>• Architectural styles, patterns, tactics<br>• Design approaches<br>• Architecture evaluation<br>• Modern architecture paradigms like service-orientation<br>• Technical debt<br>• Software Ecosystems<br>• Architectures for Big Data Systems |
| Submodules | SM 1: Software Architectures, Lecture<br>Type: 2 HPW Lecture (5 CPs) Lecturer: Prof. Dr. Klaus Schmid<br>SM 2: Software Architectures, Tutorium<br>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.<br>• R.Kazman, H. Cervantes: *Designing Software Architectures.* Addison-Wesley, 2016.<br>• F. van der Linden, K. Schmid, E. Rommes: *Software Product Lines in Action.* Springer, 2007. |
| Requirements | • Fundamental Knowledge of Software Engineering (e.g., Fundamentals of Software Engineering Course)<br>• Good Programming Skills |

Elective Modules – Application – Computer Science/Software Engineering – Software Architectures

| Exam | written exam (120 min) or an oral exam (30 min) |
|---|---|
| Recommended Term | MSc 1-3 |
| Turn | every winter term |
| Duration | 1 Semester |
| Use | <ul><li>Angewandte Informatik / MSc. Kernmodul Informatik / Gebiet Software Engineering</li><li>Data Analytics (DA) / MSc. elective module Computer Science / Software Engineering</li><li>Informationsmanagement und Informationstechnologie (IMIT) (PO 11) / MSc. Informatik / Gebiet Software Engineering</li><li>Informationsmanagement und Informationstechnologie (IMIT) (PO 14) / MSc. Kernmodul Informatik / Gebiet Software Engineering</li><li>Informationsmanagement und Informationstechnologie (IMIT) (PO 16) / MSc. Kernmodul Informatik / Gebiet Software Engineering</li><li>MSc Wirtschaftsinformatik (PO 11) - Informatik - Gebiet Software Engineering</li><li>MSc Wirtschaftsinformatik (PO 14) - Wahlbereich</li></ul> |
| Language | English |

Elective Modules – Application – Computer Science/Software Engineering – Requirements Engineering

## Module: Requirements Engineering

| | |
|---|---|
| Responsible | Prof. Dr. Klaus Schmid |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| Learning goals/ Competencies | Students know the essential methodical 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 this approaches to specific contexts. |
| Content | This lecture introduces methodical and theoretical basics in requirements engineering. The components of requirements engineering and state-of-the-art techniques and their implementation are given. In particular: <br><br> 1. elicitation techniques (interview techniques, workshops, focus groups) <br> 2. requirements analysis and modelling (use cases, EPKs) <br> 3. target-based requirements techniques <br> 4. reating contract and requirement specifications <br> 5. usability and requirements <br><br> During the tutorium they deepen their knowledge of the material taught in the lectures. They solve tasks together and do homeworks. The tutorium focusses on communicate problem-solving-competence and transfer-competence. |
| Submodules | SM 1: Requirements Engineering, Lecture <br> Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Klaus Schmid <br> SM 2: Requirements Engineering, Tutorium <br> Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Klaus Schmid and members of the study group |
| Literature | • C. Rupp: *Requirements Engineering.* Hanser, 2006. <br> • K. Pohl: *Requirements Engineering.* DPunkt, 2007. |
| Requirements | Basics in 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 | • Data Analytics (DA) / MSc. elective module Computer Science / Software Engineering |
| Language | English |

Elective Modules – Application – Computer Science/ Media Systems – Data and Process Visualization

## Computer Science/ Media Systems

### Module: Data and Process Visualization

| | |
|---|---|
| Responsible | Prof. Dr. Klaus-Jürgen Förster |
| Responsible Instructors | Dr. Jörg Cassens |
| Type | 2 HPW lecture, 1 HPW tutorial |
| Credit Points | 5 CPs |
| Learning goals/ Competencies | In this module, students, learn to know different principles, methods and processes for the visualization and exploration of data and information. Starting from cognitive and semiotic principles, different types of data are examined and methods for their visualization are introduced. Furthermore, methods for the visualization of simulation and processes are discussed. |
| Content | This moduel gives an overview over different aspects of the visualization of different types of data and information, in particular<br><br>1. Cognitive foundations<br>2. Semiotic foundations<br>3. Data types and Data representation<br>4. Statistical graphs<br>5. Interaction and Data exploration<br>6. Process visualization<br>7. Visualization of simulations |
| Submodules | SM 1: Data and Process Visualization, lecture<br>Type: 2 HPW lecture (3 ECTS) Lecturer: Jörg Cassens SM 2: Data and Process Visualization, tutorial<br>Type: 1 HPW tutorial (2 ECTS) Lecturer: Jörg Cassens and members of the study group |
| Literature | will be announced in the lecture |
| Requirements | none |
| Exam | written exam (60 - 90 min) or oral exam (20 min) |
| Recommended Term | MSc 2-4 |
| Turn | every 3rd summer term |
| Duration | 1 Semester |
| Use | <br>• Data Analytics DA / MSc. elective module Computer Science / Media Systems<br>• MSc Wirtschaftsinformatik – Spezialisierungs- und Vertiefungsbereich Unternehmensmodellierung |
| Language | English |

Elective Modules – Application – Computer Science/ Media Systems – Contextualized Computing and Ambient Intelligent Systems

## Module: Contextualized Computing and Ambient Intelligent Systems

| | |
|---|---|
| Responsible | Prof. Dr. Klaus-Jürgen Förster |
| Responsible Instructors | Dr. Jörg Cassens |
| Type | 2 HPW lecture, 1 HPW tutorial |
| Credit Points | 5 CPs |
| Learning goals/ Competenices | In this module, students learn to know different principles, methods, and processes for the development of contextualized and ambient intelligent systems. Contextualized applications take context parameters, such as location, time, persons present, into account. Ambient intelligent systems are ubiquitous and pervasive and become part of the environment. Starting form cognitive and semiotic principles, it is discussed how contextual parameters can be analyzed and modeled. Different methods and tools for context reasoning are examined. Furthermore, challenges for the development of ambient systems are outlined and technologies for their implementation presented. |
| Content | This module gives an overview over different aspects of contextualized and ambient systems, in particular<br><br>1. Cognitive foundations<br>2. Semiotic foundations<br>3. Elicitation of context parameters<br>4. Modeling context parameters<br>5. Reasoning with and about context<br>6. Challenges for ambient systems<br>7. Architectures for ambient intelligent systems |
| Submodules | SM 1: Contextualized Computing and Ambient Intelligent Systems, lecture<br>Type: 2 HPW lecture (3 CPs) Lecturer: Jörg Cassens SM 2: Contextualized Computing and Ambient Intelligent Systems, tutorial<br>Type: 1 HPW tutorial (2 CPs) Lecturer: Jörg Cassens and members of the study group |
| Literature | will be announced in the lecture |
| Requirements | none |
| Exam | written exam (60 - 90 min) or oral exam (20 min) |
| Recommended Term | MSc 2-4 |
| Turn | every 3rd summer term |
| Duration | 1 Semester |
| Use | <br>• Data Analytics DA / MSc. elective module Computer Science / Media Systems<br>• MSc Wirtschaftsinformatik – Spezialisierungs- und Vertiefungsbereich Business Intelligence |
| Language | English |

Elective Modules – Application – Computer Science/ Media Systems – Contextual Design of Interactive Systems

## Module: Contextual Design of Interactive Systems

| | |
|---|---|
| Responsible | Prof. Dr. Klaus-Jürgen Förster |
| Responsible Instructors | Dr. Jörg Cassens |
| Type | 2 HPW lecture, 1 HPW tutorial |
| Credit Points | 5 CPs |
| Learning goals/ Competencies | In this module, students deepen their understanding of how to make available principles, methods and tools for user centered design and development of interactive software applications as well as how to make use of those in a systematic way. Students learn requirements elicitation, design and implementation of multimedia systems and their practical application. |
| Content | This module gives an overview over a variety of aspects of user centered design and development, in particular<br><br>1. Usabilitiy criteria and evaluation of software systems<br>2. Contextual inquiry<br>3. Interpretation and modeling<br>4. Work redesign<br>5. System design<br>6. Prototypical implementation |
| Submodules | SM 1: Contextual Design of Interactive Systems, lecture<br>Type: 2 HPW lecture (3 ECTS) Lecturer: Jörg Cassens SM 2: Contextual Design of Interactive Systems, tutorial<br>Type: 1 HPW tutorial (2 ECTS) Lecturer: Jörg Cassens and members of the study group |
| Literature | • Hugh Beyer, Karen Holtzblatt: Contextual Design – Defining Customer-Centered Systems. ISBN 978-1558604117, San Diego: Morgan Kaufmann Academic Press, 1998.<br>• Additional literature will be announced in the lecture |
| Requirements | none |
| Exam | written exam (60 - 90 min) or oral exam (20 min) |
| Recommended Term | MSc 2-4 |
| Turn | every 3rd summer term |
| Duration | 1 Semester |
| Use | • Data Analytics DA / MSc. elective module Computer Science / Media Systems<br>• MSc Wirtschaftsinformatik – Spezialisierungs- und Vertiefungsbereich Gestaltung und Entwicklung betrieblicher Informationssysteme |
| Language | English |

Elective Modules – Application – Computer Science/ Media Systems – Lab Course Media Systems

## Module: Lab Course Media Systems

| | |
|---|---|
| Responsible | Prof. Dr. Klaus-Jürgen Förster |
| Responsible Instructors | Dr. Jörg Cassens |
| Type | 3 HPW lab course |
| Credit Points | 5 CPs |
| Learning goals/ Competencies | This lab supplements the students' competence in the development of multimedia systems with some practical applications. Successful students design and implement small or medium sized projects in the area of media informatics. They make use of principles, methods and tools presented and know their limits and benefits. Students learn to solve complex problems in teams. To do this, they have to identify different tasks and divide complex tasks into solvable sub problems. They learn how to plan and manage their projects so that they can achieve the set goal. The knowledge accumulated in previous courses has to be put to use in order to acquire the technical and methodological competencies necessary to solve the task at hand. Through teamwork and interaction with the supervisor in the role of a customer, they develop social skills such as conflict solving strategies, communicative skills, team management and negotiation skills. |
| Content | This module extends different aspects of media informatics. In particular<br><br>1. Requirements elicitation for multimedia systems<br>2. Design of multimedia systems<br>3. Use of modern authoring tools<br>4. Implementation of multimedia applications<br>5. Project documentation and presentation |
| Submodules | none |
| Literature | none |
| Requirements | none |
| Exam | Colloquium, prtototype and written summary / documentation. |
| Recommended Term | MSc 2-4 |
| Turn | every summer term |
| Duration | 1 Semester |
| Use | • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik<br>• M.Sc. Wirtschaftsinformatik – Spezialisierungs- und Vertiefungsmodule – Business Intelligence<br>• Data Analytics - Elective Modules - Computer Science / Media Systems |
| Language | English |

Elective Modules – Application – Computer Science/ Media Systems – Seminar Media Systems

## Module: Seminar Media Systems

| | |
|---|---|
| Responsible | Prof. Dr. Klaus-Jürgen Förster, Dr. Jörg Cassens |
| Responsible Instructors | Dr. Jörg Cassens |
| Type | 2 HPW seminar |
| Credit Points | 4 CPs |
| 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 for using different kinds of media as a source of information are developed which will allow the students to adapt their knowledge to changing technical and societal conditions in the future. |
| Content | Thorough engagement with current research topics in the area of media informatics. |
| Submodules | none |
| Literature | will be announced in the seminar |
| Requirements | Lectures in the area of Media Informatics pertinent to the topic chosen can be helpful. |
| Exam | Colloquium and written summary. |
| Recommended Term | MSc 1-3 |
| Turn | every winter term |
| Duration | 1 Semester |
| Use | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li></ul> |
| Language | English |

Elective Modules – Application – Business Administration and Information Systems – Advanced Marketing

## Business Administration and Information Systems

### Module: Advanced Marketing

| | |
|---|---|
| Responsible | Prof. Dr. Klaus Ambrosi |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| 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 should be able to distinguish between alternative methods and to recognize possible limits. Furthermore they should be capable to analyse and evaluate data sets and interpret the results. They should be 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 | SM 1: Advanced Marketing, Lecture<br>Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Klaus Ambrosi<br>SM 2: Advanced Marketing, Tutorium<br>Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Klaus Ambrosi and members of the study group |
| Literature | <ul><li>Malhotra, N., Nunan, D., Birks, D.: *Marketing Research: An applied approach*, Pearson Education Limited, 5th Edition, 2017</li><li>Kotler, P., Armstrong, G., Harris, L., Piercy, N.: *Principles of Marketing (European Edition)*, Pearson, 7th Edition, 2016</li><li>Sorger, S.: *Marketing Analytics: Strategic Models and Metrics*, CreateSpace Independent Publishing Platform, 2013</li></ul> |
| Requirements | Machine Learning |
| Exam | written exam (120 min) |
| Term | MSc 1-3 |
| Turn | Each 2nd semester |
| Duration | 1 Semester |
| Use | <ul><li>Data Analytics DA / MSc. elective module Business Administration</li><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Betriebswirtschaft und Informationswissenschaft</li></ul> |
| Language | English |

Elective Modules – Application – Business Administration and Information Systems – Advanced Logistics

## Module: Advanced Logistics

| | |
|---|---|
| Responsible | Prof. Dr. Klaus Ambrosi |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| Learning goals/ Competencies | Students learn to competently deal with advanced, complex models and algorithms in the fields *location planning*, *storage* and *queuing systems*. They should deal with the theoretics and should independently solve problems using complex mathematics and operation research. The students should learn to transfer the techniques to similar logistical problems and should be able to judge different ways of implementation on computer-based decision support systems. Students can structure tasks and goals from treated logistic topics and know the practical application. If they have knowledge about the important associated mathematical models, they can use the introduced algorithms and include them as methods in decision support systems. They acquire methodological and analytical skills to independently expand their scientific background in every treated area. |
| Content | 1. *location planning:* Introduction to location planning, discrete location planning, continuous location planning<br>2. *storage:* deterministic models, stochastic models<br>3. *queuing systems*: components of queuing systems, queuing system M/M/1, queuing system M/M/s |
| Submodules | SM 1: Advanced Logistics, Lecture<br>Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Klaus Ambrosi, Dr. Felix Hahne SM 2: Advanced Logistics, Tutorium<br>Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Klaus Ambrosi and members of the study group |
| Literature | • W. Domschke, A. Drexl: *Logistik: Standorte.*<br>• K. Neumann, M. Morlock: *Operations Research.* |
| Requirements | none |
| Exam | written exam (120 min) or an oral exam (30 min) |
| Term | MSc 1-3 |
| Turn | Each winter term |
| Duration | 1 Semester |
| Use | • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik<br>• Data Analytics DA / MSc. elective module Business Administration |
| Language | English |

Elective Modules – Application – Business Administration and Information Systems – Product development and technologies for navigation and driver assistance systems

**Module: Product development and technologies for navigation and driver assistance systems**

| | |
|---|---|
| Responsible | Prof. Dr. Klaus Ambrosi (bis SS 2019), Prof. Dr. Julia Rieck (ab WS 2019/20) |
| Responsible Instructors | Dr. Thomas Kleine-Besten and others |
| Type | 2 HPW lecture |
| Credit Points | 3 CPs |
| Learning goals/ Competencies | The students become acquainted with the tasks and challenges of a product development on the basis of real examples. As example products navigation and driver assistance systems are used, which are developed in the automotive development process. In addition the business aspects, the underlying technologies will also be introduced. The students know the basic tasks of a product development of a complex technical product in the business environment as well as its interaction with the technical conditions. They can classify the learned content in the context of the scientific discipline and connect it to the knowledge learned so far in business economics. A discussion of the topics covered take place, enabling the students to do self-employed scientific research. |
| Content | Students are introduced to the product development process in the automotive-industry and learn about the underlying technologies using navigation- und driver assistance systems as an example. Topics covered are e.g. <ul><li>Marketing, product management</li><li>Commercial acquisition process</li><li>Technical customer acquisition: hardware and software platforms</li><li>Requirements analysis and automotive development process</li><li>Project management</li><li>Introduction to navigation systems</li><li>Bluetooth</li><li>Driver assistance</li><li>Application: The "electronic horizon"</li><li>Car to Car – Communications</li><li>Machine Learning</li><li>Digital Maps for highly-automated driving</li><li>Testing procedures</li></ul> |
| Submodules | none |

Elective Modules – Application – Business Administration and Information Systems – Product development and technologies for navigation and driver assistance systems

| | |
|---|---|
| Literature | <ul><li>Winner, Hakuli, Wolf: *Handbuch Fahrerassistenzsysteme*</li><li>Schäuffele, Zurawka: *Automotive Software Engineering: Grundlagen, Prozesse, Methoden und Werkzeuge effizient einsetzen*</li><li>Rupp: *Requirements-Engineering und -Management: professionelle, iterative Anforderungsanalyse für die Praxis*</li><li>Krüger, Reschke: *Lehr- und Übungsbuch Telematik*</li><li>Merkle, Terzis: *Digitale Funkkommunikation mit Bluetooth*</li><li>Mulcahy: *Rita Mulcahy's PMP Exam Prep*</li></ul> |
| Requirements | none |
| Exam | written exam (120 min) or an oral exam (30 min) |
| Term | MSc 1-3 |
| Turn | Each summer term |
| Duration | 1 Semester |
| Use | <ul><li>Data Analytics DA / MSc. elective module Business Administration</li><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Betriebswirtschaft und Informationswissenschaft</li><li>WI MSc / Wahlbereich / Wirtschaftsinformatik i. e. S., Betriebswirtschaftslehre und Informatik</li></ul> |
| Language | English |

Elective Modules – Application – Business Administration and Information Systems – Project Management and Scheduling

## Module: Project Management and Scheduling

| | |
|---|---|
| Responsible | Prof. Dr. Julia Rieck |
| Responsible Instructors | Prof. Dr. Julia Rieck |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| Learning goals/ Competencies | Students learn to competently deal with advanced, complex models and algorithms in the fields *location planning*, *storage* and *queuing systems*. They should deal with the theoretics and should independently solve problems using complex mathematics and operation research. The students should learn to transfer the techniques to similar logistical problems and should be able to judge different ways of implementation on computer-based decision support systems. Students can structure tasks and goals from treated project planning topics and know the practical application. If they have knowledge about the important associated mathematical models, they can use the introduced algorithms and include them as methods in project management. They acquire methodological and analytical skills to independently expand their scientific background in every treated area. |
| Content | The module covers general methods of project planning and focusses on tasks of planning of time, costs ans capacities. The module addresses different aspects of project management, varying forms of project organisation in business units as well as specific challenges in software development projects. |
| Submodules | SM 1: Project Management and Scheduling, Lecture<br>Type: 2 HPW Lecture (3 CPs) Lecturer: Prof. Dr. Julia Rieck<br>SM 2: Project Management and Scheduling, Tutorium<br>Type: 2 HPW Tutorium (3 CPs) Lecturer: Prof. Dr. Julia Rieck and members of the study group |
| Literature | <ul><li>J. Zimmermann, C. Stark, J. Rieck: *Projektplanung.*</li><li>B.J. Maddaus: *Projektmanagement.*</li></ul>(english literature to follow) |
| Requirements | none |
| Exam | Written exam (90 min) or oral exam (30 min). |
| Term | MSc 1-3 |
| Turn | Each winter term |
| Duration | 1 Semester |
| Use | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Betriebswirtschaft und Informationswissenschaft</li><li>MSc. WINF / Spezialisierungs- und Vertiefungsmodule / Industrielles Produktions- und Dienstleistungsmanagement</li><li>Data Analytics DA / MSc. elective module Business Administration</li></ul> |

Elective Modules – Application – Business Administration and Information Systems – Project Management and Scheduling

| Language | English |
|----------|---------|

Elective Modules – Application – Business Administration and Information Systems – Seminar Business Studies

## 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 |
| 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 year |
| Duration | 1 Semester |
| Use | • Data Analytics DA / MSc. elective module Business Administration |
| Language | English |

Elective Modules – Application – Business Administration and Information Systems – Business Intelligence and Data Warehousing

## 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 |
| 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 | <ul><li>J. Celko: *Joe Celko's Data Warehouse and Analytic Queries in SQL*, (2006) ISBN-13: 978-0123695123</li><li>Graziano, Linstedt: *Super Charge Your Data Warehouse*, (2011) ISBN-13: 978-1463778682</li><li>W.H. Inmon: *Building the Data Warehouse*, (2005) ISBN-13: 978-0764599446</li><li>J.E.Olson: Data Quality: *The Accuracy Dimension*, (2002) ISBN-13: 978-1558608917</li></ul> |
| 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 | <ul><li>Data Analytics (DA) / MSc. elective module Computer Science / Software Engineering</li><li>M.Sc. Wirtschaftsinformatik – Spezialisierungs- und Vertiefungsmodule – Business Intelligence</li></ul> |
| Language | English |

Elective Modules – Application – Business Administration and Information Systems – Data Warehousing in Practice

## Module: Data Warehousing in Practice

| | |
|---|---|
| Responsible | Prof. Dr. Dr. Lars Schmidt-Thieme |
| Responsible Instructors | Christoph Seck |
| Type | 2 HPW lecture, 2 HPW tutorial |
| Credit Points | 6 CPs |
| 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 have the operational data in one place "data warehouse" cleared up and systematized. |
| Content | The core of the lecture is the development of a data warehouse based on a concrete example. The starting point is a seemingly simple problem from a manufacturing company. Even more than in Business Intelligence and Data Warehousing 1 (eng.), exercises and practical work will be at the center. The focus will, therefore, be on the aspects of the DWH process that take up most of the space in such projects: analysis of source systems, handling of insufficient requirements, data quality problems, unusual reporting requirements, etc. In addition, the lecture will deal with a few topics that were not dealt with in the last semester, or only in passing. These include Master Data Management, Data Vault and the current hypertexts Self Service BI and Big Data |
| Submodules | SM 1: Data Warehousing in Practice, Lecture<br>Type: 2 HPW Lecture (3 CPs) Lecturer: Christoph Seck SM 2: Data Warehousing in Practice, Tutorium<br>Type: 2 HPW Tutorium (3 CPs) Lecturer: Christoph Seck |
| Literature | • J. Celko: *Joe Celko's Data Warehouse and Analytic Queries in SQL*, (2006) ISBN-13: 978-0123695123<br>• Graziano, Linstedt: *Super Charge Your Data Warehouse*, (2011) ISBN-13: 978-1463778682<br>• W.H. Inmon: *Building the Data Warehouse*, (2005) ISBN-13: 978-0764599446<br>• Kimball, Ross: *The Data Warehouse Toolkit*, (2013) ISBN-13: 978-1118530801<br>• Kimball, Munday, Thronthwaite: *The Microsoft Data Warehouse Toolkit*, (2011) ISBN-13: 978-0470640388<br>• J.E.Olson: *Data Quality: The Accuracy Dimension*, (2002) ISBN-13: 978-1558608917<br>• Russo, Ferrari, Webb: *Expert Cube Development with Microsoft SQL Server 2008 Analysis Services*, (2009) ISBN-13: 978-1847197221<br>• Russo, Ferrari, Webb: *Microsoft SQL Server 2012 Analysis Services: The BISM Tabular Model*, (2012) ISBN-13: 978-0735658189<br>• NBI Testing Tool und Dokumentation auf: `http://nbi.codeplex.com/` |
| Requirements | none |

Elective Modules – Application – Business Administration and Information Systems – Data Warehousing in Practice

| | |
|---|---|
| Exam | written exam (120 min) or an oral exam (30 min) |
| Recommended Term | MSc 1-3 |
| Turn | every winter term |
| Duration | 1 Semester |
| Use | <ul><li>Data Analytics (DA) / MSc. elective module Computer Science / Software Engineering</li><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Betriebswirtschaft und Informationswissenschaft</li><li>Wirtschaftsinformatik i.e.S./ MSc., Gebiet Business Intelligence</li></ul> |
| Language | English |

Elective Modules – Application – Information Retrieval and Information Sciences – Introduction Information Retrieval (IR)

## 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 |
| 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. |
| Submodules | SM 1: Introduction Information Retrieval (IR), Lecture<br>Type: 2 HPW Lecture (4 CPs) |
| 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 | • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik<br>• Data Analytics (DA) / MSc. Elective Module Business Administration and Information Systems |
| Language | English |

Elective Modules – Application – Information Retrieval and Information Sciences – Introduction
Natural Language Processing

## 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 |
| 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 | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics (DA) / MSc. Elective Module Business Administration and Information Systems</li></ul> |
| Language | English |

Elective Modules – Application – Information Retrieval and Information Sciences – Multilingual Information Systems

## 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 |
| 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<br>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 | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics (DA) / MSc. Elective Module Business Administration and Information Systems</li></ul> |
| Language | English |

Elective Modules – Application – Information Retrieval and Information Sciences – Seminar
Multilingiual Information Retrieval

## 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 |
| 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 | • Data Analytics (DA) / MSc. Elective Module Business Administration and Information Systems |
| Language | English |

Elective Modules – Application – Information Retrieval and Information Sciences – Project Multilingual Information Systems

## 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 |
| Learning goals/ Compe-tencies | 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 | • Data Analytics (DA) / MSc. Elective Module Business Administration and Information Systems |
| Language | English |

Elective Modules – Application – Information Retrieval and Information Sciences – Lab Course
Information Retrieval (IR)

## 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 |
| 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:<br><br>• manual indexing based on a classification system<br>• automatic indexing (stemming) and its evaluation<br>• search methods and search tools<br>• relevance-feedback and term extension<br>• 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 | • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik<br>• Data Analytics (DA) / MSc. Elective Module Business Administration and Information Systems |
| Language | English |

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Elective Modules – Application – Natural Language Processing – Natural Language Processing

## Natural Language Processing

## 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 |
| 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 | <ul><li>Bird, Steven, Ewan Klein, and Edward Loper. Natural language processing with Python: analyzing text with the natural language toolkit. *O'Reilly Media, Inc.* (2009)</li><li>Daniel Jurafsky and James H. Martin: Speech and Language Processing. Prentice Hall; 2nd edition (2008)</li><li>Christopher D. Manning and Hinrich Schütze: Foundations of Statistical Natural Language Processing. The MIT Press (1999)</li><li>Additional literature will be announced in the lecture</li></ul> |
| Requirements | Basic knowledge of theoretical Computer Science (Automata theory, complexity, rewriting systems, Markov models). |

Elective Modules – Application – Natural Language Processing – Natural Language Processing

| | |
|---|---|
| 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 | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics (DA) / MSc. Elective Module</li></ul> |
| Language | English |

Elective Modules – Application – Natural Language Processing – Language Modelling

## 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 |
| 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<br>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)<br><br>1. Christopher D. Manning and Hinrich Schütze: Foundations of Statistical Natural Language Processing. The MIT Press (1999)<br><br>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 | • Data Analytics (DA) / MSc. Elective Module - Application - Natural Language Processing |
| Language | English |

Elective Modules – Application – Natural Language Processing – Natural Language Processing 2

## 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 |
| Learning goals/ Competencies | Students have a great overview about state-of-the-art Natural Language Processing methods. They are able to estimate advantages and limits of those methods; they are able to make transfer relations to aspects of Information Research and Human-Machine-Interaction. The Students are familar with these method as they can give a professional opinion on their input, resources, output and integration of applications- |
| Content | The lecture treats selected areas in Natural Language Processing and Language Technology in detail with respect to state-of-the-art research, international as well as research at the institut. It focusses on methods and tools based on theses methods. Some topics are:<br><br>1. Analysis and annotation of textdata (tagging, parsing, annotation methods and representations, standards for interoperable annotated corpora, etc.)<br>2. Methods and paradigms of Language Processing evaluation: evaluation methods, degrees, gold standard, shared tasks, etc.<br>3. Statistical methods for Language Processing: lexico-statistics, co-occurences analysis, statistical parsing, statistical machine translation, etc.<br>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.)<br><br>These topics are treated in a lecture giving an overview and if necessary also from a different focus. |
| Submodules | SM 1: Natural Language Processing 2, Lecture<br>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 | • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik<br>• Data Analytics (DA) / MSc. Elective Module Business Administration and Information Systems |

Elective Modules – Application – Natural Language Processing – Natural Language Processing 2

| Language | English |
|----------|---------|

Elective Modules – Application – Natural Language Processing – Seminar Computer Linguistic Resources

## 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 |
| Learning goals/ Competencies | The students have a detailed knowledge about one part in Computer Linguistic Resources or applications in Language Technology. They are able to adapt and evaluate these processes and applications to minor research topics. The students can independently solve questions of this specific part. |
| Content | This seminar deepens the knowledge of specific topics in Computer Linguistics and Language Technology; Students are led to own minor research topics, ideally corresponding to the instituts research. Language resources, its establishemnet, management and usage: e.g. corpus linguistics, annotation of corpora, building corpus, data extraction from corpora; electronic dictionaries, terminology data bases, special lexicons for Language Technology (e.g. Sentiment-Lexicon); standards for Language resources, Language Resources applications, e.g. in the area of digital humanities or iCALL. |
| 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 2-3 |
| Turn | irregular |
| Duration | 1 Semester |
| Use | <ul><li>Data Analytics (DA) / MSc. Elective Module Business Administration and Information Systems</li></ul> |
| Language | English |

Elective Modules – Application – Natural Language Processing – Seminar Computer Linguistic Processes

## 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 |
| Learning goals/ Competencies | The students have a detailed knowledge about one part in Computer Linguistic Processes or applications in Language Technology. They are able to adapt and evaluate these processes and applications to minor research topics. The students can independently solve questions of this specific part. |
| Content | This seminar deepens the knowledge of specific topics in Computer Linguistics and Language Technology; Students are led to own minor research topics, ideally corresponding to the instituts research: Computer Linguistic Processes methods and applications: e.g. syntactic-semantic analysis, generation, models of dialogs, 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 | <ul><li>Data Analytics (DA) / MSc. Elective Module Business Administration and Information Systems</li></ul> |
| Language | English |

Elective Modules – Application – Natural Language Processing – Project Computer Linguistic Resources

## 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 |
| Learning goals/ Competencies | The students are able to analyse and evaluate Computer Linguistic Resources. The students should be able to independently solve, analyse and implement or respectively adapt or optimize questions from the area of Compuer Linguistic Resources. They are able to relate their solution to state-of-the-art research. This seminar gives the foundations for the master thesis. |
| Content | Specialization and integrated, theoretical, methodological and practical research-based treatment of topics in Computer Linguistic and Language technology with focus on Resources. The students independently solve the task with Computer Linguistic resources (if necessary in the case of joint projects like participate shared tasks, resource creation, tools or resources evaluation, etc); analyis and adaption of relevant research-literature with respect to the topic. It is possible to offer a praxis oriented tutoriums; the workload is then the sum of project and tutorium; such tutoriums can be used to mediate, to train and to deepen programming techniques, annotation-schemes and -methods, special statistical procedures, evaluation methods 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 | • Data Analytics (DA) / MSc. Elective Module Business Administration and Information Systems |
| Language | English |

Elective Modules – Application – Natural Language Processing – Project Computer Linguistic Processes

## 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 |
| Learning goals/ Competencies | The students are able to analyse and evaluate Computer Linguistic Processes or Language Technology tools and applications. The students should be able to independently solve, analyse and implement or respectively adapt or optimize questions from the area of Compuer Linguistic Processes or Language Technology respectively. They are able to relate their solution to state-of-the-art research. This seminar gives the foundations for the master thesis. |
| Content | Specialization and integrated, theoretical, methodological and practical research-based treatment of topics in Computer Linguistic and Language technology with focus on Processes. The students independently solve the task with Computer Linguistic resources (if necessary in the case of joint projects like participate shared tasks, resource creation, tools or resources evaluation, etc); analyis and adaption of relevant research-literature with respect to the topic. It is possible to offer a praxis oriented tutoriums; the workload is then the sum of project and tutorium; such tutoriums can be used to mediate, to train and to deepen programming techniques, annotation-schemes and -methods, special statistical procedures, evaluation methods 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 | <ul><li>Data Analytics (DA) / MSc. Elective Module Business Administration and Information Systems</li></ul> |
| Language | English |

Elective Modules – Application – Natural Language Processing – Lab Course Natural Language Processing

## Module: Lab Course Natural Language Processing

| | |
|---|---|
| Responsible | Dr. Folker Caroli |
| Lecturer | Dr. Folker Caroli and members of the study group |
| Type | 2 HPW lab course |
| Credit Points | 4 CPs |
| Learning goals/ Competencies | Testing of and independently work with tools, methods and resources in Language Processing; evaluation of implementation approaches; implementtation- 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: <ul><li>(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.</li><li>(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.</li><li>(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)</li><li>(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.</li></ul> |
| 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 | every year |

Elective Modules – Application – Natural Language Processing – Lab Course Natural Language Processing

| Duration | 1 Semester |
|----------|------------|
| Use | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics (DA) / MSc. Elective Module Business Administration and Information Systems</li></ul> |
| Language | English |

Elective Modules – Application – Environmental Sciences – Geographic Information Systems

## Environmental Sciences

### Module: Geographic Information Systems

| | |
|---|---|
| Responsible | Prof. Dr. Martin Sauerwein |
| Type | 2 HPW lecture, 4 HPW tutorial |
| Credit Points | 6 CPs |
| 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 | • Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik • Data Analytics DA / MSc. elective module Environmental Science |
| Language | English |

Elective Modules – Application – Soft Skills – English 1

## Soft Skills

### Module: English 1

| | |
|---|---|
| Responsible | external lecturer |
| Type | 2 HPW lecture |
| Credit Points | 3 CPs |
| 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<br>Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer SM 2: English 1 II<br>Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer |
| Requirements | none |
| Recommended Term | MSc 1-3 |
| Turn | every winter term |
| Duration | 1 Semester |
| Use | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics DA / MSc. elective module Business Administration</li></ul> |
| Language | English |

Elective Modules – Application – Soft Skills – English 2

**Module: English 2**

| | |
|---|---|
| Responsible | external lecturer |
| Type | 2 HPW lecture |
| Credit Points | 3 CPs |
| 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<br>Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer SM 2: English 2 II<br>Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer |
| Recommended Term | MSc 1-3 |
| Turn | every summer term |
| Duration | 1 Semester |
| Use | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics DA / MSc. elective module Business Administration</li></ul> |
| Language | English |

Elective Modules – Application – Soft Skills – German 1

**Module: German 1**

| | |
|---|---|
| Responsible | external lecturer |
| Type | 2 HPW lecture |
| Credit Points | 3 CPs |
| 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<br>Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer SM 2: German 1 II<br>Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer |
| Requirements | none |
| Recommended Term | MSc 1-3 |
| Turn | every winter term |
| Duration | 1 Semester |
| Use | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics DA / MSc. elective module Business Administration</li></ul> |
| Language | English/German |

Elective Modules – Application – Soft Skills – German 2

**Module: German 2**

| | |
|---|---|
| Responsible | external lecturer |
| Type | 2 HPW lecture |
| Credit Points | 3 CPs |
| 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<br>Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer SM 2: German 2 II<br>Type: 2 HPW Lecture (3 CPs) Lecturer: external lecturer |
| Requirements | German 1 or equivalent German knowledge |
| Recommended Term | MSc 1-3 |
| Turn | every summer term |
| Duration | 1 Semester |
| Use | <ul><li>Informationsmanagement und Informationstechnologie (IMIT) / MSc. Wahlmodul Informatik</li><li>Data Analytics DA / MSc. elective module Business Administration</li></ul> |
| Language | English/German |

# Master Thesis

## Module: Master Thesis

| | |
|---|---|
| Responsible | Professors in the course of study |
| Type | Master Thesis |
| Credit Points | 30 CPs |
| 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<br>Type: written thesis (27 CPs) Lecturer: Professors in the course of study SM 2: Master Thesis, Tutorium<br>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 | • Data Analytics/ MSc compulsory module Master Thesis |
| Language | English |